Section 19 Flood Investigation

23 December 2020

Lavernock Road, Vale of Glamorgan

Version 4

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Contract

This report describes work commissioned by Michael Clogg on behalf of Vale of Glamorgan Council, by an email dated 10 May 2021. Helen Cardy, Fiona Hartland and Faye Tomalin of JBA Consulting carried out this work.

Prepared by ..... Helen Cardy BSc

Senior Analyst

Fiona Hartland MSci

Senior Analyst

Reviewed by ..... Faye Tomalin BSc (Hons) MSc MCIWEM C.WEM

Principal Analyst

Purpose

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Executive summary

This report has been produced in-line with the duties placed upon The Vale of Glamorgan Council (VoCG) 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 (LLFA) 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 which occurred on 23 December 2020 and the flooding that happened at Lavernock Road, Penarth, Vale of Glamorgan, South Wales as a result. The investigation focuses on the area located to the roads and land around Sully Brook at Cosmeston. It has also been informed in part by Section 19 data analysis for Dinas Powys produced by JBA Consulting in March 2021.

The Section 19 data analysis report identifies that due to a series of storm events which occurred throughout the month of December 2020, the soils were already saturated prior to the rainfall on 23 December 2020.

The nearby Cog Moors rainfall gauge recorded an initial short and intense burst of rainfall between 09:00 and 10:00. However, the main burst of rainfall started at 12:45 and continued until 18:00, with 47.8mm of rainfall falling over this 5.25hr period, giving an average intensity of 9.1mm/hr. The maximum hourly intensity over the period was 14.4mm/hr between 14:00 and 15:00. The rainfall intensity was >10mm/hr between 13:15 and 15:30 and between 15:45 and 17:00. The storm is reported to have been equivalent to a 1 in 20 year rainfall event, which equates to a 5% chance of occurrence in any given year.

The source of the flooding originated from the heavy storm event which caused localised surface water flooding.

The evidence gathered in this report demonstrates that the cause of the flooding was a result of heavy rainfall combined with already high water levels in the Sully Brook, plus the highway drainage systems were hydraulically locked and unable to discharge, resulting in flooding to Lavernock Road.

However, it is noted that the capacity of the existing surface and highway drainage system is not fully understood and so the full impact of this reduced capacity cannot be accurately determined.

Key recommendations of this report include:

- Review maintenance plan for the Sully Brook
- Review maintenance plan for the Highway network and surface water drainage
- Consider catchment-wide options, including retrofit of SuDS and NFM to reduce the risk of surface water flooding to Lavernock Road
- Consider including the Sully Brook contributing catchment as an area where new development requires specific hydraulic control within forthcoming updates to the Local Flood Risk Management Strategy

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Abbreviations

AEP	Annual Exceedance Probability
DCWW	Dŵr Cymru Welsh Water
FWMA	Flood and Water Management Act 2010
JBA	Jeremy Benn Associates Ltd
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LTA	Long Term Average
NRW	Natural Resources Wales
RMA	Risk Management Authority
SuDS	Sustainable Drainage System
S19	Section 19
TBR	Tipping bucket rain gauge
VoGC	The Vale of Glamorgan Council

Definitions

Annual Exceedance Probability: The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

Risk: In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.

Surface water flooding: Flooding as a result of surface water runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing pluvial flooding.

1 Introduction

1.1 Background to investigation

As the Lead Local Flood Authority (LLFA) The Vale of Glamorgan Council (VoGC) has a duty to prepare and publish the results of investigations into significant flood incidents, as detailed within Section 19 (S19) of the Flood and Water Management Act 2010 (FWMA). The Act states, "On becoming aware of a flood in its area, a Lead Local Flood Authority (LLFA) 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 report has been prepared for the purpose of meeting the LLFA S19 requirements by providing a detailed, factual account of the flooding that occurred in December 2020 in the vicinity of Lavernock Road, Penarth, Vale of Glamorgan, South Wales. During this event, Lavernock Road (B4267), the main road from Sully to Penarth, was flooded over a length of approximately 1km from its junction with Fort Road to the junction with Brockhill Rise. One residential property was reported to have flooded internally. This report will focus on investigating the causes of the flooding at Lavernock Road as a result of the storm event (Figure **1**-**1**).

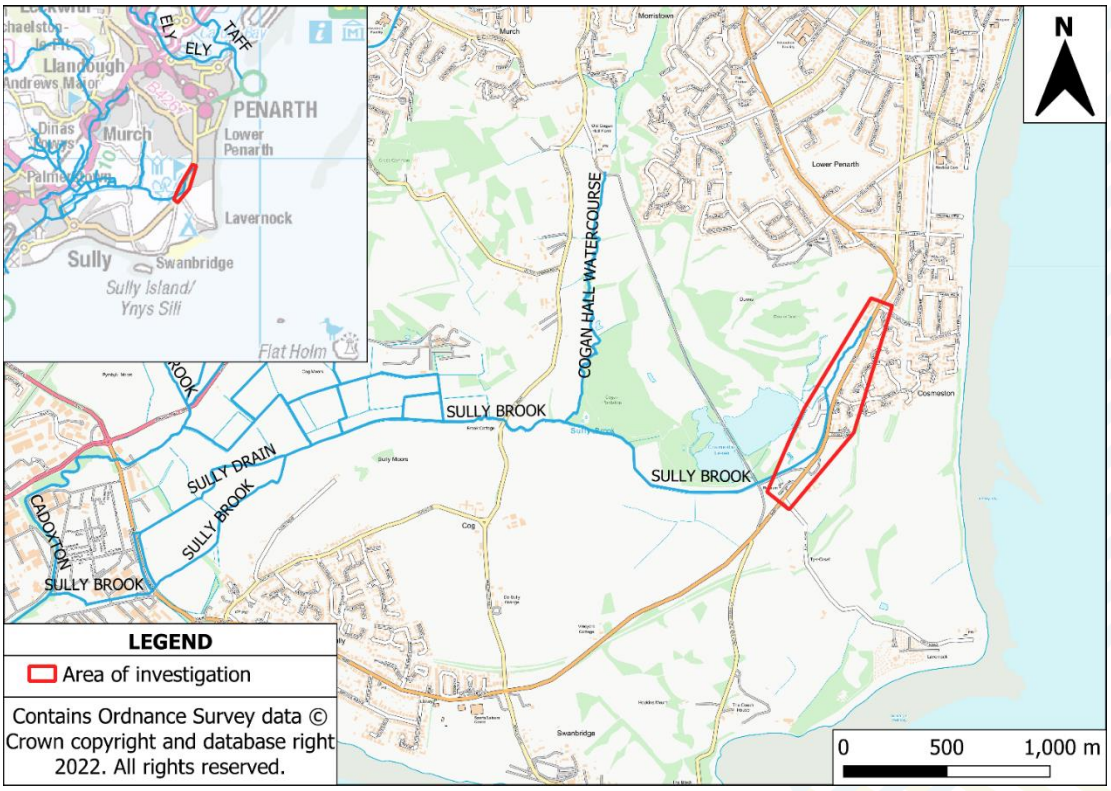

Figure 1-1: Overview map

Previous to this report, Section 19 reports have been undertaken by JBA Consulting for the areas of Sully and Dinas Powys which also experienced flooding on 23 December 2020, on behalf of The Vale of Glamorgan Council. This involved the collection and analysis of hydrological data relating to the flood event and documenting the findings. Where relevant, the analysis has been used in this S19 report.

To provide an accurate account of the flood event, this S19 Report for Lavernock Road, Penarth will:

- Identify events leading up to the flood;
- Investigate the number of properties flooded;
- Investigate which Risk Management Authorities (RMAs) have flood risk management functions in respect of the flooding;
- Investigate whether each RMA has exercised or is proposing to exercise those functions in response to the flood.

1.2 Site location

Penarth is a small seaside town located in the Vale of Glamorgan, South Wales. Population in the 2011 census was 27,226, with an estimated population of 30,106 in 2020[1].

The main road through Penarth is the B4267 which runs along the western side of the town, in a north-south direction. Towards the southern extent of Penarth, the road becomes known as Lavernock Road and continues southwards out of Penarth towards the village of Sully.

The investigation area is a 1km stretch of Lavernock Road between the junction of Fort Road in the south, next to Cosmeston Lakes and Country Park, to Brockhill Rise in the north. This area sits within the Cosmeston suburb of Penarth, in the southern part of the town. The investigation area is shown in Figure **1**-**2**.

The area is located within the Sully Brook catchment, and the Sully Brook (an NRW Main River) flows in a north-east to south-west direction along the west side of Lavernock Road for the length of the investigation area. The Vale of Glamorgan has sole riparian ownership of the Sully Brook for 1.4km and shared ownership (with the neighbouring landowner) of 700m of this stretch of the watercourse. An un-named ordinary watercourse joins the Sully Brook within the investigation area at a point opposite Cosmeston Drive.

Figure **1**-**3** shows the topography of the area using Opensource LiDAR data. Ground levels are shown to fall to a low point of Lavernock Road between Cosmeston Drive and 1-2 Cosmeston Cottages. Ground levels fall from 14.25mAOD at the junction with Brockhill Rise, to the northern extent of the investigation area and 14.57mAOD at the junction with Fort Road to the south of the investigation area, to levels of 12.4mAOD at the low point of the road in the centre of the investigation area. The residential area to the east of Lavernock

[1] Penarth - - Compare | Understanding Welsh Places http://www.understandingwelshplaces.wales/

Road is also sited at higher ground levels, with Brockhill Rise, Cosmeston Drive and Upper Cosmeston Farm falling towards Lavernock Road.

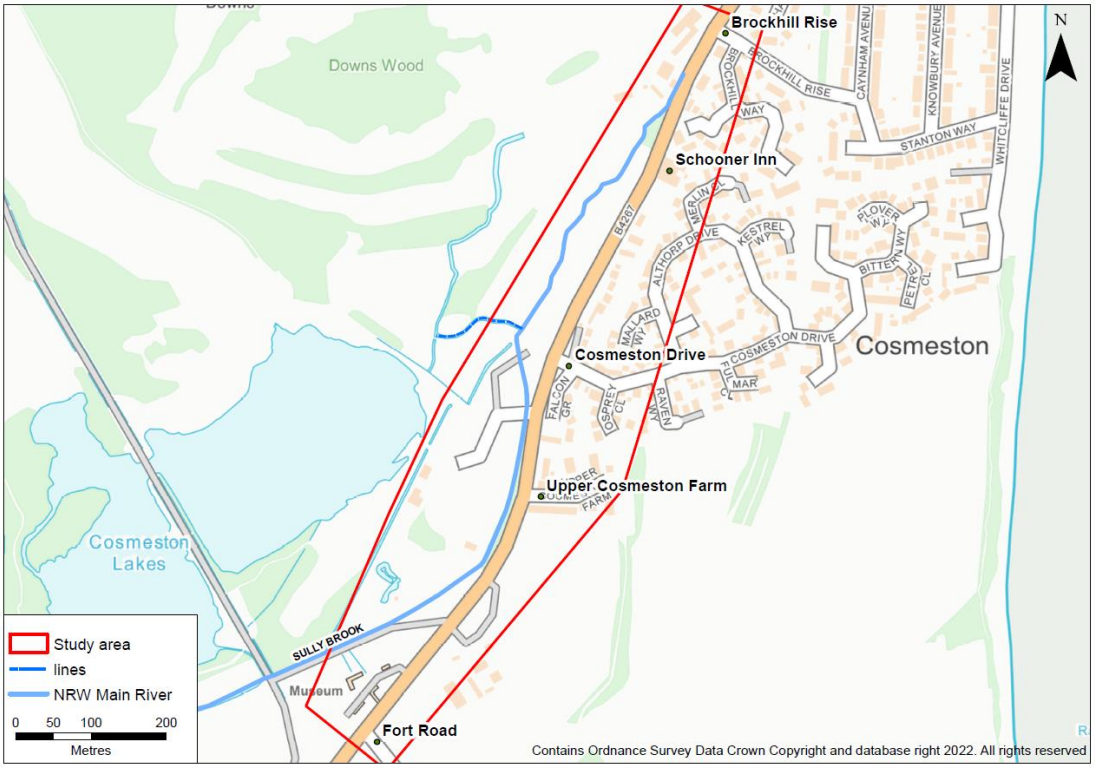

Figure 1-2: Area of investigation

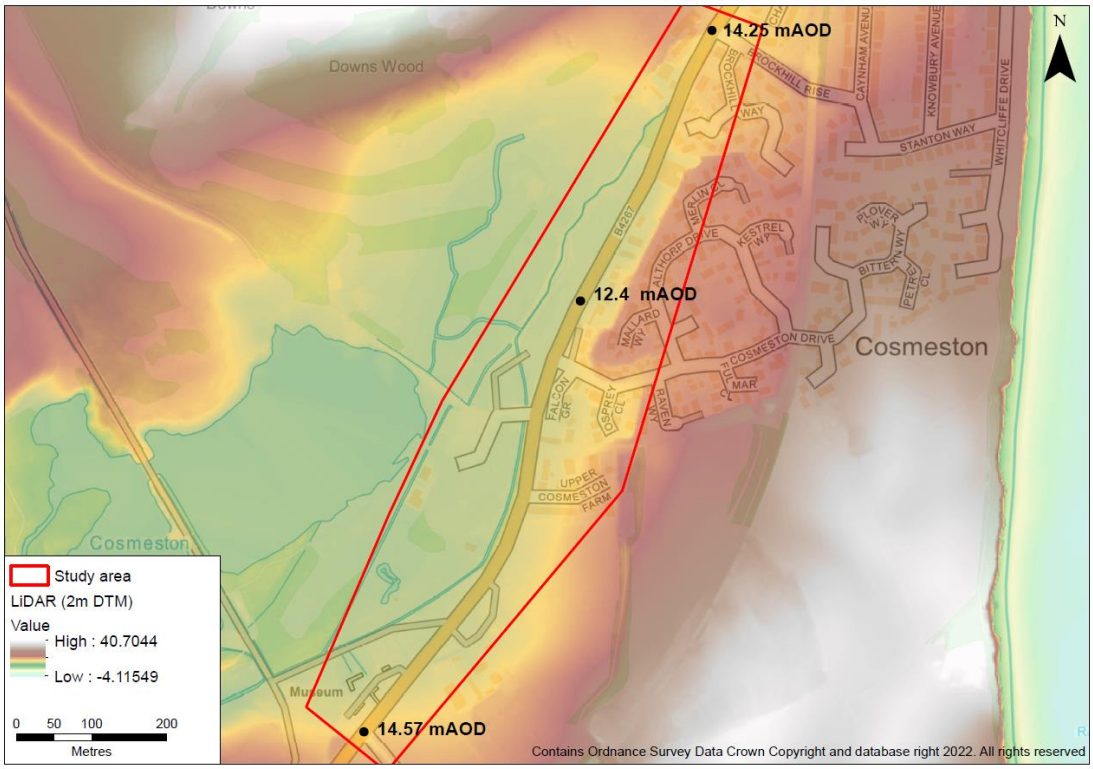

Figure 1-3: LiDAR

2 Roles and responsibilities

2.1 Duties under 'Flood and Water Management Act (2010): Section 19 - Local authorities: Investigations'

Under Section 19 of the Flood and Water Management Act 2010, the Lead Local Flood Authority, VoGC, have a duty to investigate and publish reports on flood events that occur within its area to the extent that it considers it necessary or appropriate.

(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 response to the flood.

(2) Where 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 authorities.

2.2 Risk Management Authorities

2.2.1 Lead Local Flood Authority

The Vale of Glamorgan Council has been established as the LLFA for its administrative area under the Flood and Water Management Act 2010. It is responsible for managing the risk of flooding from ordinary watercourses, surface runoff and groundwater.

Additionally, the LLFA takes on role of the Sustainable Drainage Systems (SuDS) Adopting and Approving Body in which they are responsible for approving designs and adopting and maintaining finished SuDS.

As the LLFA, VoGC has statutory duties:

1 to prepare local flood risk management strategies;

2 to comply with the National Strategy for Flood and Coastal Erosion Risk Management;

3 to co-operate with other authorities, including sharing data;

4 to investigate all flooding within its area, insofar as a LLFA consider it necessary or appropriate;

5 to maintain a register of structures and features likely to affect flood risk;

6 to contribute to sustainable development; and

7 through consenting powers on ordinary watercourses.

2.2.2 Natural Resources Wales

Natural Resources Wales (NRW) has statutory duties and permissive powers, including:

1. Operational responsibilities for flooding from main rivers, the sea and coastal erosion.
2. Oversight responsibilities in relation to all flood and coastal erosion risk management in Wales.

NRW's powers to manage flood risk include the management and maintenance of Main Rivers, the construction of new flood risk management assets and maintaining existing flood assets. NRW assesses developers' flood assessments (and supporting documentation) to decide with developers have met the requirements of *Planning Policy Wale*s and *Technical Advice Note 15: Development and Flood Risk* in relation to the risks of flooding from main rivers, the sea and reservoirs. NRW is a statutory consultee in Local Authorities' planning processes and provides support to Welsh Ministers in their preparation of the National Flood and Coastal Erosion Management (FCERM) Strategy.

NRW provides a direct flood warning service, primarily for areas at risk of fluvial and coastal flooding.

2.2.3 Highways Authority

The Vale of Glamorgan Council undertake the role of the Highways Authority, being responsible for the maintenance of all adopted highways in the Vale and their associated infrastructure. This includes ensuring the highway has a drainage system that controls the surface water that enters onto the highway, providing and managing highway drainage and roadside ditches to ensure they are clear of obstructions. The above duties and responsibilities of the Highways Authority are not applicable to Trunk Roads, which are the responsibility of the Welsh Government.

2.2.4 Dŵr Cymru Welsh Water

As a Water Utility Company, the role of Dŵr Cymru Welsh Water (DCWW) as a risk management authority is to manage the risk of flooding to water supply and sewerage facilities and flood risk arising from their infrastructure. The main responsibilities of the Water Utility Company are to:

- Ensure their systems have the appropriate level of resilience to flooding, and maintain essential services during emergencies;
- maintain and manage their water supply and sewerage systems to manage the impact and reduce the risk of flooding and pollution to the environment;
- advise LLFAs on how their assets affect local flood risk and work with RMAs to coordinate management of flood risk management assets; and
- work with developers, landowners and LLFAs to understand and manage risks

2.3 Other Authorities

2.3.1 Landowners and riparian owners

Riparian Landowners are legally responsible under common law for the maintenance of the land from the edge of the waterbed to the middle of the riverbed. The landowner is responsible for removal of obstructions caused within the boundaries of their land affecting the watercourse. This includes the maintenance of the bed, banks and any boundary features e.g. through routine clearance of debris and/or blockages. Due to the surface water source of the flooding Riparian Landowner responsibilities are not applicable to this flood event.

2.3.2 Residents

Residents and property owners are responsible for the protection of their own properties against flooding. Residents have the right to defend their property provided they do not increase the risk of flooding to other properties.

2.4 Permissive Powers

Risk Management Authorities have direct permissive powers under the Flood and Water Management Act 2010, as well as the Land Drainage Act 1991. For NRW and the LLFA this includes:

- Powers to request information.
- The ability to raise levies for local flood risk management works.
- Powers to designate certain structures or features that affect flood or coastal erosion risk.
- The expansion of powers to undertake works to include broader risk management actions.
- The ability to cause flooding or coastal erosion under certain conditions.

3 Stakeholder Engagement

Following flooding in December 2020, VOGC issued flood incident forms to residents across the Vale of Glamorgan. One flood incident report forms was received from residents within the Lavernock Road investigation area. In addition to requests for resident feedback, Dŵr Cymru Welsh Water (DCWW), South Wales Fire and Rescue and NRW were contacted to provide information on any flood records, response or additional information they hold on the December 2020 flood event. Their responses are detailed throughout this report.

4 Catchment characteristics

4.1 Catchment overview

The site is located in the Sully Coastal catchment. This catchment drains into the Cadoxton catchment to the west. The topographic characteristics of the Sully Coastal and Cadoxton catchment are varied. High land to the east and west of the site acts as a natural watershed, but the main area of investigation is low-lying and relatively flat.

The catchment is predominantly underlain by Triassic Rocks comprised of mudstone, siltstone, and sandstone. There are smaller areas of Carboniferous Dinantian Rocks (limestone with subordinate sandstone and argillaceous rocks), and Jurassic Lias Group (mudstone, siltstone, limestone, and sandstone). Superficial deposits of alluvium (clay, silt, and sand) are found along, and in the areas adjacent to, the nearby watercourse. Soils are predominantly loamy and clayey with impeded drainage, with freely draining soils in smaller areas to the north and south of the catchment.

4.2 River network

The Sully Brook, an NRW Main River, is one of the largest tributaries of the River Cadoxton. Its source is just west of Penarth and flows in a predominantly south-westerly direction before joining with the River Cadoxton and finally discharging into the Bristol Channel at Barry Docks. An un-named ordinary watercourse joins the Sully Brook within the investigation area at a point opposite Cosmeston Drive (see Figure **1**-**2**). Within the area of investigation, the Sully Brook flows in a man-made channel that appears to have been constructed during quarrying operations.

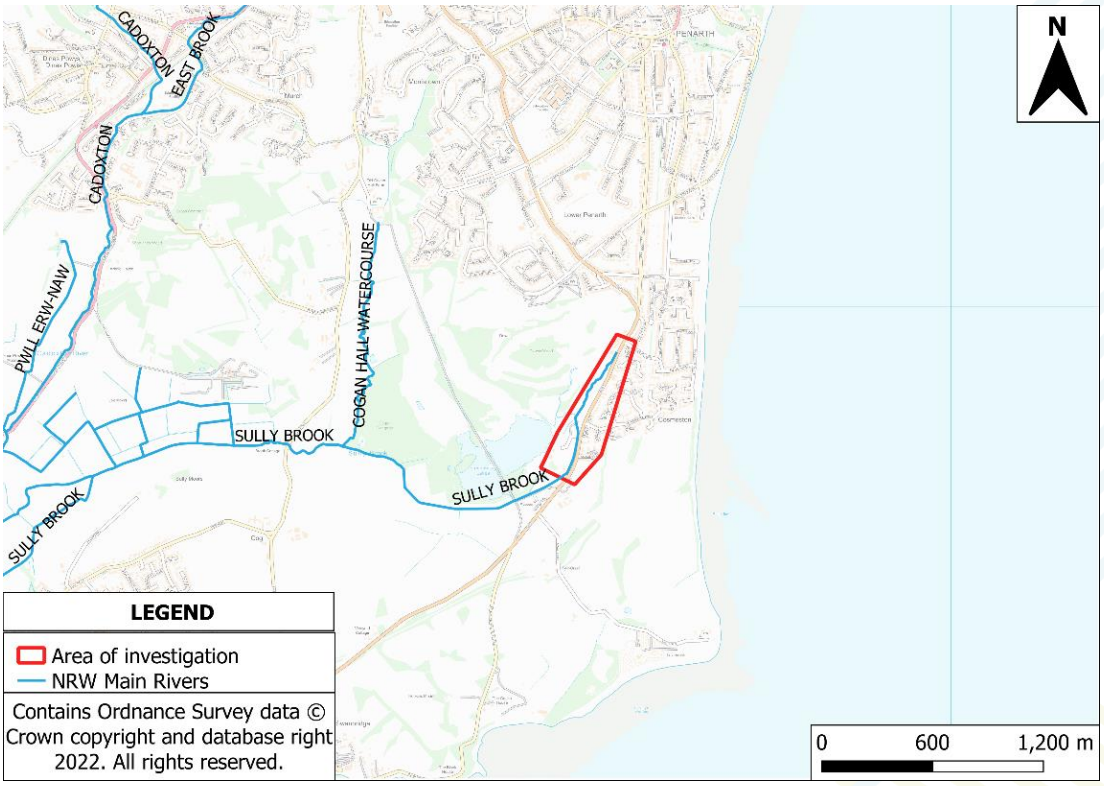

Figure 4-1: Map of Main Rivers

4.3 Drainage system

It should be noted that responsibility for different sections of drainage systems lies with individual RMAs, and that RMAs have different system capacity targets for their drainage networks. DCWW aim to maintain a 1 in 30-year (0.33% AEP) capacity, while the Highways Authority aims to maintain a 1 in 5-year (20% AEP) capacity. It should be noted that any DCWW surface water system is designed to take roof and yard drainage only, whilst the highway network is designed to take flows from the highway only. Across the Vale of Glamorgan, the highway network is cleansed on a 15 to 18 month average rotation. Most systems are not designed with the intention of receiving sheeting overland flows from greenfield areas or floodwater from fluvial systems.

The Lavernock Road study area is served by surface water, foul and combined sewer networks, as well as a highway drainage network.

4.3.1 Sewer network

The public sewer network in the study area is comprised of combined, foul and surface water systems. A combined sewer system runs along Lavernock Road itself, whereas the residential areas of Cosmeston to the east are served by separate foul and surface water sewer networks. The foul, surface water and combined sewer systems within the study area are described in further detail in the following sections. All DCWW asset maps are contained in Appendix A.

Surface water sewers

The DCWW surface water network is largely split into two areas across this investigatory site, to the north and south of the Schooner Inn Public House, situated on Lavernock Road. The northern section of network drains the residential area of Brockhill Rise and the southern network drains the residential area of Cosmeston Drive.

To the north of the Schooner Inn, the surface water sewer network serves Brockhill Way and drains north west before it outfalls into the Sully Brook at the junction between Lavernock Road and Brockhill Rise. The southern part of Whitcliffe Drive also drains north west, and discharges into the combined sewer network on Brockhill Rise, to the west of Aynham Avenue.

South of the Schooner Inn, the surface water sewer network serves the residential areas of Cosmeston Drive, Althorp Drive and Bittern Way. It drains south west towards the junction of Cosmeston Drive and Lavernock Road, before passing below Lavernock Road and discharging into the Sully Brook, upstream of the Cosmeston Lakes car park. To the south, a separate surface water sewer network serves Upper Cosmeston Farm and outfalls directly into the Sully Brook.

Foul sewers

The foul sewer network runs in parallel to the surface water network, serving the same residential areas as described in the above section. The foul network for the southern section of the study area (south of the Schooner Inn), which drains Cosmeston Drive and Upper Cosmeston Farm, joins the combined sewer system at the Cosmeston Lakes car park. The foul network in the northern section of study area drains northwards into the combined sewer network at two points on

Brockhill Rise, to the west of Anyham Avenue and at the junction with Lavernock Road.

Combined sewers

The combined sewer network drains by gravity and runs parallel to Lavernock Road. It receives foul and surface water flows from Penarth in the north, as well as from properties on Lavenock Road, between Althorp Drive and Brockhill Rise.

At the junction of Brockhill Rise and Lavernock Road the combined sewer network is met by incoming combined sewers from Penarth in the north. A series of three Combined Sewer Overflows (CSOs) on Brockhill Rise allow water from the combined system to discharge eastwards into the Bristol Channel at Whitcliffe Drive. At the Cosmeston Lakes car park, the combined sewer system continues as a rising main, and is pumped from the DCWW pumping station north west towards Dinas Powys.

4.3.2 Highway drainage

CCTV survey data supplied by VoGC identifies that Lavernock Road is served by a highway drainage network, comprising gullies connecting into a carrier drain in the western verge of Lavernock Road, which runs parallel to the Sully Brook. The carrier drain ranges from 150mm to 300mm in diameter and discharges into the Sully Brook via a series of at least four outfalls, including one opposite the Schooner Inn and a second at the Cosmeston Lakes car park. The highway gullies on Lavernock Road are reported to be cleansed on a 15 to 18 month average rotation. It has been anecdotally reported that upgrades to the highway drainage inlets were undertaken around December 2012, following flooding within the study area.

5 Information gathering

5.1 Flood risk

5.1.1 Long-term flood risk information

5.1.2 Rivers

The Flood Risk Assessment Wales (FRAW) map showing long-term flood risk from Rivers shows that a significant proportion of Lavernock Road is at medium to high risk of flooding, as shown in Figure **5**-**1**. Medium risk means between 1 in 100 (1%) and 1 in 30 (3.3%) chance of flooding in any year. High risk of flooding means greater than 1 in 30 (3.3%) probability in any year.

Residential properties to the east of Lavernock Road are generally located within an area of very low flood risk, meaning there is less than 1 in 1,000 (<0.1% AEP) chance of river flooding in any year (Figure **5**-**1**). There are three buildings: the Schooner Inn and two residential properties on Lavernock Road that are shown to be at medium to high risk of flooding.

The functional floodplain of the Sully Brook is predominantly located to the west of Lavernock Road and this area is at medium to high risk of flooding.

The functional floodplain area to the west of the Lavernock Road is covered by the NRW 'River Cadoxton Flood Alert', this does not extend to the east of Lavernock Road. The area of investigation is not included in an NRW Flood Warning Area, however, further west, the main River Cadoxton is covered by the NRW Flood Warning Area 'River Cadoxton at Dinas Powys'.

There is an existing fluvial model of the River Cadoxton but this does not extend along the Sully Brook to the study area.

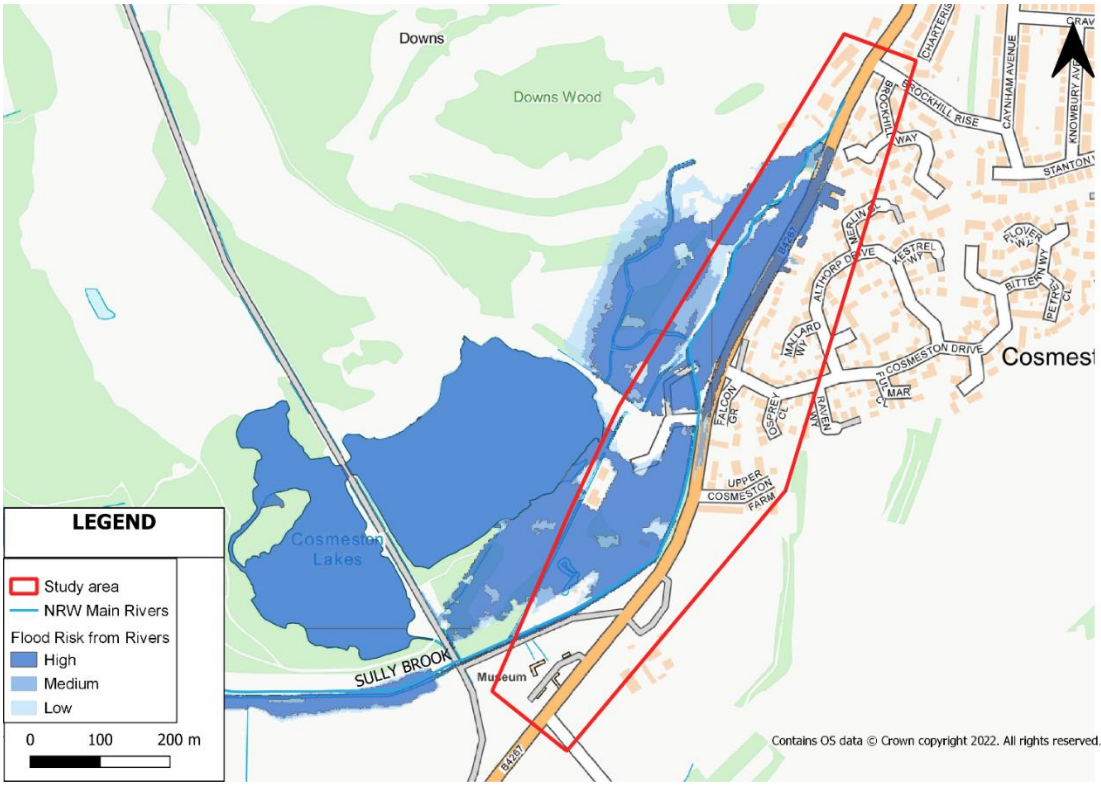

Figure 5-1: Risk of flooding from rivers

5.1.3 Tidal

The FRAW map for flood risk from seas indicates that the entirety of the investigation area has a very low risk of flooding from the sea. As the 'very low' flood risk areas are shown as a transparent layer on the mapping, no figure has been provided.

5.1.4 Surface Water

The FRAW Map for Surface Water shows that almost the entire length of Lavernock Road is at high risk of surface water flooding, as shown in Figure **5-2**.

Across the wider investigation area, there is a variable risk of flooding from surface water. Two main surface water flow paths indicating a high risk of surface water flooding (defined as a chance of flooding of greater than 1 in 30 (3.3%) in any year as a result of rainfall) are shown draining towards Lavernock Road from Cosmeston Drive and north of Brockhill Rise.

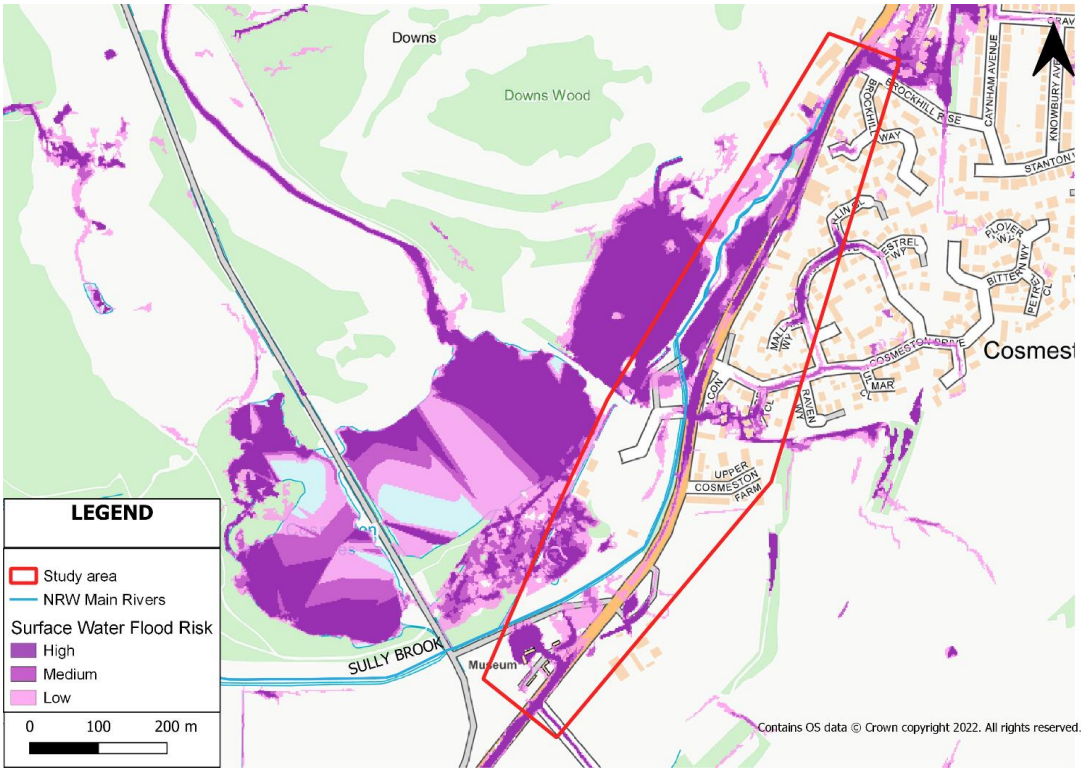

Figure 5-2: Risk of flooding from surface water

5.1.5 Groundwater

Historic borehole records have been checked and records show a range of ground water levels from no groundwater present to water levels at 1.3m below ground level across the investigation area.

As groundwater levels rise in response to precipitation, groundwater can contribute to an increased level of surface water overland flow and a faster flow of water to river channels. However, flooding as a direct result of groundwater rising was not reported and the rapid onset and short duration of the flood event does not characterise groundwater flooding. Although groundwater is not considered to be a direct source of flooding for this event it is acknowledged that a substantial amount of rain fell over a short period of time and on an already saturated catchment, which is likely to have led to surcharging of surface water systems, combined with high water levels in the river.

5.1.6 Flood history

Vale of Glamorgan Council LLFA holds four records of highway flooding on Lavernock Road. There are no records of property flooding. Lavernock Road is shown to be prone to surface water flooding and the west side of the site within the floodplain of the Sully Brook is at high risk of flooding from rivers.

6 Hydrological analysis of the December 2020 event

6.1 Conditions at the time

The overall rainfall for January to December 2020 was above average across most of the UK, particularly across western regions. December featured a series of cyclonic systems, with successive spells of unsettled weather generating rainfall over saturated ground. Overall, December rainfall was substantially above average with 139% of the long-term average (LTA) for the UK and in a broad portion of Wales rainfall exceeded 150% of the LTA.

Soil moisture deficits (SMD) were near-zero across the whole of the UK, the wettest soils for late December at a national scale since 2012, meaning there was little capacity for the ground to retain additional water. Mean river flows over January to December 2020 were exceptionally high in Wales. As a result of these conditions surface water flooding causing significant disruption was a recurrent characteristic of the month.

6.2 Overview of Event

The flood event on 23 December 2020 occurred in response to a short and intense storm event. A short sharp period of intense rainfall was observed between 09:00 and 10:00 at Cog Moors Sewage Treatment Works (STW) TBR rain gauge (the closest rain gauge to the site), recording 8.2mm in 1 hour. After a period of no rainfall for 1.5 hours and 1mm between 11:30 and 12:00 a longer period of persistent heavy rainfall between 12:45 and 18:00 occurred. During this 5.25hr period 47.8mm of rain fell with an average intensity of 9.1mm/hr. The maximum rainfall intensity occurred between 14:00 and 15:00 equalling >10mm/hr. Figure **6-1** below shows the rainfall hyetograph of the flood event at the Cog Moors STW TBR, as detailed in the Section 19 Data Analysis report undertaken by JBA Consulting.

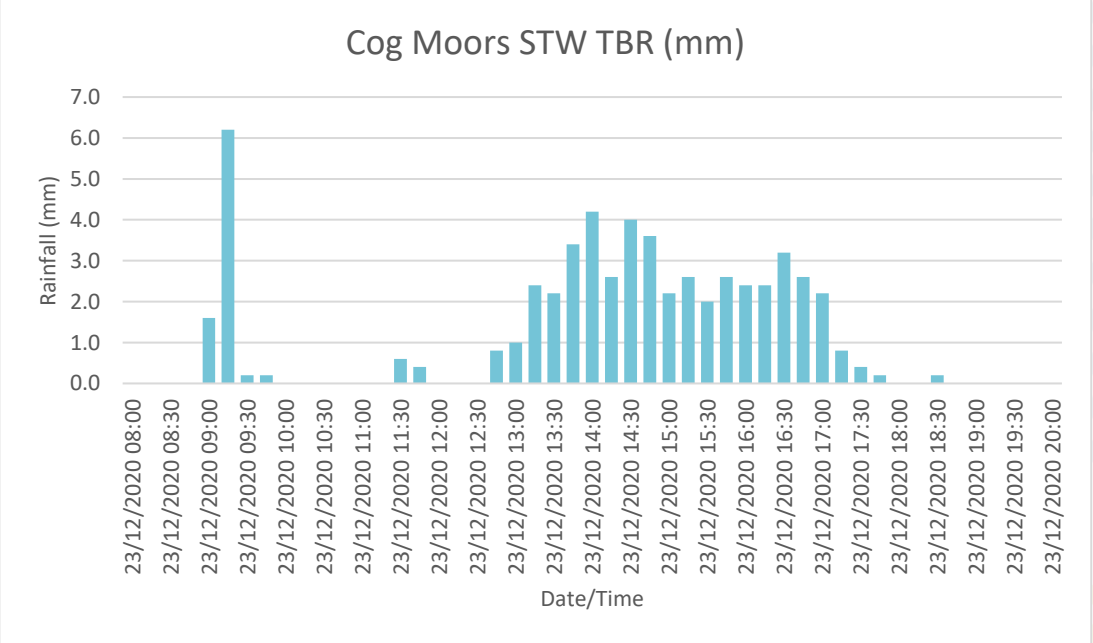

Figure 6-1: Rainfall hyetograph of December 2020 flood event

As described above, prior to the flood there had been a succession of storm events, which had left behind a highly saturated catchment. As a result of this there would have been little capacity for storage within the catchment.

The outcome of this high volume of rainfall falling on a saturated catchment was rapid flows of surface water run-off across non-permeable urban surfaces and slopes. This also caused problems for the surface water sewer networks, which were unable to cope with a large volume of water over this short timeframe.

The days following the event were comparatively dry in the area with short periods of light rainfall on the 24 and 26 December and no impacts resulting from the additional rainfall were reported.

7 Source-pathway-receptor analysis

7.1 Source

7.1.1 River

One Main River, the Sully Brook, runs through the area of investigation. The Sully Brook is one of the largest tributaries of the River Cadoxton. The source of the Sully Brook is located west of Penarth and it flows in a predominantly south-westerly direction, flowing parallel to Lavernock Road on its eastern side until Brockhill Rise, where it passes through a culvert to the western side of Lavernock Road. Upstream of Brockhill Rise the Sully Brook is culverted, and is reported to receive inflows from surface water drainage systems which serve large areas of south west Penarth. An un-named ordinary watercourse joins the Sully Brook at a point opposite Cosmeston Drive and the river continues to flow south westwards before joining the River Cadoxton and finally discharging into the Bristol Channel at Barry Docks. Within the area of investigation, riparian ownership for the watercourse predominantly lies with the Vale of Glamorgan Council and private landowners.

The Sully Brook is not tidally influenced as it flows through the investigation area and the Section 19 data analysis for Dinas Powys produced by JBA Consulting in March 2021 identified that is no tidal influence seen at the Sully Moors Road gauge. Additionally, the timing of the peak water level at the Sully Moors Road gauge during the December 2020 event occurred at a trough in the tidal curve at Barry Port, indicating that the tide did not adversely impact levels at the gauge location.

7.1.2 Extreme rainfall

The primary source of the flood water is the extreme rainfall experienced across South Wales on 23 December 2020.

This investigation presents Cog Moors STW TBR gauge data due to it being the closest gauge to the site being investigated. Rainfall totals at other local rain gauges were also assessed for the 23 December 2020 event (detailed in Table 7-**1** Rainfall gauge data) that provide context for the storm event across South Wales. Note: Rain fell at slightly different times at the gauges, hence the period and duration vary for each.

The findings indicate that the Cog Moors STW TBR gauge recorded substantially larger rainfall totals than at the other gauges within the vicinity of the storm event. NRW has indicated confidence in the Cog Moors STW TBR gauge due to the data being consistent between the primary and secondary gauges that operate independently and after quality checks undertaken on 31 December following the event. Rainfall radar data did not indicate a localised storm around Cog Moors STW TBR, so it is unclear why local rainfall totals differ so substantially from other rain gauges.

The Dinas Powys S19 Data Analysis Report provided an analysis to estimate the flood frequency of the event. The inference of flood rarity from rainfall data is seldom accurate, as treating rainfall rarity as a measure of flood rarity neglects

the complex scenarios leading to flood formation. Therefore, a flood frequency specific to the site investigated in this S19 report is not inferred. However, the rainfall frequency estimation suggested Cog Moors STW TBR indicates a frequency of about 5% AEP (1 in 20yr return period) and the other rain gauges suggest a frequency of about 70% to 20% AEP (between a 1 in 1.5yr and 1 in 5.0yr return period) across the wider area.

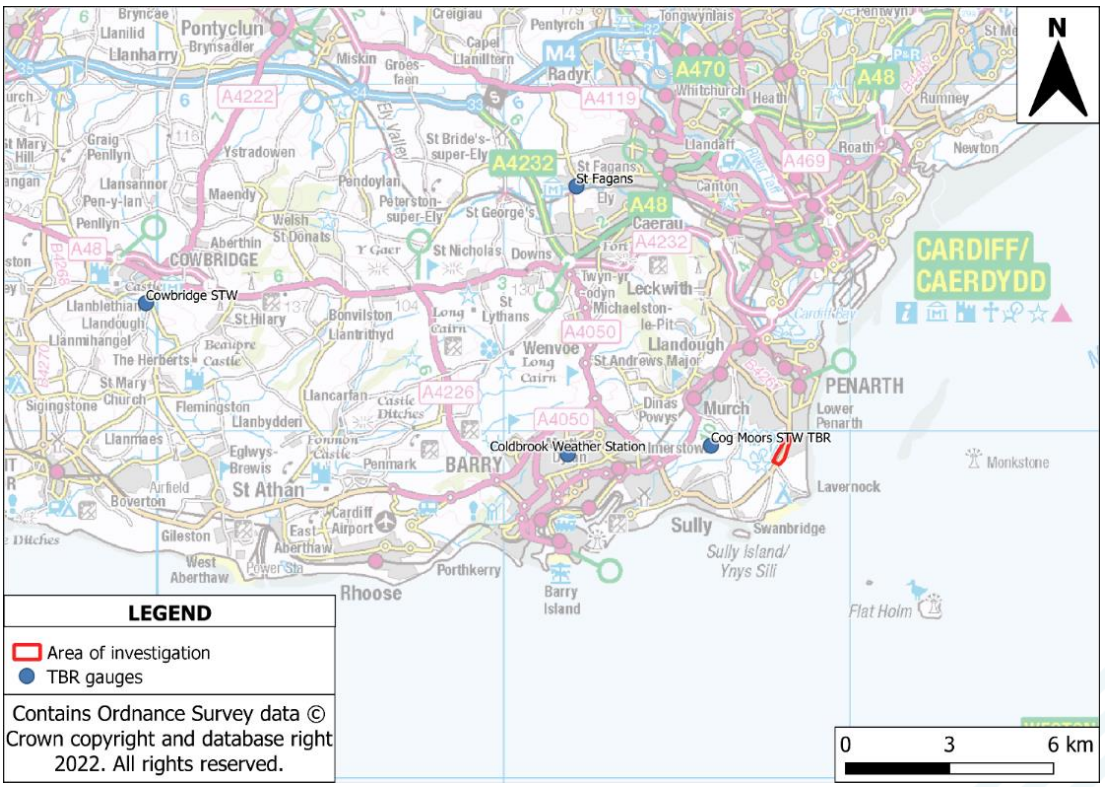

Figure 7-1: Rainfall gauge locations

Table 7-1 Rainfall gauge data

Rain gauge	Distance from site location (km)	Rainfall (mm) on 23/12/2020	Coordinates (XY)
Cog Moor STW TBR	2.07	47.8 in 5.25 hrs	315986,169586
		57.2 in 9.75 hrs	
Cold Brook Weather Station	6.19	29.0 in 5.25 hrs	311853,169334
		37 in 9.75 hrs	
St Fagans TBR	9.69	30.8 in 5.25 hrs	312103,177055
		43.6 in 9.75 hrs	
Cowbridge TBR	18.84	28.8 in 6.75 hrs	299675,173689
		35.2 in 9.25 hrs	

7.1.3 Groundwater

As groundwater levels rise in response to precipitation, groundwater could contribute to an increased level of surface water overland flow and a faster flow

of water to river channels. The flood incident report received by residents indicated water rising through the floor of the property resulting in internal property flooding. This is likely as a result of an increase in water table int he area as fluvial levels also increase. The rapid onset and short duration of the flood event does not characterise groundwater flooding. Therefore, groundwater is considered to be a secondary source of flooding for this flood event.

7.2 Pathway

7.2.1 Fluvial

The main fluvial pathway is from exceedance of the channel capacity of the Sully Brook and the exceedance of capacity of a number of culverts along the Sully Brook in this area. This resulted in floodwater overtopping the banks of the Sully Brook and flowing eastwards onto Lavernock Road and into the Cosmeston Country Park car park. Fluvial floodwaters also flowed in a northerly direction into the functional floodplain of the Sully Brook within Cosmeston Country Park.

7.2.2 Surface water and drainage

A significant pathway for flooding in this area is understood to have been via surface water flows. Due to the high intensity of rainfall during the event, surface water pooled directly on impermeable surfaces, such as roads and pavements. Surface water is also reported to have run off higher land to the west of Lavernock Road which flowed down towards the Sully Brook and is likely to have contributed to flooding from the watercourse. It is also likely that greenfield run-off from fields to the east of the main road contributed to watercourse exceeding capacity.

The local public surface water sewer and highway drainage systems in the investigation area discharge via outfalls to the Sully Brook. Due to high water levels in the Sully Brook during the event, the highway drainage system was hydraulically locked and unable to discharge, resulting in flooding to Lavernock Road. In addition, the systems within Brockhill Rise, Cosmeston Drive and Upper Cosmeston Farm surcharged resulting in surface water flowing towards Lavernock Road – the topographic low point of the investigation area. There have been no reports from DCWW with regards to flooding from the public surface water system in the area at the time of the event.

The depth of flooding on Lavernock Road increased until the floodwater overtopped the kerb and flowed towards the residential properties on the eastern side of the highway. Cars travelling along the road through the flood water also created bow waves (as shown in Figure **7**-**3**) which exacerbated the movement of water towards the properties on the eastern side of the road.

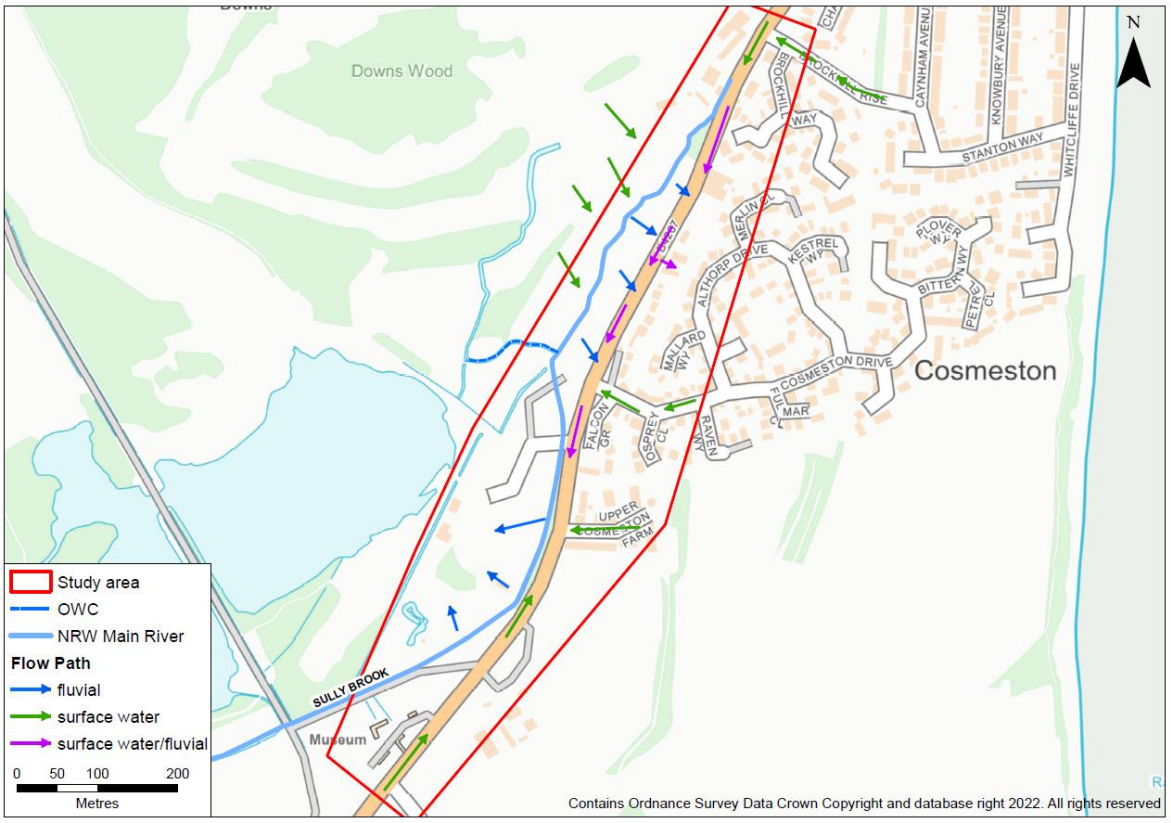

Figure 7-2: Flood water pathways

7.3 Receptor

7.3.1 People

The emotional impact of experiencing flooding and how it can have a harmful impact on mental health is well documented. The flood event occurred on the 23 December, with the majority of residents and families celebrating Christmas, which would have increased the mental strain and devastation felt by the community at the time of the event, whilst also experiencing possible detriment to their mental health as a result of the ongoing Covid-19 pandemic. The water flowing along Lavernock Road resulted in disruption to journey time, therefore impacting the wider community which was also experiencing significant flood events.

7.3.2 Property

One residential property was reported to have flooded internally on Lavernock Road. Internal flood depths at the property were reported to have reached 100mm and external flood depths were approximately 600mm.

The residents reported that the property had not flooded since 1911 and as such they were not prepared for such an event. No flood warnings were issued for the event.

It should be noted that since this flood event, the property has been provided with Property Flood Resilience Measures.

7.3.3 Infrastructure

Evidence collected by VoGC identified that the Cosmeston Country Park car park and a 1km stretch of Lavernock Road were impacted by the flooding. A combination of surface water runoff, exceedance of the drainage system and the overtopping of the Sully Brook resulted in flood depths of approximately 300-500mm on the main road.

Road access into Penarth and Sully was restricted due to flooding of Lavernock Road, resulting in widespread traffic problems. However, it is understood that vehicles continued to travel along the road throughout the event.

Figure 7-3: Lavernock Road at Farm Entrance (Facebook Video Still)

Figure 7-4:Wales Online Video Still at Brockhill Rise

Figure 7-5:Cosmeston Country Park Car Park Looking South (Ranger Photo)

8 Causal factors

Determining the exact cause of flooding is complicated and flooding often results from a combination of factors. Where location specific issues, such as blockages, are identified these will be described in the following section.

The main causal factors leading to flooding of Lavernock Road are limited channel capacity of the Sully Brook and hydraulic locking of the highway and surface water sewers in the area resulting in surface water being unable to discharge into the Sully Brook. The NRW surface water flood map is largely in line with the recorded flood extent for this event.

A small section of the Sully Brook is managed and maintained by the Vale of Glamorgan Council in their role as riparian owners. It is reported that VoGC undertake shallow removal of silt along a 70m section of the Sully Brook in the vicinity of the Cosmeston Country Park car park on a 3-4 year rotation. The exact date of silt removal prior to this flood event is unknown. Vegetation management of the watercourse is also unknown. However, VoGC undertake vegetation maintenance to the watercourses within the country park area. The maintenance regime of private riparian owners is also unknown within the investigation area. Given the timing of the event, in winter, vegetation coverage in channel will have been at its lowest, and as a result the impact of any vegetation is likely to be minimal.

Surface water systems were at capacity and overwhelmed by the extreme rainfall of the event, with systems hydraulically locked as a result of high river levels. There have been no reports from DCWW as to flooding from the public surface water system. As the Highways Authority, VoGC investigate reports of blocked drains from residents and regularly cleanse the highways surface water drainage network. The current cleansing rotas result in a 15 -18 month average rotation, although this cycle was disrupted by the Covid-19 pandemic.

The Highways Authority have stated that the highway gullies within the Lavernock Road area were cleansed on the following dates:

- 24/09/2020
- 12/08/2020
- 16/01/2019
- 14/01/2019

Following the flood event, the VoGC LLFA commissioned an independent inspection of the highway drainage network to be completed in November 2021. The investigation identified that the highway network at this location is in a poor condition, with a number of blockages and collapses within the network. A number of these blockages are as a result of pipe crossings within the highway network causing debris to build up against the pipe crossing, reducing the cross-sectional area of the network and its ability to convey flow. The poor condition of the highway network is a contributing factor to the volume of surface water flooding experienced on Lavernock Road. However, as the highway network is not designed to provide flood storage during a storm event of this size or hydraulic locking of the system, it is likely that the system would have been at capacity and overwhelmed during this rainfall event, regardless of its condition. It is therefore

not known as to what extent the poor condition of the system exacerbated flooding in this area without full capacity modelling of the system. Following the survey of the system, the highway network was cleansed in November 2021, January 2022 and August 2022. It is noted that the results of the investigation into the highway system are being reveiwed to determine a programme of repairs to bring the network to as close to 100% capacity as possible.

9 Conclusion and recommendations

9.1 Conclusions

This report has detailed the investigation into the flooding of Lavernock Road on 23 December 2020. This investigation has reviewed evidence provided by responders and residents and has been informed by a Section 19 data analysis for Dinas Powys produced by JBA Consulting.

Within the area of investigation, the impacts from the storm event primarily occurred in two areas: Lavernock Road; and Cosmeston Country Park car park.

The impact of the event was that a 1km stretch of Lavernock Road was flooded to depths of approximately 500mm, causing traffic disruption, flooding to Cosmeston Country car park and internal flooding to one known property.

The evidence gathered in this report demonstrates that the cause of flooding was due to heavy rainfall resulting in rapid surface water flows and exceedance of channel capacity of the Sully Brook. This was likely exacerbated by hydraulic locking of the surface water network in the area, resulting in increased surface water flows within Lavernock Road.

The below actions are recommended in response to these findings.

9.2 Recommendations

Risk Management Authority/Stakeholder	Recommended actions
Riparian Owner (VoGC/Private Landowners)	Review maintenance actions and frequency of maintenance to the Sully Brook
Lead Local Flood Authority (VoGC)	Undertake CCTV survey of the culverted section of Sully Brook to determine condition and maintenance requirements. Consider modelling the system to determine capacity.
LLFA (VoGC)	Consider catchment-wide options, including retrofit of SuDS and NFM to reduce the risk of surface water flooding to Lavernock Road
Highways Authority (VoGC)	Investigate the feasibility of increasing the current frequency of cleansing on the Lavernock highway drainage system, including main drainage runs and outlets.
Highways Authority (VoGC) / DCWW	Remediate the condition of the highway network on Lavernock Road.
VoGC (LLFA)	Consider including the Sully Brook contributing catchment as an area where new development requires specific hydraulic control within forthcoming updates to the Local Flood Risk Management Strategy

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Registered Office
1 Broughton Park
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Broughton
SKIPTON
North Yorkshire
BD23 3FD
United Kingdom

+44(0)1756 799919
info@jbaconsulting.com
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