RHONDDA CYNON TAF COUNTY BOROUGH COUNCIL

Flood and Water Management Act 2010

Section 19 Flood Investigation Report

Storm Dennis –

Flood Investigation Area RCT27

November 2021

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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 a factual report of the storm event that occurred on 15 and 16th of February 2020 within the Rhondda Cynon Taf County Borough Council area, focusing investigation on the flooding at Treherbert in the Rhondda Fawr valley (Flood Investigation Area RCT 27, Figure 1).

This report was undertaken to identify the mechanism for 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 reduce/alleviate the risk of flooding.

The flooding that affected RCT on 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 RCT27 resulted in internal flooding to 21 residential properties, two commercial properties and 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, Public Health, 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 RCT27 on the 15 and 16th February 2020 was a result of significant overland runoff being generated from the steep hillsides above Treherbert 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 five culvert inlets identified as sources of flooding to properties, it was confirmed that the two culvert inlets associated to the Abertonllwyd Street network became hydraulically overloaded during the storm event.

Both inlets were identified as being below current design standards, in addition to being in poor structural and operational condition. The remaining three culvert networks were assessed as having adequate standards of protection of up to 1 in 1000-year event. This confirms that the three inlets had sufficient capacity to manage the expected flows, but its capacities were significantly reduced due to blockages, resulting in flooding to several properties.

RCTCBC as the Lead Local Flood Authority and Land Drainage Authority has been determined as the relevant Risk Management Authority responsible for managing the ordinary watercourse, surface water and groundwater flooding that occurred in Treherbert during Storm Dennis.

In response to the flooding in Treherbert during Storm Dennis, the LLFA has undertaken 13 actions and have proposed to undertake a further 6. 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 800 meters of culverted ordinary watercourse network length within the investigation area;
- 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
- Developing a flood routing scheme along the A4061 (Abertonllwyd Street) to manage overland flows.

As the relevant Risk Management Authority for ordinary watercourse flooding, RCTCBC as the Lead Local Flood Authority will also look to better understand the catchment above Treherbert through the development of a Strategic Outline Business Case to provide recommendations for suitable management mechanisms to mitigate the wider risk of ordinary watercourse, surface water and groundwater flooding in the community.

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 in area RCT27, however, further measures

have been proposed by RMAs to better address preparedness and response to surface water 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 Taff CBC

RCT27 – Flood Investigation Area RCT 27

RMA – Risk Management Authority

SAB – Sustainable Drainage Approval Body

SFRA – Strategic Flood Risk Assessment

SOC – Strategic Outline Business Case

SuDs – Sustainable Drainage Systems

TABLES AND FIGURES

1 INTRODUCTION

1.1. PURPOSE OF INVESTIGATION

On the 15 and 16th 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 27 which covers the village and community of Treherbert in the Rhondda Fawr valley.

The reason behind RCT's investigation is in response to the duties of the local authority in regard to 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 RMA's 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)

1.2. SITE LOCATION

The area investigated within this report covers the village of Treherbert, located in the north-western sector of RCT in the Rhondda Fawr valley, to the north of Treorchy (Figure 1).

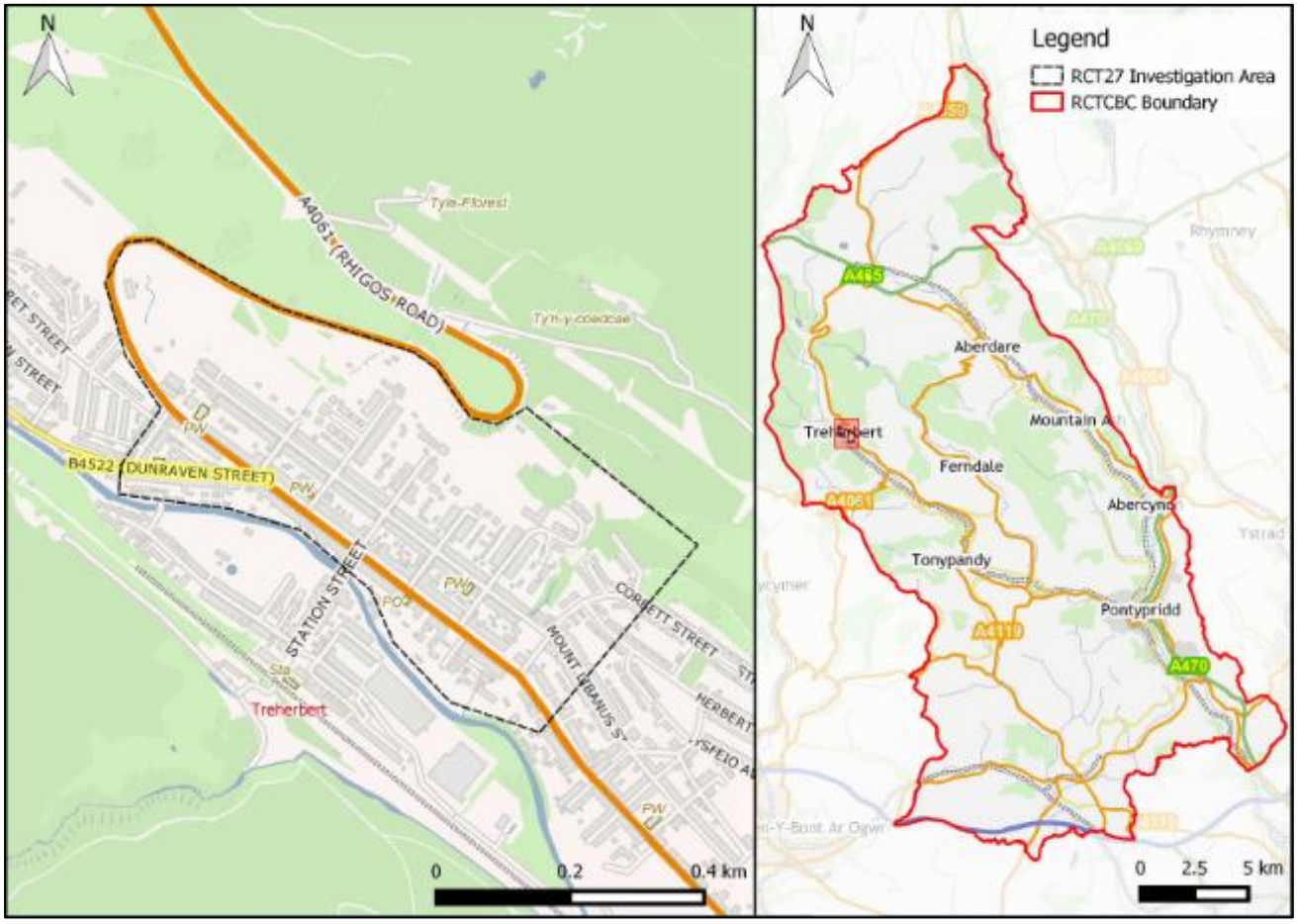

Figure 1: Flood Investigation Area RCT27 Location Plan

Treherbert is located within the River Rhondda catchment which flows north to south through the centre of the village. The area under investigation is bounded to the south west by the Rhondda Fawr River, and to the north and east by steep mountain sides of Mynydd Tynewydd and a large network of unnamed ordinary watercourses which form part of the River Rhondda Fawr catchment. Notable watercourses include the Nant Coedcaetylefforest, Nant Ton-llwyd and Nant Pwll-Brwyn which drain the hillsides above the investigation area and are partially culverted beneath Treherbert's urban settlements.

Investigation area RCT27 sits within the Electoral Ward and Community of 'Treherbert' which is ranked second highest risk of surface water flooding according to the FRMP and ranked 6th in Wales for surface water and ordinary watercourse flood risk according to the CaRR.

Treherbert has some of the steepest topography in RCT and as a result the highlands have remained undeveloped whilst residential development is confined to the valley floor. These steep slopes largely contribute to Treherbert's significant ordinary watercourse and surface water flood risk.

The highest risk posed to people and properties according to the FRMP is broadly associated with culvert inlets located to the north of investigation area RCT27[3]. The risk of flooding from pluvial sources (surface water and ordinary watercourse) is illustrated within Natural Resources Wales' Flood Risk Assessment Wales (FRAW) mapping (Figure 2). A low risk of flooding from the Main River is noted within the floodplains adjacent to the River Rhondda Fawr.

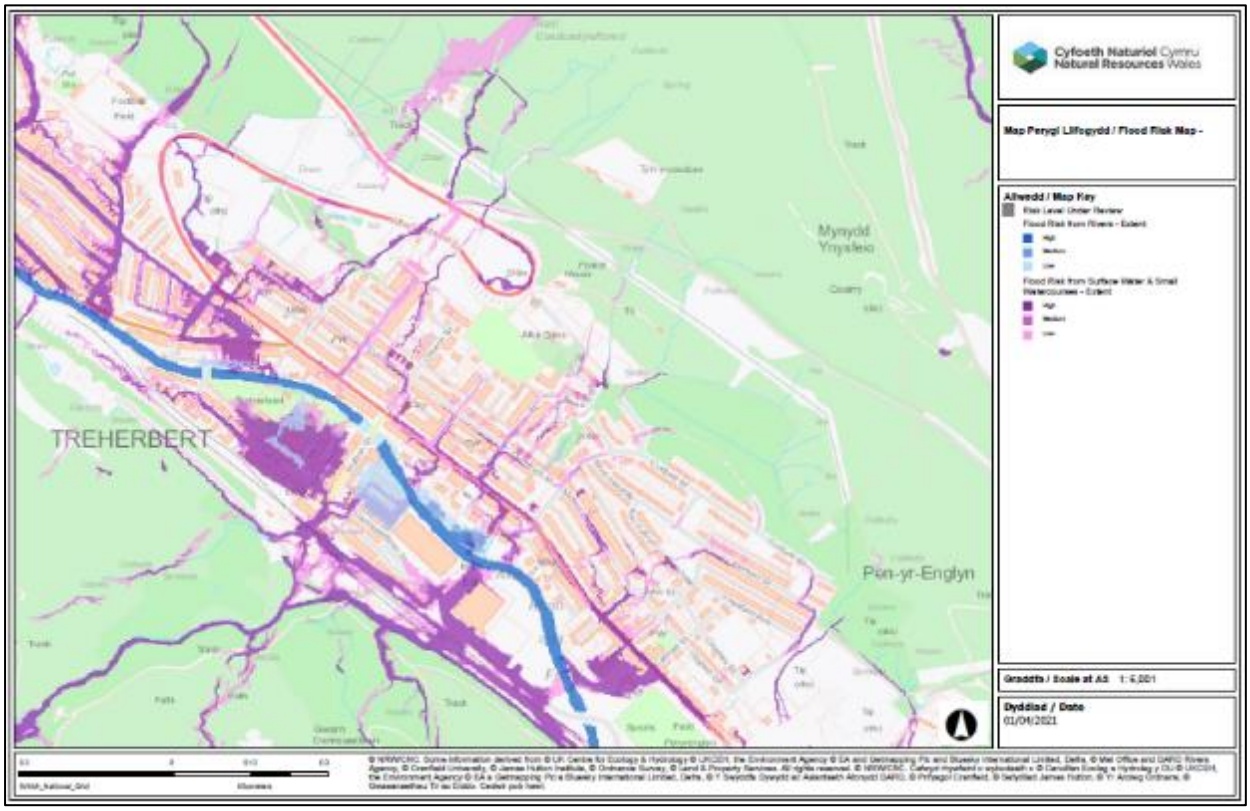

Figure 2: Natural Resources Wales' Flood Risk Assessment Wales (FRAW) map for rivers and ordinary watercourse and surface water flood risk at investigation area RCT27. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

[3] Flood Risk Management Plan, RCTCBC, December 2015

1.3. Drainage System

The surface water drainage system that serves investigation area RCT27 is that of the highway drainage network designed to manage the surface water within the highway and public surface water sewer and combined sewer networks 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 the 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[2])
Rain Gauges	RCT and NRW operated gauge information (see FRM – Storm Dennis – Overview Report[2])
Natural Resources Wales	River Level and Flood Warning data
RCT Flood Risk Management Plan	Site specific information and data for each electoral ward in RCTCBC
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 RCTCBC 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 15th 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 through the village of Treherbert. 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 2018 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 and Storm Callum on 12-13th October 2018.

According to RCT's Flood Risk Management team, flooding at Abertonllwyd Street has been attributed to the culvert inlet adjacent to the New Park Garage. The result of which is overland flows that have internally flooded a number of residential properties within the Abertonllwyd Street and Dunraven Street area. Residents also report that flooding to properties along Abertonllwyd Street from groundwater sources has been an issue since the 2018 storms.

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 21 residential properties and two commercial properties as internally flooded.

A summary of the source(s) and pathway(s) of flooding within investigation area RCT27 during Storm Dennis have been outlined in Table 2 and further described throughout this section. For the purpose of this investigation, the flood incident at investigation area RCT27 will be described in two parts: the incident at 'Treherbert West' sub-catchment and the incident at 'Treherbert East' sub-catchment. The sub-catchment areas are illustrated below Table 2, within Figure 3.

Table 2: Summary of the source(s), pathway(s) and receptor(s) affected during Storm Dennis within investigation area RCT 27

Source	Pathway	Receptor
Treherbert West Sub-Catchment		
Intense rainfall running off the steep hillsides to the north of Treherbert draining to lower ground via a series of unnamed ordinary watercourses. A culvert inlet adjacent to New Park Garage surcharged during the storm event.	Surcharging flows from the culvert inlet adjacent to New Park Garage resulted in water conveyance into the commercial unit and onwards towards Abertonllwyd Street, Glenrhondda Court and Dunraven Street.	Directly caused internal flooding to 1 commercial property on Abertonllwyd Street. The flow path also contributed to the internal flooding of 18 residential properties on Abertonllwyd and Dunraven Streets.
Surcharged ordinary watercourse manhole on Abertonllwyd Street.	Surcharging flows from the ordinary watercourse manhole contributed additional overland flows	Contributed to the internal flooding of 18 residential properties on Abertonllwyd and Dunraven Streets.

	along Abertonllwyd Street and onwards towards Glenrhondda Court and Dunraven Street.	
Residents at Abertonllwyd Street reported water ingress through the basements of properties indicating a potential groundwater source contributed to the flooding.	The exact flow path is unknown however, the conveyance is attributed to Throughflow within the subsurface.	Contributed to the internal flooding of 9 residential properties on Abertonllwyd Street.
Intense rainfall running off the steep hillsides to the north of Treherbert draining to lower ground via the Nant Coedcaetylefforest ordinary watercourse. The Nant Coedcaetylefforest ordinary watercourse surcharged at the inlet due to debris blockages.	Surcharging flows from the culvert inlet flowed south down Dumfries Street before continuing its pathway towards Dunraven Street. On its course of flow surface water is considered to have travelled east along Dumfries Street due to local gradient.	Surface water flows along the highway contributed to the internal flooding of 9 residential properties at Dunraven Street. Flow paths along Dumfries Street caused internal flooding to 1 residential and 1 commercial property.
Intense rainfall running off the steep hillsides to the north and east of Treherbert draining to lower ground via a series of unnamed ordinary watercourses. A culvert inlet located below the A4061 was observed as fully submerged during the storm event.	Surcharging water flowed overland and conveyed via a track road leading to Dumfries Street. Water continued its pathway downhill towards Dunraven Street. On its course of flow surface water is considered to have travelled east along Dumfries Street due to local gradient.	Flowpaths along Dumfries Street caused internal flooding to 1 residential and 1 commercial property. Exceedance flows along the highway contributed to the flooding at Dunraven Street.
Treherbert East Sub-Catchment		
Intense rainfall running off the steep hillsides to the north and east of Treherbert draining to lower ground via a series of unnamed ordinary watercourses including the Nant Pwll-	Surcharging flows from both culvert inlets caused water to flow downhill directly towards Tyle-Fforest and onto Ross Rise with flows channelled through the gardens of several properties.	Internal flooding to 1 residential property at Tyle-Fforest and 1 property at Ross Rise. This flow path also externally impacted several properties in the area.

brwyn ordinary watercourse. Two culvert inlets located near Tyn-y-Coedcae surcharged during the storm event.		

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 Treherbert draining to lower ground. This runoff was routed towards the investigation area via several ordinary watercourses, many of which became overwhelmed during Storm Dennis and caused flooding associated to blocked culvert inlets.

Figure 3 depicts the topographic watershed of the Rhondda Fawr and Fach valleys (bold pink line), with rainfall to the south east of the watershed draining to the Rhondda Fawr catchment. The catchment above investigation area RCT27 can be sub-divided into further sub-catchments to illustrate the area of land that would expect to drain towards the investigation area (hatched areas in Figure 3). The flood incident at investigation area RCT27 will be further described in two parts: the incident at ‘Treherbert West’ sub-catchment (red hatched area, Figure 3) and the incident at ‘Treherbert East’ sub-catchment (blue hatched area, Figure 3).

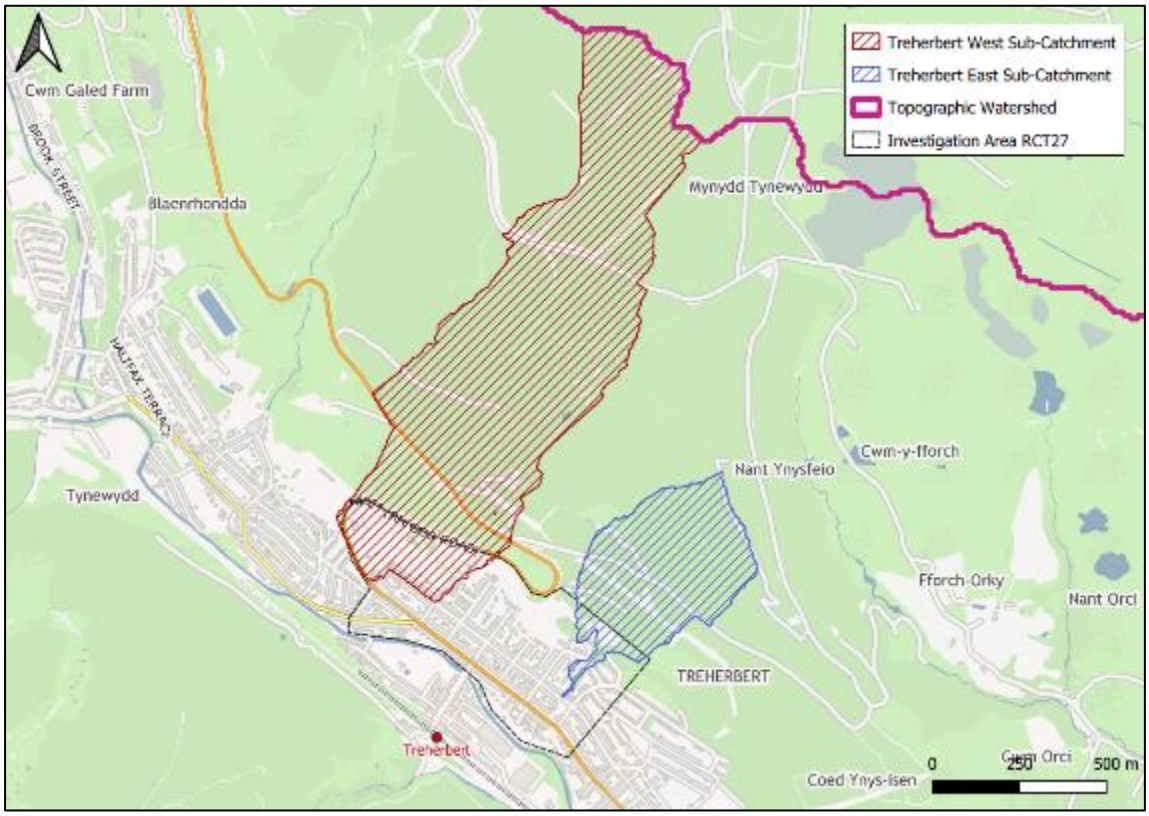

Figure 3: Rainfall Topographic Watershed and Sub-catchments above investigation area RCT27

2.2.1. TREHERBERT WEST SUB-CATCHMENT

The steep hillsides above the western half of investigation area RCT27 form the 'Treherbert West' sub-catchment. This area is drained by a network of ordinary watercourses, with the Nant Coedcaetylefforest ordinary watercourse being the most notable.

Figure 4 depicts the observed pathways of flooding within the 'Treherbert West' sub-catchment during Storm Dennis. The infrastructure known to have surcharged and contributed to the flooding are also illustrated in Figure 4.

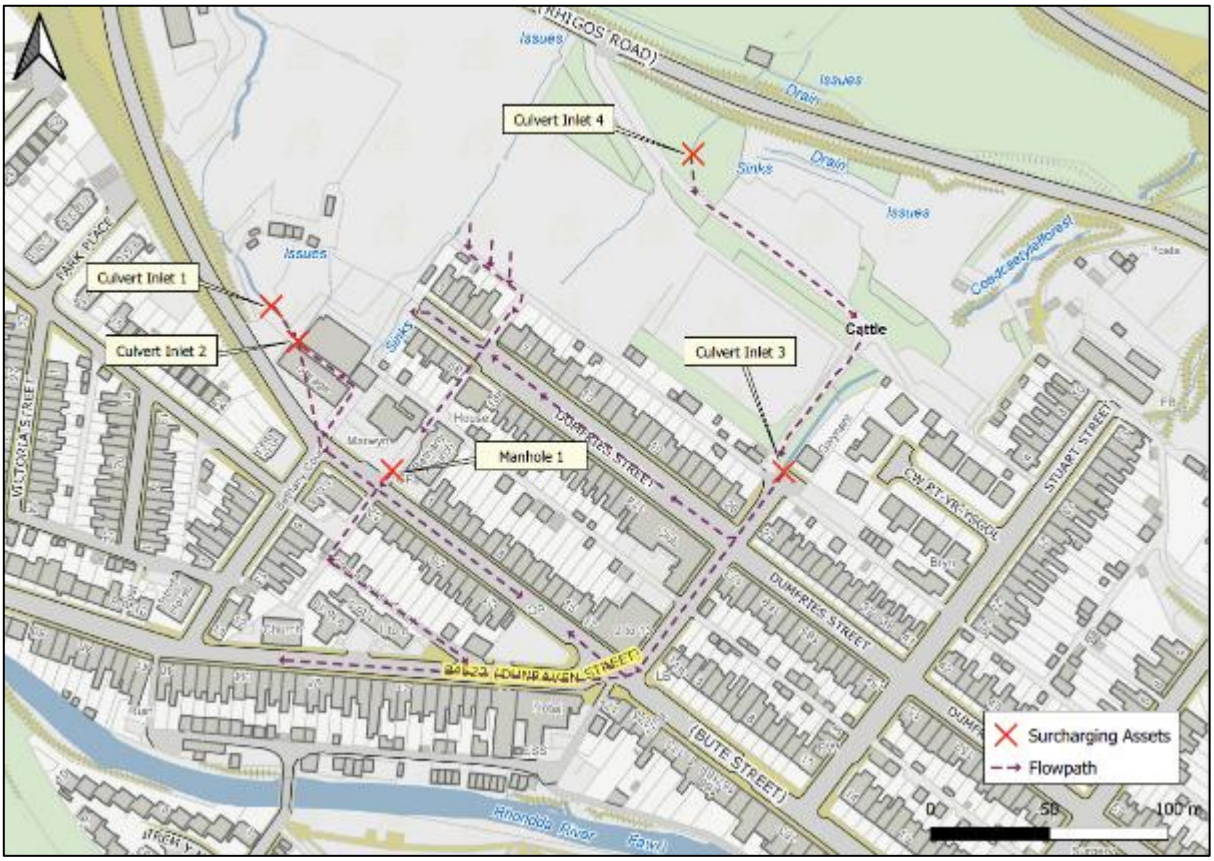

Figure 4: Observed flow paths within 'Treherbert West' sub-catchment during Storm Dennis (16th February 2020)

Several calls were received from residents at Abertonllwyd Street and Dunraven Street on the 16th February 2020 to report water ingress into multiple residential properties. Upon a site inspection undertaken by RCT's Flood Risk Management team on the 18th February 2020, a culvert inlet adjacent to New Park Garage on Abertonllwyd Street (labelled 'Culvert Inlet 1' in Figure 4) was identified as half-submerged (Figure 5), indicating that the inlet was operating at a limited capacity post storm event.

The culvert inlet downstream of 'Culvert Inlet 1', labelled 'Culvert Inlet 2' in Figure 4, was also reported as surcharging by residents. It is considered that the surcharging flows from 'Culvert Inlet 1' overtopped the inlet structure and flowed overland towards 'Culvert Inlet 2', exacerbating the surcharging at this location.

Exceedance flows from both inlets resulted in water conveying through the commercial unit and continuing its pathway east along Abertonllwyd Street.

Figure 5: Evidence of submerged 'Culvert Inlet 1' which surcharged during Storm Dennis (captured by RCT's Flood Risk Management team on 18th February 2021)

A manhole located downstream of the surcharged inlets (labelled ‘Manhole 1’ in Figure 4) also showed evidence of surcharge. Exceedance flows from the ordinary watercourse manhole reportedly contributed additional overland flow towards Abertonllwyd Street. Water also conveyed down the path to the rear of Abertonllwyd Street towards Glenrhondda Court and onto Dunraven Street, as depicted in Figure 4.

Figure 6: 'Manhole 1' located at Abertonllwyd Street surcharged during Storm Dennis (captured by RCT's Flood Risk Management team on 18th February 2021)

Despite the significant pluvial flows travelling along the highway during Storm Dennis, residents at Abertonllwyd Street state no water conveyed into the fronts of their

properties from the surface. Residents reported water ingress primarily occurred through the basements of their properties, indicating a secondary source of flooding. Reports from residents demonstrated a combination of clear and dirty brown water was entering their properties during the storm event. This would suggest that the source of flooding was originating underground, from either groundwater sources or a defective drainage system (culverted ordinary watercourse/sewer system).

A total of nine residential properties along Abertonllwyd Street were internally flooded during Storm Dennis as a result.

The site inspection also identified evidence of a third surcharged culvert inlet located near Dumfries Street (labelled ‘Culvert Inlet 3’ in Figure 4). This culvert inlet conveys flows from the Nant Coedcaetylefforest ordinary watercourse. Evidence of cleared debris was identified (Figure 7) post event, indicating that the culvert inlet became blocked during Storm Dennis, resulting in surcharge.

Figure 7: 'Culvert Inlet 3' to the rear of Dumfries Street which surcharged during Storm Dennis (captured by RCT's Flood Risk Management team on 19th February 2021)

Furthermore, a culvert on private land to the rear of Dumfries Street was identified as fully submerged during RCT’s site inspection (Figure 8), which resulted in overland flows travelling along the track road and contributing additional surface water flows towards Dunraven Street during the storm event.

Figure 8: Overland runoff originating from 'Culvert Inlet 4' flowing along the track road to the rear of Dumfries Street (image captured by RCT's Flood Risk Management team post event on 18th February 2020)

Exceedance flows from the surcharged inlet travelled down Dumfries Street and onwards to Dunraven Street, exacerbating the flooding in this area.

Surface water was also observed flowing west along Dumfries Street due to its declining gradient. One residential property and one commercial property at Dumfries Street is considered to have been impacted by internal flooding as a result of this overland flow.

The pathways of flood water conveying along Abertonllwyd Street and Dumfries Street combined to form a pathway onto Dunraven Street before ponding at a low point in the locality of the impacted properties. Nine residential properties at Dunraven Street were confirmed as internally flooded during Storm Dennis.

The surcharging of ‘Culvert Inlet 4’ is considered to have avoided the inlet downstream from surcharging. It was however, reported by residents at the western edge of

Dumfries Street, that overland flows originating from the hillside was contributing surface water flows to the highway, although no internal flooding to properties was confirmed as a result.

2.2.2. TREHERBERT EAST SUB-CATCHMENT

The steep hillsides above the eastern half of investigation area RCT27 form the 'Treherbert East' sub-catchment. This area is drained by a network of ordinary watercourses, with the Nant Pwll-Brwyn ordinary watercourse being the most notable.

Figure 9 shows the observed pathways of flooding within the 'Treherbert East sub-catchment during Storm Dennis. The infrastructure known to have surcharged and contributed to the flooding are also illustrated in Figure 9.

Figure 9: Observed flow paths within 'Treherbert East' sub-catchment during Storm Dennis (16th February 2020)

Calls were received by residents at Tyle Fforest on the 16th February 2020 to report water emanating from a culvert inlet situated to the rear of Tyn-y-coedcae. Upon wider inspection of the area, undertaken by RCT's Flood Risk Management team on 19th

February 2020, two culvert inlets, labelled ‘Culvert Inlet 5’ and ‘Culvert Inlet 6’ in Figure 9, located to the north of Ross Rise and Tyn-y-coedcae, showed evidence of surcharge (Figure 10).

Figure 10: 'Culvert Inlet 5' (left) and 'Culvert Inlet 6' (right) located to the rear of Tyn-y-coedcae which surcharged during Storm Dennis (captured by RCT’s Flood Risk Management team on 19th February 2020)

Water from both culvert inlets flowed overland towards Tyle Fforest and Ross Rise, with some of the flow channelled via the highway and through the rear gardens of several properties, before discharging back into the Nant Pwll-brwyn ordinary watercourse downstream.

Internal flooding to two residential properties at Ross Rise and Tyle Fforest was confirmed by RCT officers during post event investigations. A further three properties suffered external flooding.

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 RCT27 there are several unnamed watercourses which drain the hillsides above the village of Treherbert and discharge into the Rhondda Fawr River. Many of these watercourses are culverted beneath Treherbert's urban settlement (previously described in Section 1.2).

Several culvert inlets were inspected by RCT's Flood Risk Management team and the Council's Highways 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 Treherbert. 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.

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.

For the purpose of this investigation, the culvert conditions within investigation area RCT27 will be described in two parts: the 'Treherbert West' sub-catchment and the 'Treherbert East' sub-catchment.

3.1.1. TREHERBERT WEST SUB-CATCHMENT

Figure 11 outlines the three networks surveyed within the 'Treherbert West' sub-catchment and highlights the culvert inlets and manhole known to have surcharged.

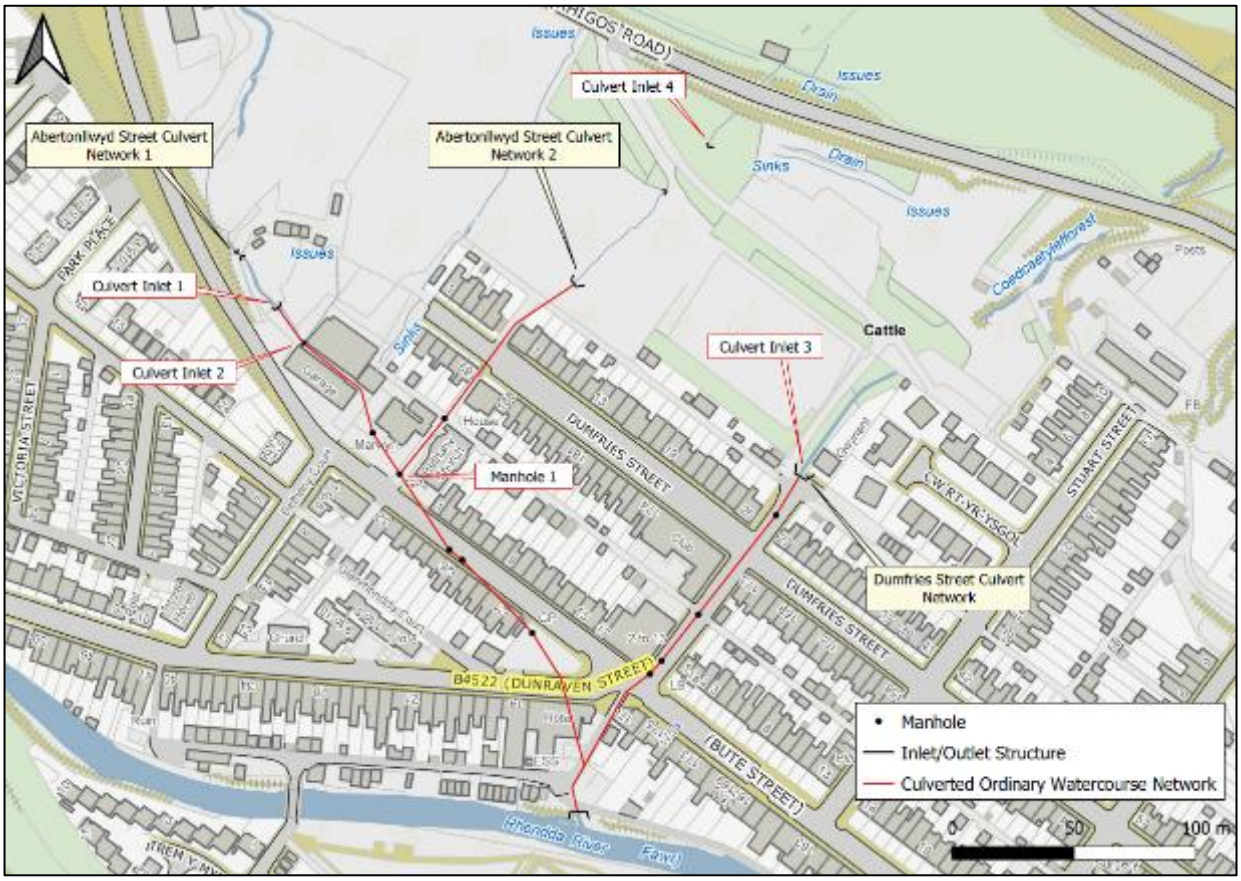

Figure 11: Surveyed culverted ordinary watercourse network within the 'Treherbert West' sub-catchment

3.1.1.1. ABERTONLLWYD STREET CULVERT NETWORK 1

Both ‘Culvert Inlet 1’ and ‘Culvert Inlet 2’, associated to ‘Abertonllwyd Street Culvert Network 1’, were identified as contributing sources of flooding to properties along Abertonllwyd and Dunraven Streets during Storm Dennis. Both inlets are identified as privately owned assets.

The culvert network length between ‘Culvert Inlet 1’ and ‘Culvert Inlet 2’, situated behind New Park Garage, consists of a 450mm plastic pipe which was noted as deformed during CCTV survey operations (Figure 12). Upon site inspections of the inlet during storm event conditions, water is observed to bypass ‘Culvert Inlet 1’ and flow over the top of the pipework towards ‘Culvert Inlet 2’. This flow path is assumed to have occurred during Storm Dennis.

Figure 12: 'Culvert Inlet 1' captured during CCTV survey operations on 30/06/2020

'Culvert Inlet 2' primarily consists of an outfall pipe which discharges underneath New Park Garage (Figure 13). The inlet also receives flow from an ordinary watercourse which runs adjacent to the garage. As depicted in Figure 13, the outfall pipe is relatively level with the surface, resulting in standing water surrounding the inlet.

Figure 13: Outfall pipe entering 'Culvert Inlet 2' (left) and standing water surrounding 'Culvert Inlet 2' (right) (captured during CCTV survey operations on 30/06/2020)

The poor condition of both culvert inlets is considered to have contributed to the surcharging of both inlets.

The ‘Abertonllwyd Street Culvert Network 1’ was initially surveyed by a Council appointed contractor on 26th June 2020 following Storm Dennis. The survey identified multiple structural and operational defects within the system, which eventually led to the survey being abandoned at two locations; downstream of ‘Culvert Inlet 2’ and downstream of ‘Manhole 1’ due to debris identified in the network.

A second Council appointed contractor undertook a further survey of the culvert network on 21st October 2020. The survey had to be abandoned again approximately 27 meters downstream of ‘Culvert Inlet 2’ due to a high volume of settled debris reducing the networks cross-sectional area by 70% (depicted in Figure 14). This debris is considered to have reduced the culvert’s hydraulic capacity to manage the flow of water entering the network, contributing to the surcharging at ‘Culvert Inlet 2’.

Figure 14: Internal view of 'Abertonllwyd Street Culvert Network 1' looking up towards 'Culvert Inlet 2’ (CCTV survey footage captured 23/10/2020)

Surcharging at ‘Manhole 1’ was also identified as a secondary source of flooding to properties at Abertonllwyd and Dunraven Streets during Storm Dennis. Both CCTV survey operations were also abandoned downstream of ‘Manhole 1’ due to settled deposits and large debris identified within the network (depicted in Figure 15). The culvert network downstream of ‘Manhole 1’ was also graded as being in very poor structural condition.

Figure 15: Internal view of 'Abertonllwyd Street Culvert Network 1' downstream of 'Manhole 1' (CCTV survey footage captured 24/10/2020)

The poor condition of the culvert network downstream of 'Manhole 1' is considered to have contributed to its surcharging during Storm Dennis. The debris identified within the network is also indicative of the high flow rates which enabled the erosion and transportation of a significant volume of debris from the upper catchment and subsequent deposition within the culvert network during the storm event.

Several jetting and cleansing operations to clear the internal culvert barrel of debris utilising specialised contractors were undertaken following both CCTV survey exercises, however, continued debris mobilisation in the network resulted in several phases of cleansing operations to complete the surveying of the network. It is estimated that approximately 15 tons of material was removed from the network during both exercises.

3.1.1.2. ABERTONLLWYD STREET CULVERT NETWORK 2

The 'Abertonllwyd Street Culvert Network 2' drains the hillside above Dumfries Street and enters the main culvert network at 'Manhole 1'. The network was surveyed to be in poor operational condition with settled deposits reducing the network's cross-sectional area by 40%.

Despite its poor condition, no flooding was observed along the culvert network. The observed surcharging at 'Culvert Inlet 4', upstream of the culvert network, is considered to have reduced the volume of water entering the network during the storm event, and thereby reduced the risk of surcharge downstream.

3.1.1.3. DUMFRIES STREET CULVERT NETWORK

Following reports that ‘Culvert Inlet 3’, which conveys the Nant Coedcaetylefforest ordinary watercourse beneath Dumfries Street, was a contributing source of flooding to properties at Dumfries and Dunraven Streets, post event inspections were carried out. These inspections found evidence of debris surrounding the inlet structure, indicating that the inlet had surcharged due to blockage during the event (see Figure 7).

The inlet is identified as a privately owned asset, however the Council’s Highway Authority maintain an inspection schedule of the asset pre storm events due to the inherent risk associated to the inlet.

The ‘Dumfries Street Culvert Network’ was also surveyed to be in poor condition, with significant operational and structural defects identified throughout the network. The volume of settled deposits led to operators abandoning the CCTV survey operations on two occasions. As a result, approximately 5 tonnes of debris was removed from the network (shown in Figure 16).

Figure 16: Debris removed from the 'Dumfries Street Culvert Network' during cleansing operations (image captured on 29/06/2020)

Similarly to the Abertonllwyd Street culvert networks, the debris identified within the Dumfries Street network highlights the strength of the ordinary watercourse flows that would have been travelling down the hillsides above RCT27 and entering the culvert networks during the storm event. Its poor condition is considered to have contributed to the surcharging of 'Culvert Inlet 3', however, the blockage to the inlet structure has been determined as the most significant contributor to the flood flow path along Dumfries and Dunraven Streets during Storm Dennis.

3.1.2. Treherbert East Sub-Catchment

Figure 17 outlines both networks surveyed within the 'Treherbert East' sub-catchment and highlights the culvert inlets known to have surcharged.

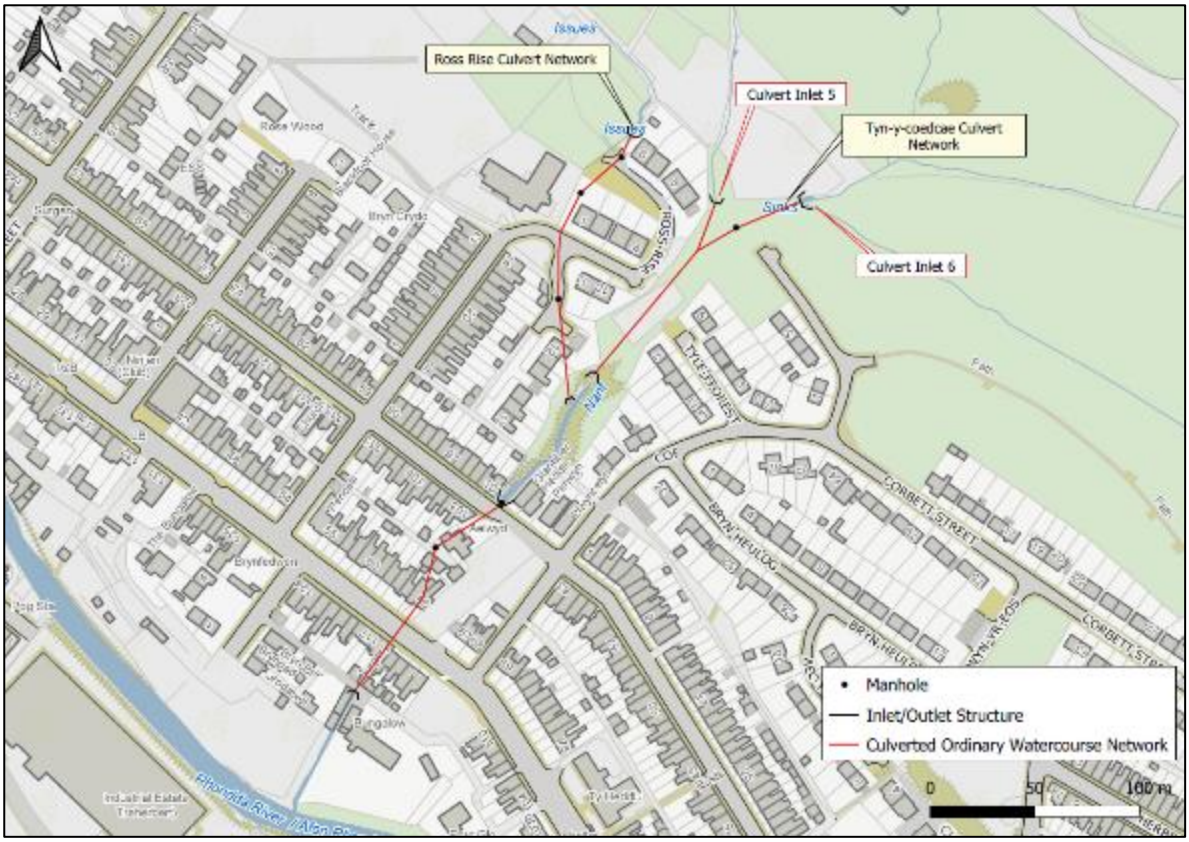

Figure 17: Surveyed culverted ordinary watercourses within the 'Treherbert East' sub-catchment

3.1.2.1. TYN-Y-COEDCAE CULVERT NETWORK

The source of flooding to three properties at Ross Rise and Tyle Fforest was identified as originating from two surcharged culvert inlets located to the north of Tyn-y-coedcae, labelled ‘Culvert Inlet 5 and 6’ in Figure 17.

The ‘Culvert Inlet 6’ structure was identified by first responders as being blocked with debris and was subsequently cleansed. Figure 18 captured post event by FRM officers depicts the inlet following clearance works.

Figure 18: Photo of 'Culvert Inlet 6' captured by RCT's Flood Risk Management team following debris clearance post Storm Dennis (19/02/2020)

The inlet is identified as a privately owned asset, however the Council’s Highway Authority maintain an inspection schedule of the asset pre storm events due to the inherent risk associated to the inlet.

The ‘Tyn-y-coedcae Culvert Network’ downstream of ‘Culvert Inlet 6’ was surveyed to be in acceptable structural and operational condition, indicating that the blockage to the inlet structure caused by debris was the primary cause of surcharge.

‘Culvert Inlet 5’ was identified as being in very poor condition, with the surrounding area showing evidence of surcharge according to on site officers. The CCTV survey identified the network downstream of the inlet to be in acceptable condition, however

the condition of the ‘Tyn-y-coedcae Culvert Network’ downstream of the connecting networks was in poor condition, with settled deposits identified.

Despite its poor condition, no flooding was observed along the culvert network downstream of both inlets.

3.1.2.2. Ross Rise Culvert Network

Although no flooding was observed along the Ross Rise culvert network, the culvert inlet was inspected by FRM officers post event to assess its condition. The inspection found no evidence of surcharge or blockage to the inlet.

It can be concluded that the Ross Rise culvert network did not contribute to the flooding that occurred within the ‘Treherbert East’ sub-catchment.

3.2. ORDINARY WATERCOURSE CONDITIONS

Several sections of natural ditches and open watercourses which drain the steep catchment above Treherbert are identified to flow through the investigation area, as illustrated in Figure 19. The most notable watercourses include the Nant Coedcaetylefforest, the Nant Ton-llwyd and Nant Pwll-brwyn.

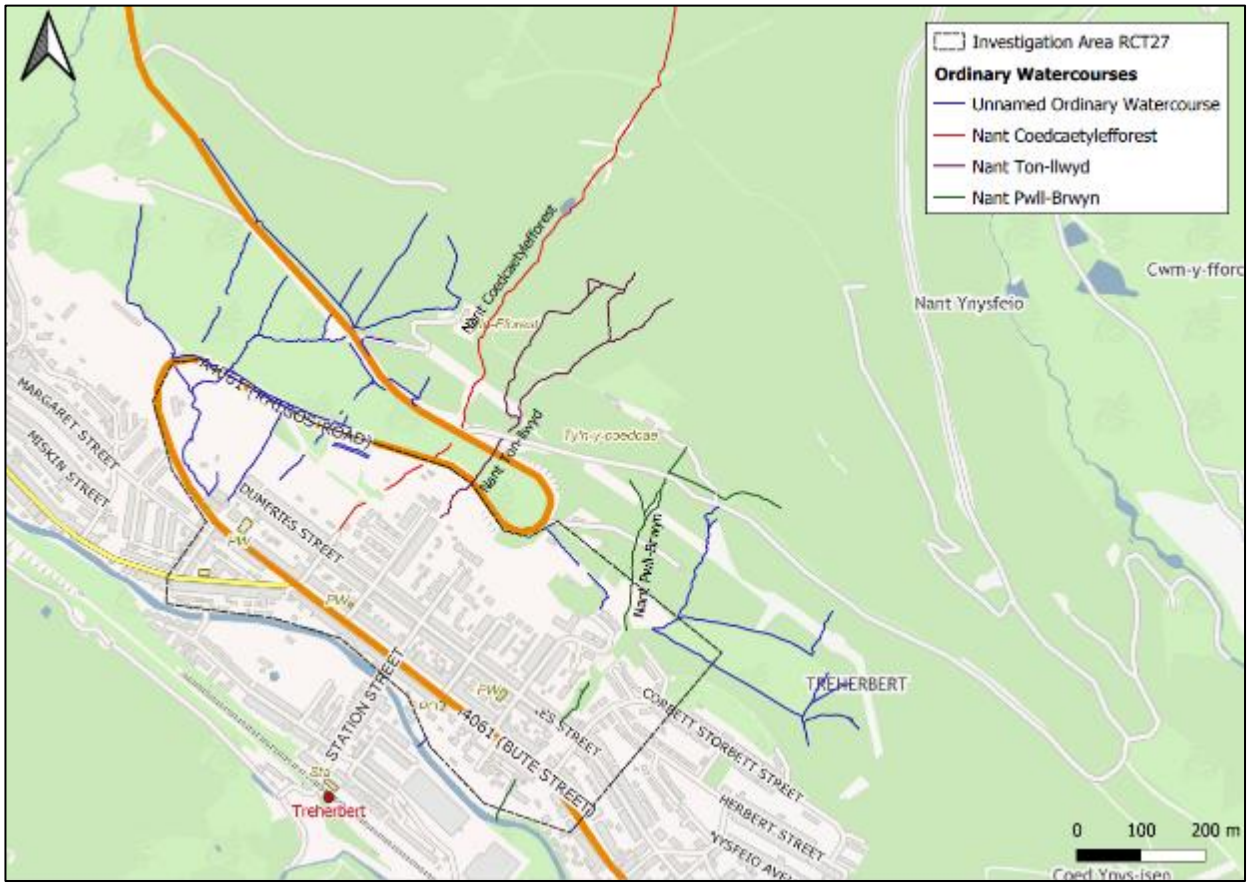

Figure 19: Map of Ordinary Watercourses which feed into investigation area RCT27

Following the storm event, RCT Flood Risk Management officers carried out a site walk-over assessment of the ordinary watercourses upstream of the culvert inlets identified as sources of flooding 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. TREHERBERT WEST UNNAMED ORDINARY WATERCOURSES

On review of the unnamed open watercourse conditions identified within the 'Treherbert West' sub-catchment, a large proportion were identified as heavily overgrown with dense vegetation restricting on-site inspections.

According to on-site officers, several sections of open watercourse upstream of the ‘Abertonllwyd Street Culvert Network 1’ (Figure 11) had significant build-up of debris within the channels, indicating significant mobilisation of debris occurred during the storm event (depicted in Figure 20). The conveyance of sediment, silt and stone downstream is considered to have contributed to the surcharging of ‘Culvert Inlet 1’ and ‘Culvert Inlet 2’ during Storm Dennis. This debris is also considered to have entered the culvert network, contributing to the surcharge of ‘Manhole 1’ during the event.

Figure 20: Image of debris accumulation within the unnamed ordinary watercourse channel upstream of 'Culvert Inlet 1' (Figure 4) (captured during CCTV operations on 30/06/2020)

The unnamed ordinary watercourses located above ‘Abertonllwyd Street Culvert Network 2’ (Figure 11) did not show evidence of significant debris mobilisation, however, it was apparent during post event inspections that significant overland flows had occurred along the hillside upon identifying evidence of flattened vegetation and saturated ground. The ordinary watercourse channel upstream of ‘Culvert Inlet 4’ (Figure 11), which surcharged during the storm event, was largely undefined and is considered to have contributed to the inlet becoming submerged, resulting in out-of-bank flows (Figure 8)

3.2.2. NANT COEDCAETYLEFFOREST ORDINARY WATERCOURSE

Following the surcharging of 'Culvert Inlet 3' (Figure 4) caused by debris blockage during Storm Dennis, the Nant Coedcaetylefforest ordinary watercourse was inspected by Flood Risk Management officers for signs of debris mobilisation. The watercourse was inspected at three areas, depicted in Figure 21.

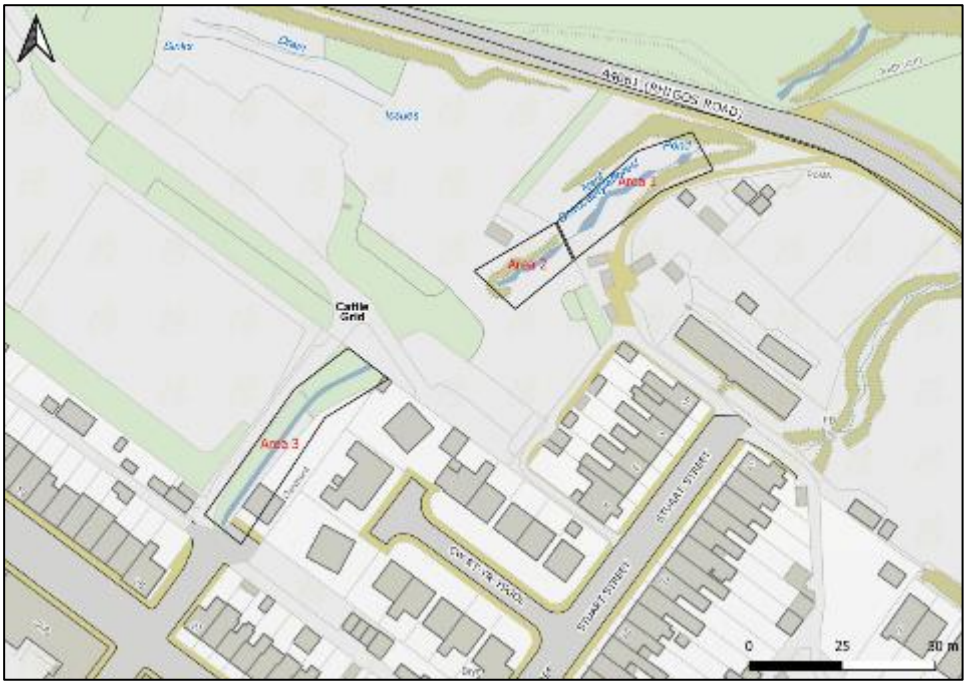

Figure 21: Nant Coedcaetylefforest ordinary watercourse inspection location plan

The upstream sections of the Nant Coedcaetylefforest ordinary watercourse (Area 1, Figure 21) showed evidence of debris deposition within the man-made channel, along with significant accumulation of material across the upper debris screens and headwall structure. Figure 22 and 23 depicts the material, which consists of coarse stone, silt and woody debris, within the upper channel. This material is assumed to have been mobilised from the upper reaches above the A4061 (Rhigos Road) and carried downstream by the high flows during Storm Dennis.

Figure 22: Photo of debris deposition behind the upper debris screen of the Nant Coedcaetylefforest ordinary watercourse (captured by RCT's Flood Risk Management team on 19/02/2020)

Figure 23: Photo of debris accumulation in the upper reaches of the Nant Coedcaetylefforest ordinary watercourse (below the A4061) (captured by RCT's Flood Risk Management team on 19/02/2020)

Below the headwall structure, the channel and culvert inlet (Area 2, Figure 21) did not show evidence of debris conveyance or blockage to the inlet, as shown in Figure 24. It is considered that the upstream debris screens at Area 1 succeeded in minimising the volume of debris travelling downstream.

Figure 24: Culvert inlet at Area 2 which conveys the Nant Coedcaetylefforest ordinary watercourse towards Area 3 (captured by RCT's Flood Risk Management team on 19/02/2020)

The channel immediately upstream of 'Culvert Inlet 3' (Area 3, Figure 21) is identified as man-made and therefore showed no signs of bank erosion. Upon an inspection of the surrounding area post Storm Dennis however, material on the banking area was evident (Figure 7). This material is not considered to have originated from Area 1.

It is assumed that the watercourse at Area 3 exceeded its usual capacity, resulting in out-of-bank flows mobilising debris from the surrounding bank area which caused the blockage at 'Culvert Inlet 3' (Figure 4), resulting in surcharge.

3.2.3. Nant Pwll-Brwyn Ordinary Watercourse and Tributaries

The Nant Pwll-Brwyn ordinary watercourse and its tributaries convey towards the Rhondda Fawr River via 'Culvert Inlet 5' and 'Culvert Inlet 6' (Figure 9) which were identified as sources of flooding during Storm Dennis. The watercourses rise very steeply from the investigation area which restricted on-site inspections.

Despite this, on review of the Nant Pwll-Brwyn ordinary watercourse and its tributaries, the channels were identified as being very steep with significant embankment erosion evident in the upstream reaches. The debris removed from both culvert inlet structures was also indicative of natural scour material, indicating that the condition of the upstream ordinary watercourses contributed erosive material to both culvert inlets during Storm Dennis.

Following evidence from the Storm Dennis flooding event, it is clear that morphological processes can be a key contributor to flood risk. As a result, a geomorphological review of the upper catchment above Treherbert was carried out in early November 2020 by JBA Consulting, on behalf of RCT, which identified evidence of "localised hillslope failure" and "multiple areas of active bank erosion" which were "seen to be inputting sediment to the watercourses" during surveying exercises[4].

Observations made during the geomorphic assessment indicates a high availability of sediment in the mid-hillslope area which has resulted in severe bed incision in places, particurarly in the upper 'Treherbert East' sub-catchment. The delivery of sediment and stone towards the investigation area during Storm Dennis has primarily been attributed to "natural erosional processes associated with an extreme flood event" which is exacerbated by the steep slope profiles of the ordinary watercourses flowing towards Treherbert which produce faster velocities and increased sheer stresses.

The material in the upper reaches of Treherbert is believed to have contributed to the surcharging of several culverts during Storm Dennis.

[4] Fluvial Geomorphology Assessment: Treherbert, JBA Consulting, December 2020

3.3. MAIN RIVER

The designated main river Rhondda Fawr flows through the village of Treherbert (Figure 1), to the south of the investigation area.

The hydrograph in Figure 25 illustrates the rapid rise in levels of the River Rhondda Fawr in response to rainfall, captured at NRW's Tynewydd station. The River Rhondda Fawr at Tynewydd reached its highest peak ever recorded at 02:45 on 16th February 2020, reaching 1.62 meters.

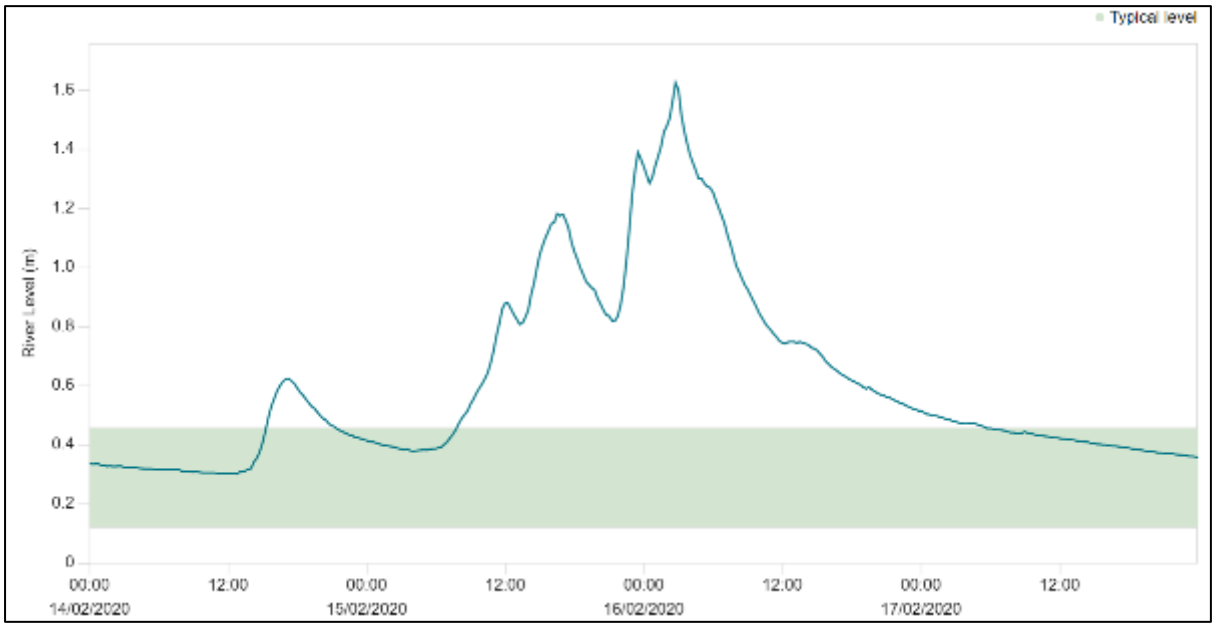

Figure 25: The Rhondda Fawr River levels at Tynewydd station between the 14th and 17th February 2020 (Natural Resources Wales)

The green bar displayed on the hydrograph shows the typical level of the River Rhondda Fawr at Tynewydd station, ranging between 0.1 and 0.5 meters. At its peak, the River Rhondda Fawr was over twice its average level, stressing the extreme and unprecedented levels that RCT's rivers rose to during the storm's peak intensity.

There is no evidence from this investigation to suggest that the main River Rhondda Fawr significantly contributed to the recorded flooding of properties at RCT27 during Storm Dennis.

3.4. Highway Drainage Conditions

Anecdotal reports note surface water was observed to convey down several streets within the investigation area during Storm Dennis. Notably, much of the observed surface water originated from ordinary watercourse flooding associated to culvert inlets surcharging.

Overland flows from areas of hillside and runoff originating from surcharged culvert inlets across RCT27 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 RCT27. 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 Treherbert.

3.5. DCWW Apparatus

Six incidences of flooding to properties within the investigation area were reported to DCWW during Storm Dennis, namely at Abertonllwyd Street and Dumfries Street.

DCWW attended Abertonllwyd Street on the 16th February 2020. Upon an investigation into DCWW's network in the area, it was found to be coping albeit with very high flows. DCWW also inspected the private surface water network in the area which was also operating with no issues.

Based on their findings, and in addition to RCT's post event investigations, it was concluded that the surcharging of 'Culvert Inlet 1' and 'Culvert Inlet 2' (Figure 4) caused water to discharge overland along Abertonllwyd Street and enter the sewer system in the rear gardens of several properties. These additional flows would have been unable to drain away quick enough, resulting in internal flooding to properties on Abertonllwyd Street.

It has been concluded that the groundwater source of flooding reported by residents at Abertonllwyd Road did not originate from a defective sewer system.

3.6. SURFACE WATER

Surface water runoff as a result of ordinary watercourse flooding associated to blocked and overwhelmed culvert inlets has been determined as a contributing source of flooding to properties within the lower reaches of Treherbert, along Abertonllwyd and Dunraven Streets, where water naturally accumulates.

The volume of water conveying to these low points within RCT27 during Storm Dennis would have been unable to drain away via surface water drainage systems, resulting in surface water accumulation on the highway which entered the front and rear of several properties.

3.7. GROUNDWATER

Residents at Abertonllwyd Street referenced clear water entering the basements of their properties during the storm event, indicating a potential groundwater source contributed to the flooding of nine residential properties. The exact flow path is unknown however, the conveyance is attributed to Throughflow within the subsurface.

Throughflow is the lateral flow of water within the soil layer which normally takes place when the ground is completely saturated with water following heavy and persistent rainfall. This process causes water to return to the surface before entering a watercourse, drainage system or returning as groundwater flow. Given the prolonged period of rainfall during February 2020, it is considered likely that the groundwater table was high during Storm Dennis, indicating Throughflow conveyance of groundwater likely impacted those properties at Abertonllwyd Street.

A review of available geological information indicates that RCT27 is underlain by superficial deposits consisting of Glacial Till and River Deposits, overlying Lower and Middle Carboniferours Coal Measures, consisting of mudstone, sandstone and siltstone[3]. Superficial deposits associated with fluvial deposition, such as river gravels and alluvial clays and sands, are found at the base of the main river valleys. According to the Environment Agency, flooding from groundwater is most common in these areas with sand and gravel in the river valleys[5], again indicating that the investigation area is susceptible to groundwater flooding.

[5] Flooding from Groundwater, Environment Agency, September 2011 (publishing.service.gov.uk)

3.8. 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.

3.9. System at Capacity

Culvert networks within the investigation area (Figure 11 and 17) 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 summarized in the Table below (refer to Figures 4 and 9 for culvert labels).

Table 3: Summary of culvert capacity assessment results which indicate the current standard of protection of the culverted networks in free flowing and blockage conditions

Culvert Network	Standard of Protection (SOP) – Free Flowing	Standard of Protection (SOP) – Blockage Conditions
Culvert Inlet 1 (Abertonllwyd Street)	Q2 (50% AEP)	<Q2 (50% AEP)
Culvert Inlet 2 (Abertonllwyd Street)	<Q2 (50% AEP)	<Q2 (50% AEP)
Culvert Inlet 3 (Dumfries Street)	Q1000 (0.1% AEP)	Q200 (0.5% AEP)
Culvert Inlet 5 (Tyn-y-coedcae)	Q1000 (0.1% AEP)	Q1000 (0.1% AEP)
Culvert Inlet 6 (Tyn-y-coedcae)	Q1000 (0.1% AEP)	Q1000 (0.1% AEP)

The results from the culvert capacity assessments and hydraulic modelling undertaken as part of Redstart's FIR, infer that 'Culvert Inlet 1' and 'Culvert Inlet 2' associated to the Abertonllwyd Street culvert network, has a SOP of Q2, which is further reduced with the presence of blockage.

The remaining culvert networks have been assessed as having a SOP in accordance with current design standards, as defined by CIRIA C786, or greater when considering the free-flowing scenario.

On review of the culvert capacity assessments, it is inferred that both 'Culvert Inlet 1' and 'Culvert Inlet 2' surcharged due to hydraulic overload. It is also considered that the poor condition of both culvert inlet structures contributed to the surcharging of both inlets. Furthermore, the significant volume of debris identified within the culvert network and consequently reducing its hydraulic capacity to manage the flow of water entering the network, has been attributed to the surcharging of 'Manhole 1' during Storm Dennis.

On review of the condition of 'Culvert Inlet 3' post Storm Dennis, a sensitivity analysis was undertaken to review the impact of flooding during both free-flowing and 'medium' (67%) blockage conditions[6]. The network was assessed as having adequate capacity in accordance with the design standards. In 'medium' blockage conditions the capacity is reduced to Q200, however it was concluded by on-site inspectors that the blockage to 'Culvert Inlet 3' was akin to a full blockage (100%). Consequently, the capacity of the inlet would have been further reduced to below design standards. The blockage to the inlets' debris screen which reduced the networks' capacity to manage the flow of water has been determined as the primary cause of flooding.

Both 'Culvert Inlet 5' and 'Culvert Inlet 6' have been assessed as having adequate capacity in both free-flowing and 'medium' (67%) blockage conditions. On review of both inlets post storm event, it was also concluded that the total blockage percentage on the structure was greater than 67%, thus reducing the capacity of both culvert inlets to manage the flow of water, which would account for the surcharging at both locations.

[6] Natural Resources Wales Guidance Note (Ref No GN43)

3.10. Summary of Possible Causes

The above sections have identified and described the possible causes of flooding within investigation area RCT27 during Storm Dennis (15-16th February 2020). A summary of the identified sources and possible cause(s) of flooding (issue) has been outlined below in Table 4.

Table 4: Summary of the source(s) and possible cause(s) of flooding in investigation area RCT27 during Storm Dennis

Ref No	Asset (Source)	Issue	Asset Owner	Type of Flooding
1	Culvert Inlet 1 (Abertonllwyd Street)	The culvert inlet became hydraulically overloaded during the storm event, causing water to overtop the inlet structure and convey overland towards 'Culvert Inlet 2', exacerbating the surcharging at this location.	Private Landowner	Ordinary Watercourse
2	Culvert Inlet 2 (Abertonllwyd Street)	The culvert inlet became hydraulically overloaded during the storm event, causing water to overtop the inlet structure and convey overland towards Abertonllwyd Street and onwards to Dunraven Street.	Private Landowner	Ordinary Watercourse
3	Manhole 1 (Abertonllwyd Street)	The manhole showed evidence of surcharge during post event inspections. This has been attributed to debris accumulation within the culvert network reducing the cross-sectional area by up to 70%.	RCT Corporate Estate	Ordinary Watercourse and Surface Water
4	Culvert Inlet 3 (Dumfries Street)	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from the surrounding bank area. This resulted in water flowing down Dumfries Street and accumulating at Dunraven Street.	Private Landowner	Ordinary Watercourse
5	Culvert Inlet 4	The culvert inlet was identified as submerged during post event inspections. This resulted in	Private Landowner	Ordinary Watercourse

		water flowing overland and contributing surface water flows towards Dumfries and Dunraven Streets.		and Surface Water
6	Culvert Inlet 5 (Tyn-y-coedcae)	The culvert inlet became hydraulically overloaded during the storm event, causing it to surcharge towards properties at Tyle Fforest and Ross Rise.	Private Landowner	Ordinary Watercourse
7	Culvert Inlet 6 (Tyn-y-coedcae)	The culvert inlet became hydraulically overloaded during the storm event, resulting in surcharge towards properties at Tyle Fforest and Ross Rise. Debris accumulation at the inlet has also been determined as a contributing factor as to the cause of surcharge.	Private Landowner	Ordinary Watercourse
8	Groundwater	Residents at Abertonllwyd Street referenced clear water entering the basements of their properties during the storm event, indicating potential groundwater source of flooding.	Private Landowner	Groundwater

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 'FRM – Storm Dennis - Overview Report'[2].

Table 5: Risk Management Authority with relevant functions 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 Land Drainage Act 1991 and Highways Act 1980. Through the investigation of the flooding that impacted investigation area RCT27, the flood risk management functions exercised, or proposed to exercise, by relevant RMA's was recorded in response to the duties placed on the local authority in regard to Section 19 of the Flood and Water Management Act 2010, which 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 the response to the flood."

Through the investigation process, the source(s) and possible cause(s) of flooding in investigation area RCT27 as a result of Storm Dennis has been previously identified and summarised within Table 4. The Risk Management Authority(ies) responsible for managing that flooding have been determined as the Lead Local Flood Authority and Land Drainage Authority (Table 6). Table 6 also presents a series of recommendations put forward by the LLFA.

Table 6: Recommendations provided by the LLFA to be considered by the relevant Risk Management Authority identified in response to the source(s) of flooding in investigation area RCT27 (as per Table 4)

Ref No	Asset (Source)	Asset Owner	Type of Flooding	Risk Management Authority Responsible for Managing Risk	Recommendations	
1	Culvert Inlet 1 (Abertonllwyd Street)	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R1A	The LLFA and LDA to identify drainage 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 engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
					R1E	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
2	Culvert Inlet 2 (Abertonllwyd Street)	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R2A	The LLFA and LDA to identify drainage 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 engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
					R2E	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
3	Manhole 1 (Abertonllwyd Street)	RCTCBC Corporate Estate	Ordinary Watercourse and Surface Water	Lead Local Flood Authority and Land Drainage Authority	R3A	The LLFA and LDA to identify drainage 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 to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
4	Culvert Inlet 3 (Dumfries Street)	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R4A	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R4B	The LLFA and LDA to investigate the standard of protection and the condition of the culvert structure and network as a whole.
					R4C	Jet and cleanse the ordinary watercourse network.
					R4D	The LLFA and LDA to engage and work with the riparian landowner to regulate the ordinary watercourse

						infrastructure to ensure the infrastructure is free flowing and unobstructed.
					R4E	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
					R4E	The LLFA to install remote telemetry monitoring at Culvert Inlet 3 to monitor the risk of blockage.
5	Culvert Inlet 4	Private Landowner	Ordinary Watercourse and Surface Water	Lead Local Flood Authority and Land Drainage Authority	R5A	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R5B	The LLFA and LDA to exercise their permissive powers under Section 64 of the Land Drainage Act to investigate the drainage arrangements on the area of land where the watercourse and inlet is situated.

					R5C	The LLFA and LDA to engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
					R5D	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
6	Culvert Inlet 5 (Tyn-y-coedcae)	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R6A	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R6B	The LLFA and LDA to investigate the standard of protection and the condition of the culvert structure and network as a whole.
					R6C	Jet and cleanse the ordinary

						watercourse network.
					R6D	The LLFA and LDA to engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
					R6E	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
7	Culvert Inlet 6 (Tyn-y-coedcae)	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R7A	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R7B	The LLFA and LDA to investigate the standard of protection and the condition of the culvert structure and network as a whole.

					R7C	Jet and cleanse the ordinary watercourse network.
					R7D	The LLFA and LDA to engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
					R7E	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of ordinary watercourse and surface water flooding in Treherbert.
8	Groundwater	Private Landowners	Groundwater	Lead Local Flood Authority and Land Drainage Authority	R8A	The LLFA and LDA to exercise their permissive powers under Section 64 of the Land Drainage Act to investigate the source and possible causes of groundwater flooding to properties at

						Abertonllwyd Street.
					R8B	The LLFA to develop a SOC to identify suitable management methods to reduce the risk of flooding from all local sources (ordinary watercourse, surface water and groundwater) in Treherbert.

4.1. Lead Local Flood Authority

In review of Ref 1-8 Table 6, the LLFA and LDA have been determined as the responsible Risk Management Authorities in relation to the flooding which occurred at investigation area RCT27 during Storm Dennis.

The LLFA exercised the following functions in response to the flooding at investigation area RCT27;

- 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 RCT 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 conditions and its impact on the flooding within the investigation area. **(R1B, R2B, R3B, R4B, R5B, R6B, R7B)**

- An estimated 800 meters of culvert network length within RCT27 has been surveyed following the event to ascertain both the operation condition of the network, and its structural integrity along sections of the network. **(R1B, R2B, R3B, R4B, R6B, R7B)**
- An estimated 40 tonnes of material and debris was removed from the culvert networks within RCT27 during jetting and cleansing operations. **(R1C, R2C, R3C, R4C, R6C, R7C)**
- The LLFA and LDA have undertaken clearance works to the culvert network systems which fall under the responsibility of the Authority **(R3C)**. In addition to this, the LLFA and LDA have carried out clearance works to the culvert inlet structures which fall under private land ownership utilising powers under Section 14A of the Land Drainage Act. **(R1C, R2C, R4C, R6C, R7C)**
- The LLFA commissioned Redstart to investigate the standard of protection of the existing culvert networks in Treherbert to determine their hydraulic capacity following the identification of several structural and operational defects within sections of the network. **(R1B, R2B, R3B, R4B, R6B, R7B)**
- 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. **(R1D, R2D, R4D, R5C, R6D, R7D)**
- The LLFA have installed remote telemetry monitoring devices at key culvert structures to enable operators to ensure the drainage systems in Treherbert are operating effectively. **(R4E)**
- The LLFA have commissioned JBA Consulting to undertake a formal SFRA of the Upper Rhondda catchment area to better understand the overall risk from ordinary watercourse and surface water flooding and make recommendations for suitable measures to alleviate the 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. As part of this, JBA were also commissioned to carry out a geomorphic assessment of the upper catchment above Treherbert to determine the risk of culvert blockages due to geomorphic instability of the hillside. **(R1E, R2E, R3D, R4E, R5D, R6E, R7E)**

The LLFA propose to exercise the following functions in response to the flooding at investigation area RCT27;

- Following the surveying of culvert networks in RCT27, the LLFA propose to input and update all relevant asset data. **(R1A, R2A, R3A, R4A, R5A, R6A, R7A)**
- The LLFA propose to develop a SOC 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). **(R1E, R2E, R3D, R4E, R5D, R6E, R7E, R8B)**
- The LLFA propose to develop a flood routing scheme along the A4061 (Abertonllwyd Street). The scheme will involve working with the Highway Authority to make improvements to the highway drainage infrastructure of surrounding street to intercept overland flow routes and alleviate flooding to the A4061 (Abertonllwyd Street). **(R1E, R2E, R3D, R4E, R5D, R6E, R7E)**
- The LLFA and LDA propose to undertake further investigations to identify the source(s) and possible cause(s) of groundwater flooding at Abertonllwyd Street following reports of clear water entering their basements, indicative of underground source(s) of water. **(R8A)**
- The LLFA and LDA intend to clarify drainage asset owners and management responsibilities to make them aware of riparian responsibility. 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. **(R1A, R2A, R3A, R4A, R5A, R6A, R7A)**
- 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. **(R1D, R2D, R4D, R5C, R6D, R7D)**

4.2. Natural Resources Wales

Natural Resources Wales were not identified as a responsible authority in relation to the flooding at investigation area RCT27 on the 15th and 16th February 2020. Furthermore, the authority does not propose to undertake any functions in relation to the event.

4.3. WATER COMPANY

Following the results into the investigation of flooding at Treherbert, DCWW were not identified as a responsible authority in relation to the flooding at investigation area RCT27 on the 15th and 16th February 2020. Despite this, calls were received by DCWW in relation to the flooding at RCT27.

DCWW have exercised the following functions in response to the flooding at investigation area RCT27;

- DCWW carried out their own investigations in response to the incidents of flooding that were reported by residents directly to DCWW.
- DCWW contacted residents affected by flooding to offer support and advice to assist in the recovery following Storm Dennis.
- DCWW investigated the performance of their network at Abertonllwyd Street during the storm event to ensure their assets were operating with no issues.

DCWW do not propose to undertake any further functions in relation to the event at investigation area RCT27.

4.4. HIGHWAY AUTHORITY

During the investigation into the flooding at investigation area RCT27 during Storm Dennis, the Highway was identified as flooding as a result of ordinary watercourse flooding associated to blocked and overwhelmed culvert inlets.

RCT as the Highway Authority have exercised the following functions in response to the flooding at investigation area RCT27;

- The Highway Authority assisted with the emergency response during the event by supplying equipment and sandbags, some to individual properties and 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.

- The Highway Authority also carried out maintenance works to clear any vegetation from the surrounding area of their drainage infrastructure to reduce the risk of further blockages.
- The Highway Authority has undertaken emergency clearance works to the culvert inlets identified as sources of flooding. **(R4C, R7C)**

RCT as the Highway Authority propose to undertake the following functions in relation to the event at investigation area RCT27;

- The Highway Authority intend to increase 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 drainage infrastructure.

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