Cyfoeth Naturiol Cymru
Natural Resources Wales

Flood Investigation Report

St Asaph and Elwy Communities

Storm Ciara
9th February 2020

Executive summary

Under Section 19 of the Flood and Water Management Act 2010 (FWMA10), the Lead Local Flood Authority (LLFA), in this case Denbighshire County Council (DCC), on becoming aware of a flood in its area must to the extent that it considers 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 Flood Investigation Report (FIR) has been prepared for the purposes of documenting the flood event on the Afon Elwy which occurred in February 2020 as a result of Storm Ciara. Information has been gathered from a number of sources and reviewed against activity logs from various duty officers and risk management authorities. The report examines the preceding conditions within the Afon Elwy catchment, the extent and magnitude of the rainfall event and the sequence of physical events which led to multiple residential and commercial properties being affected. Conclusions are drawn based on the information available and recommendations are made with agreement from the appropriate risk management authorities.

A significant number of properties are known to have flooded internally from solely main river, ordinary watercourse or surface water, and a small number of properties have experienced flooding from multiple sources in combination during this event. The main focus of this report is flooding arising from designated “main rivers” for which NRW is the Risk Management Authority. Where appropriate, any impact on people and property from non-main rivers (Ordinary Watercourse) will be assessed and documented in the context of its relationship to main river flooding mechanisms. All incidences of impact from non-main river will be communicated to the relevant risk management authority for further investigation.

Document Control Sheet

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Version History

Date	Version No.	Status	Summary of Changes
02/10/2020	1.0	First draft	First draft sent internal to NRW for comment
06/01/2021	2.0	Draft	Amendments made after internal consultation
25/02/2021	3.0	Draft	Further amendments made following review by NRW Operations Manager
22/03/2021	4.0	Draft	Amendments made on recommendations received from professional partners.
01/04/2021	4.0	Final	Final draft ready for publication.
03/06/2021	5.0	Final	Final Draft with accessibility amendments.

Distribution

Name	Organisation	Position	Date	Version
Keith Ivens	Natural Resources Wales	Operations Manager, Flood Risk & Water Management	25th February 2021	3.0
Paula Harley	Natural Resources Wales	Operational Resource Manager	25th February 2021	3.0
Wayne Hope	Denbighshire County Council	Flood Risk Manager	25th February 2021	3.0
Owen Conry	Conwy County Borough Council	Flood Risk Manager	25th February 2021	3.0
Nick Holt	Dwr Cymru Welsh Water	Data & Risk Manager	25th February 2021	3.0

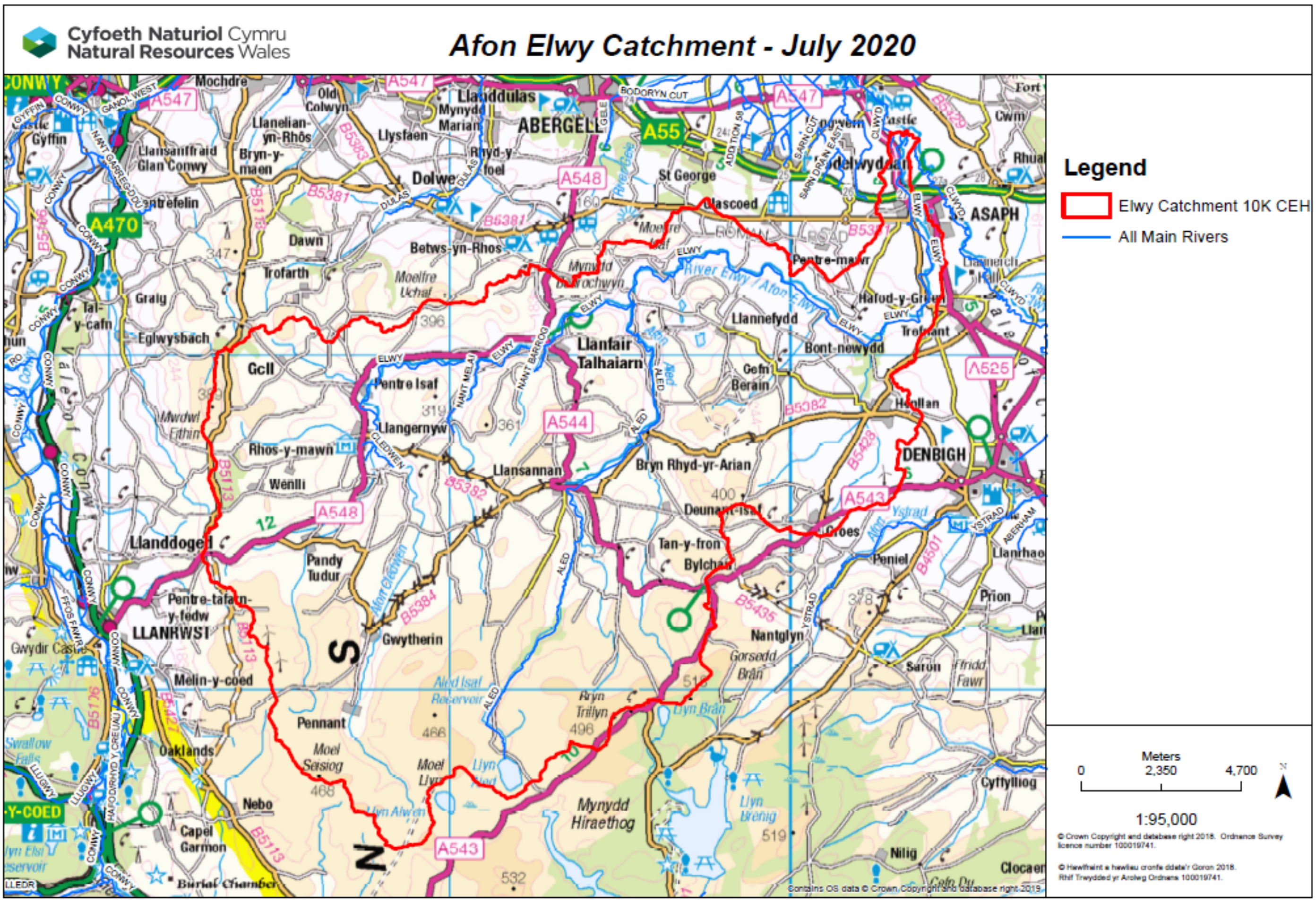
Contents

List of Figures

1. Location

The Afon Elwy is a designated “main river” watercourse with a catchment area of 194km^2 (Figure 1) rising to a maximum altitude of 515 mAOD, consisting mainly of grassland (89%) and urban extent of 0.25% (CEH, 2020). The standard average annual rainfall (SAAR) in the period 1961-1990 is recorded as 1185mm (CEH, 2020). The Elwy flows through a flat-bottomed, U-shaped valley with well-connected floodplains of agricultural land (mainly improved pasture) and some areas of woodland. Channel morphology is generally observed to be a mix of pool riffle sequences with long lengths of wandering channel in the mid reaches. Significant debris loading is often observed during high flow events derived from tributary characteristics and vegetation composition in the upper reaches. A large proportion of the upstream sections have had some historic bank revetment, both hard and soft, usually to address localised erosion issues impacting farming practices. Channel modification is observed in various locations most notably discrete areas of channel straightening and revetment to maintain bridge structures. Significant lengths of floodplain disconnection through embanking & walling is observed in two main locations, Llanfair Talhaiarn and St Asaph.

Figure 1: Afon Elwy catchment extent (adapted from CEH, 2020)



A number of small communities and isolated properties are located adjacent to the Elwy channel along much of the middle and upper reaches. The larger communities of Llanfair Talhaiarn and St Asaph are located is the mid and lower sections respectively.

The Elwy has a number of tributaries along its length, most notably the reservoired catchment of the Afon Aled and the narrow flashy catchment of the Nant Barrog. The Elwy tributaries are generally characterised by confined, heavily wooded valleys, opening out into areas of agriculturally improved land with minimal urban development.

Llyn Aled in the upper reaches of the catchment is a natural lake of approximately 45 hectares which is dammed at its Northern outfall. A short section of steep sided, narrow channel flows into Llyn Aled Isaf which is also impounded for water resource, environmental and recreational benefits. Both Llyn Aled and Llyn Aled Isaf are managed by Dwr Cymru Welsh Water (DCWW). Llyn Aled and Aled Isaf provide approximately 1.7 million m^3 and 1.1 million m^3 of storage respectively (DCWW, 2019). During the period between 1st September to 25 January, valves in the Aled Isaf Reservoir drawoff tower remain open to facilitate flood mitigation (Figure 2 &

Figure 3), but during high reservoir levels excess water can spill over the dam crests contributing unregulated flow.

Figure 2: Mean daily water levels Aled Isaf (DCWW, 2019)

Percentage of time lake level equalled or exceeded	Mean daily reservoir level, metres, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum reservoir level	15.2	15.2	15.2	15.1	15.1	15.2	15.1	15.1	15.2	15.1	15.2	15.1	15.2
10% (high level)	15.0	15.1	15.1	15.1	15.0	15.0	14.7	14.6	14.8	15.0	15.0	15.0	15.0
50%	14.9	15.0	15.0	15.0	15.0	14.3	12.9	11.5	11.1	12.5	14.0	14.8	14.7
80%	14.5	14.9	14.8	14.8	14.6	13.4	11.3	9.5	9.2	9.8	11.5	12.8	12.1
90%	13.3	14.6	14.7	14.3	14.1	12.9	10.3	8.4	8.8	9.0	9.3	11.5	10.1
95%	12.1	12.8	13.9	13.9	13.8	12.7	9.3	5.7	7.6	7.4	8.3	11.0	9.2
99% (low level)	11.4	11.4	13.1	12.6	12.1	12.0	6.5	3.9	6.6	6.8	7.6	10.1	6.8
Minimum reservoir level	10.5	11.2	12.3	12.4	11.8	10.9	2.0	2.0	5.1	6.4	6.5	7.5	2.0

Figure 3: Mean daily water levels Llyn Aled (DCWW, 2019)

Percentage of time lake level equalled or exceeded	Mean daily reservoir level, metres, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum reservoir level	5.2	5.2	5.1	5.3	5.2	5.2	5.2	5.1	5.2	5.1	5.2	5.1	5.3
10% (high level)	5.1	5.1	5.1	5.1	5.1	5.0	5.1	5.0	5.0	5.1	5.1	5.1	5.1
50%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.7	4.5	5.0	5.0	5.0
80%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	3.9	3.8	4.5	5.0	4.9
90%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.2	3.5	3.5	4.1	4.9	4.4
95%	5.0	5.0	5.0	5.0	4.9	5.0	5.0	4.0	3.3	3.2	3.8	4.7	4.0
99% (low level)	4.1	5.0	5.0	4.9	4.8	4.8	4.9	3.8	3.1	3.0	3.4	3.3	3.3
Minimum reservoir level	3.4	4.0	5.0	4.9	4.7	4.8	4.7	3.5	2.1	2.4	2.7	3.2	2.1

The lower limit of the Elwy is just north (downstream) of St Asaph at Junction Pool where the Elwy and Afon Clwyd converge, also forming the tidal limit in normal conditions. A study undertaken after the 2012 flood event on the Elwy concluded that tidal conditions do not impact the community of St Asaph but increases in fluvial water levels in the flood plain in and around the confluence area can be attributed to very high tides on the Afon Clwyd.

2. Flooding History

There is a long history of flood events, of varying magnitude, observed within the Elwy catchment, many of which have occurred in recent history. A plaque on the Laundry Cottage St Asaph states 'Height of Flood August 17th 1879', positioned approximately 700mm from ground levels

Although details are scarce, flooding is known to have impacted the City of St Asaph in 1964 when channel capacity was exceeded; although records do suggest properties on Lower Denbigh Road were not flooded internally. The 1964 event occurred before the construction of any formalised, raised, flood defences in the confines of the main residential areas of the city. Flooding is also known to have impacted the Elwy floodplain upstream of St Asaph in 2000, but again details of properties affected are minimal.

Figure 4: Plaque on Laundry Cottage, St Asaph

Figure 5: Historic photographs; flooding on the Elwy circa 1964 (Source unknown)

The community of St Asaph experienced widespread and catastrophic flooding in November of 2012, when the Afon Elwy exceeded its channel capacity in multiple locations and overtopped earth embankments. In the 2012 event, approximately 320 properties, including a mixture of private residential dwellings, commercial premises and approximately 70 static caravans were flooded with many more homes and businesses impacted by water levels within the catchment.

Multiple incidents of high levels on the Elwy have been observed since 2012, notably in December 2015 when the Elwy inundated its flood plain around the Lower Denbigh Road section, causing internal flooding to residential properties and external damage to residential and commercial premises.

The community of Llanfair TH has experienced multiple flooding incidents, again many of which have been experienced in recent history. Llanfair TH is mainly impacted by out of channel flows from the Nant Barrog, which is often observed to flow down Water Street to its confluence with the Afon Elwy. *A separate FIR will investigate the flood event which occurred in February 2020 as a result of the Nant Barrog*. Anecdotal evidence from the November 2012 flood incident suggests out of channel flow from the Elwy entered the village from school lane, thus exacerbating flood

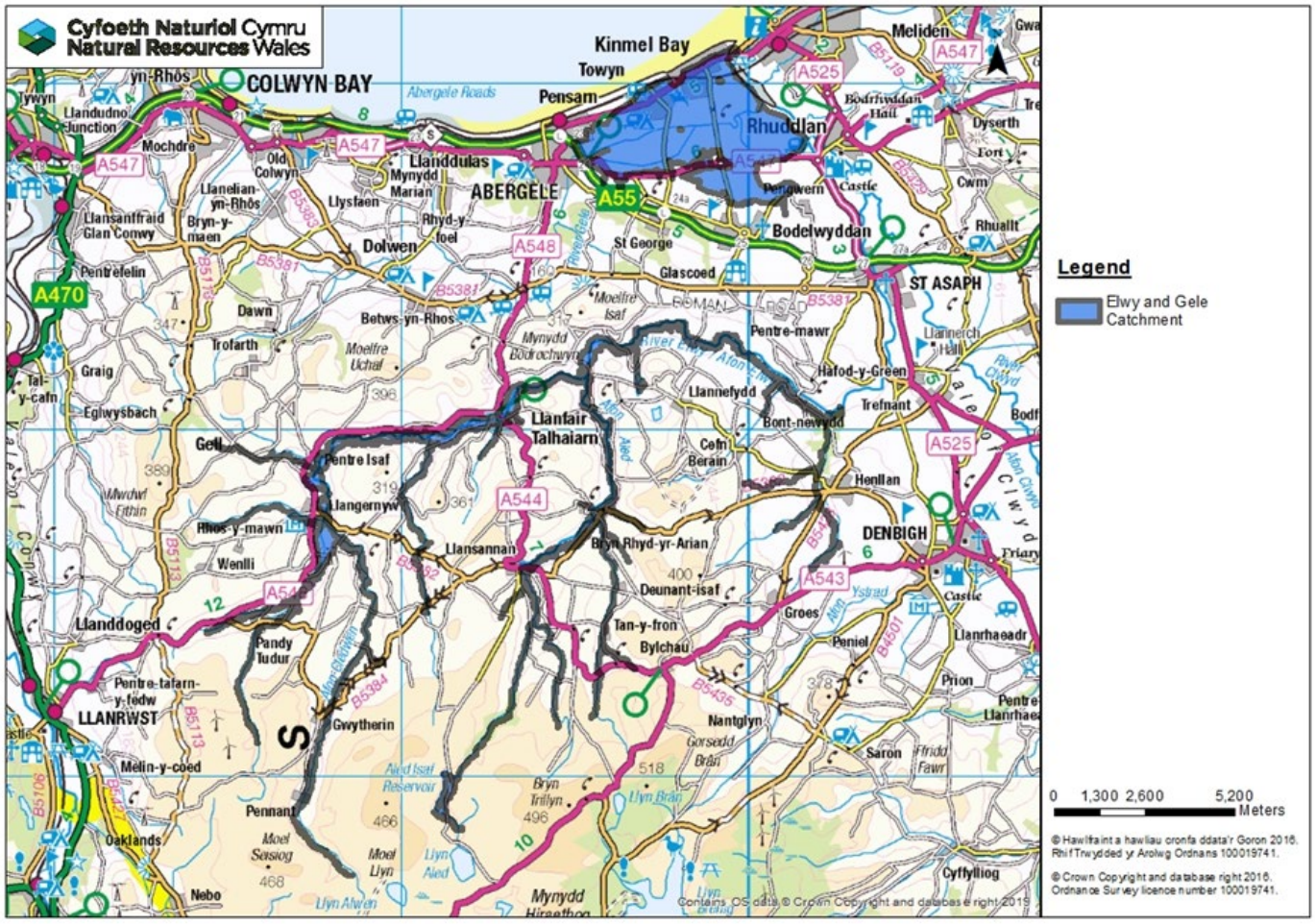
depths in the lower village. However, details are limited and observations were not fully substantiated during post event investigations.

Many isolated properties within the middle reaches of the Elwy have been observed to flood internally in 2012 and 2015 and have been impacted by out of channel flows on many occasions before and since these two documented incidents.

3.Warning and Informing

The Elwy and Gele Catchment Flood Alert covers areas around the river Elwy and river Gele, from Gwytherin to St Asaph and including Abergele (Figure 6).

Figure 6: Map showing the Elwy and Gele Catchment Flood Alert Area



Registration for flood warnings should be obtained for each individual property; details on availability and registration can be found on the NRW website.
https://naturalresources.wales/flooding/sign-up-to-receive-flood-warnings/?lang=en

A Catchment Flood Alert means that flooding of low-lying land and roads is possible, and for people to be prepared. Flooding of property is not expected to occur at the Flood Alert level. Issuing of a Catchment Flood Alert is based on a pre-determined river level being observed at Pont y Gwyddel gauging station located between Llanfair TH upstream and St Asaph downstream.

The Elwy has a flood forecasting model which uses predicted and real-time rainfall data to inform flood duty officers of potential river levels which may in-turn impact properties and communities. Duty officers use this information to devise an efficient and proportionate response, i.e. inspection of flood risk assets to ensure structural integrity before the event. Forecast rainfall depths can be inputted to the model prior to the event reaching the catchment but the uncertainties associated with pre-event modelling can be extensive. During an event the forecasting model is highly dependent on receiving good quality data from the rain-gauges and river level stations to translate accurate levels downstream at various temporal and spatial extents.

The general understanding of flood forecasting models is that the longer the lead-in time the more uncertainties are associated with the outputs. It is therefore vital that flood duty officers are familiar with the catchment and understand the dynamics of both modelled and observed outputs. All decisions based on outputs from the forecasting model are made using clear and informed discussion between multiple duty officers, technical experts and local operatives.

The communities and isolated properties located in the lower Elwy are covered by three flood warning outlines;

- River Elwy from Spring Gardens Bridge to Rhuddlan
- River Elwy at St Asaph
- River Elwy at Lower Denbigh Road

The three site-specific Flood Warning Areas comprise of;

Flood Alert - Flooding is possible, be prepared.

A Flood Alert means that flooding of land and roads is possible, and defences are expected to be impounded but not overtop. Flooding of property is not expected at this level of warning.

Flood Warning - Flooding is expected, immediate action required.

A Flood Warning means that flooding of property is expected and for people to take action to protect themselves and their property.

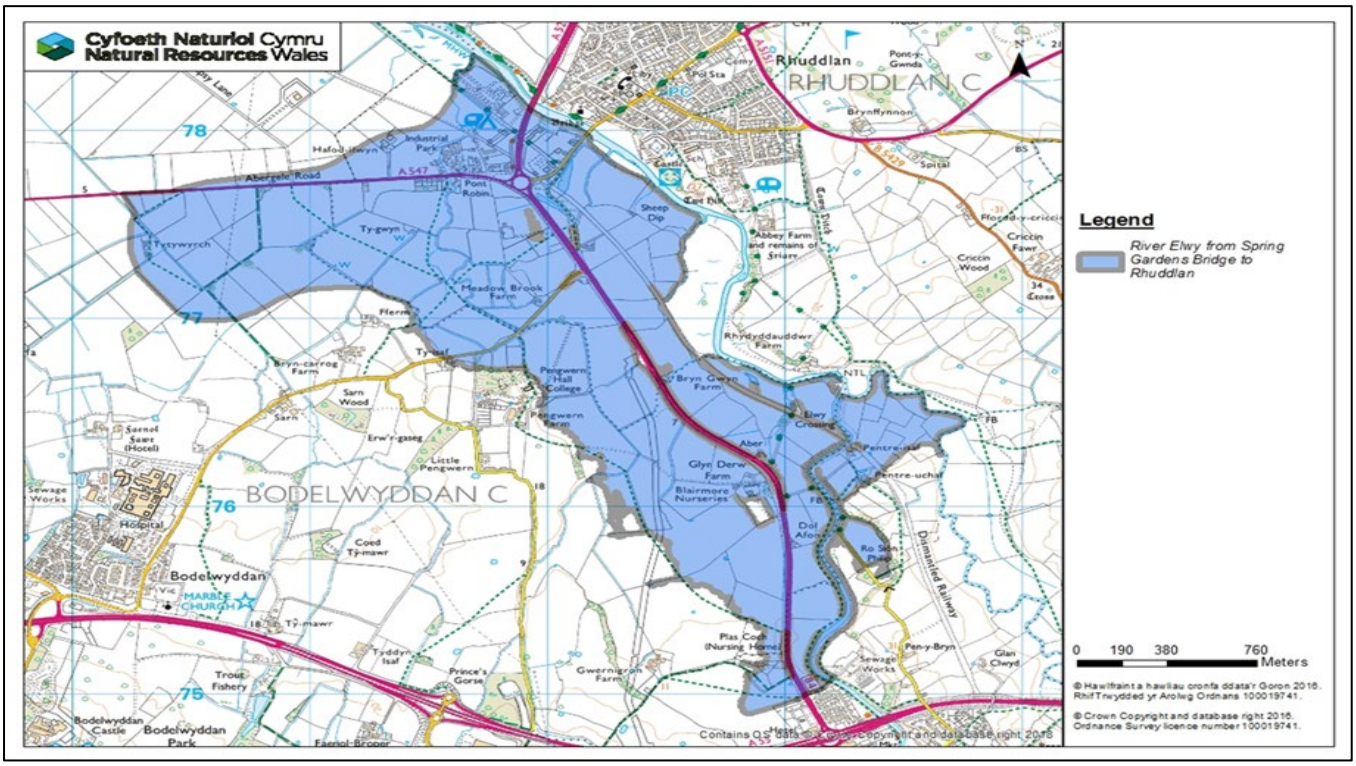
These Flood Alert and Flood Warning messages can either be issued based on flood forecasting models or on observed conditions at Pont y Gwyddel and St Asaph river level stations.

Severe Flood Warning - Danger to life.

Severe Flood Warnings are issued based on site conditions and observations, and involve duty officers agreeing whether the criteria of significant risk to life and/or significant disruption to communities has been met.

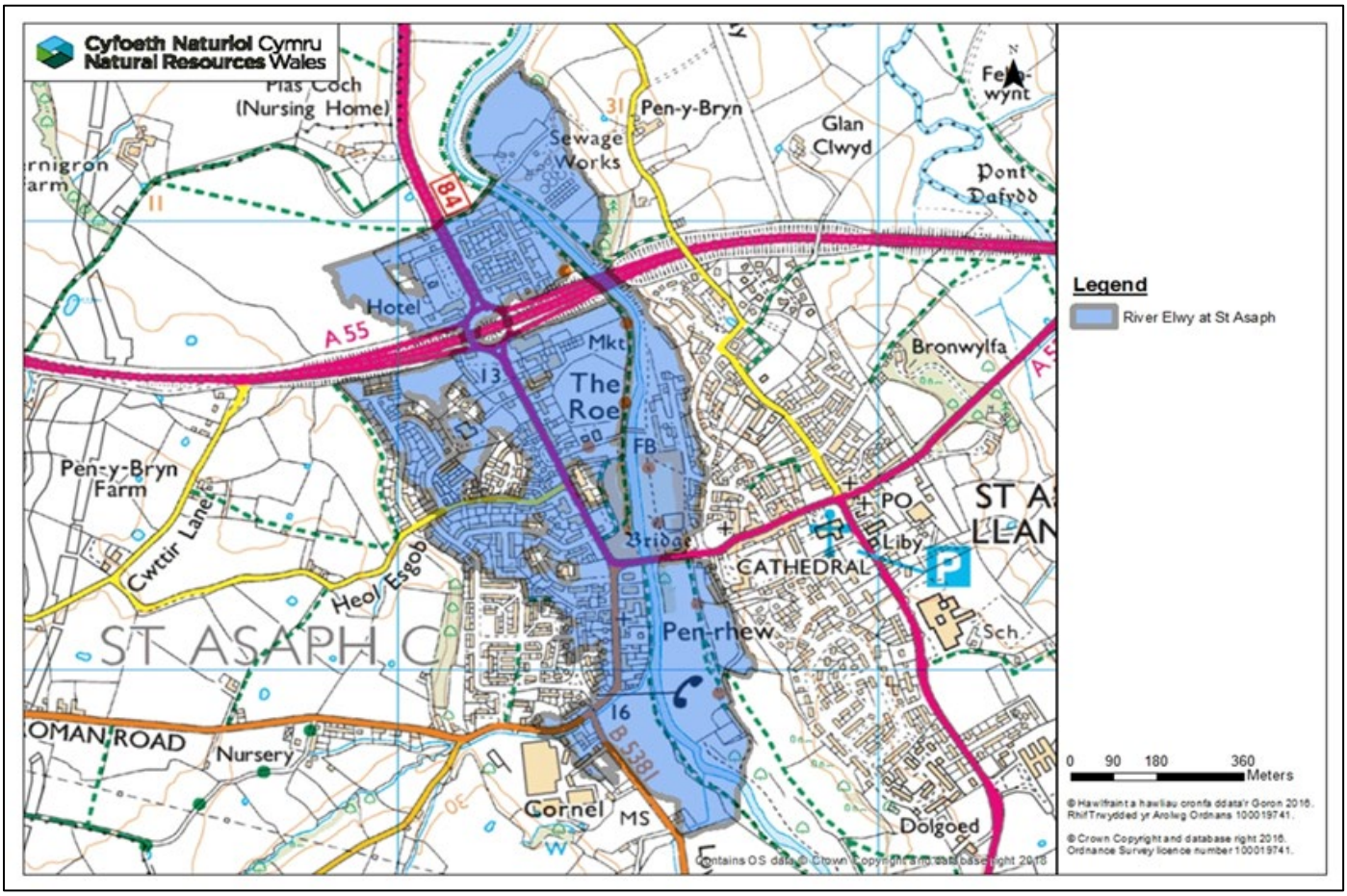
The River Elwy from Spring Gardens Bridge to Rhuddlan (Figure 7) covers the lower reaches of the Elwy from Spring Gardens Bridge down to the Afon Clwyd at Rhuddlan including the HTM Business Park, Dol Afon, Bryn Gwyn Farm, Pentre Uchaf & Mount Road, parts of the A547 Abergele Road, A525 St Asaph Road and Station Road.

Figure 7: Flood Warning area for River Elwy from Spring Gardens Bridge to Rhuddlan



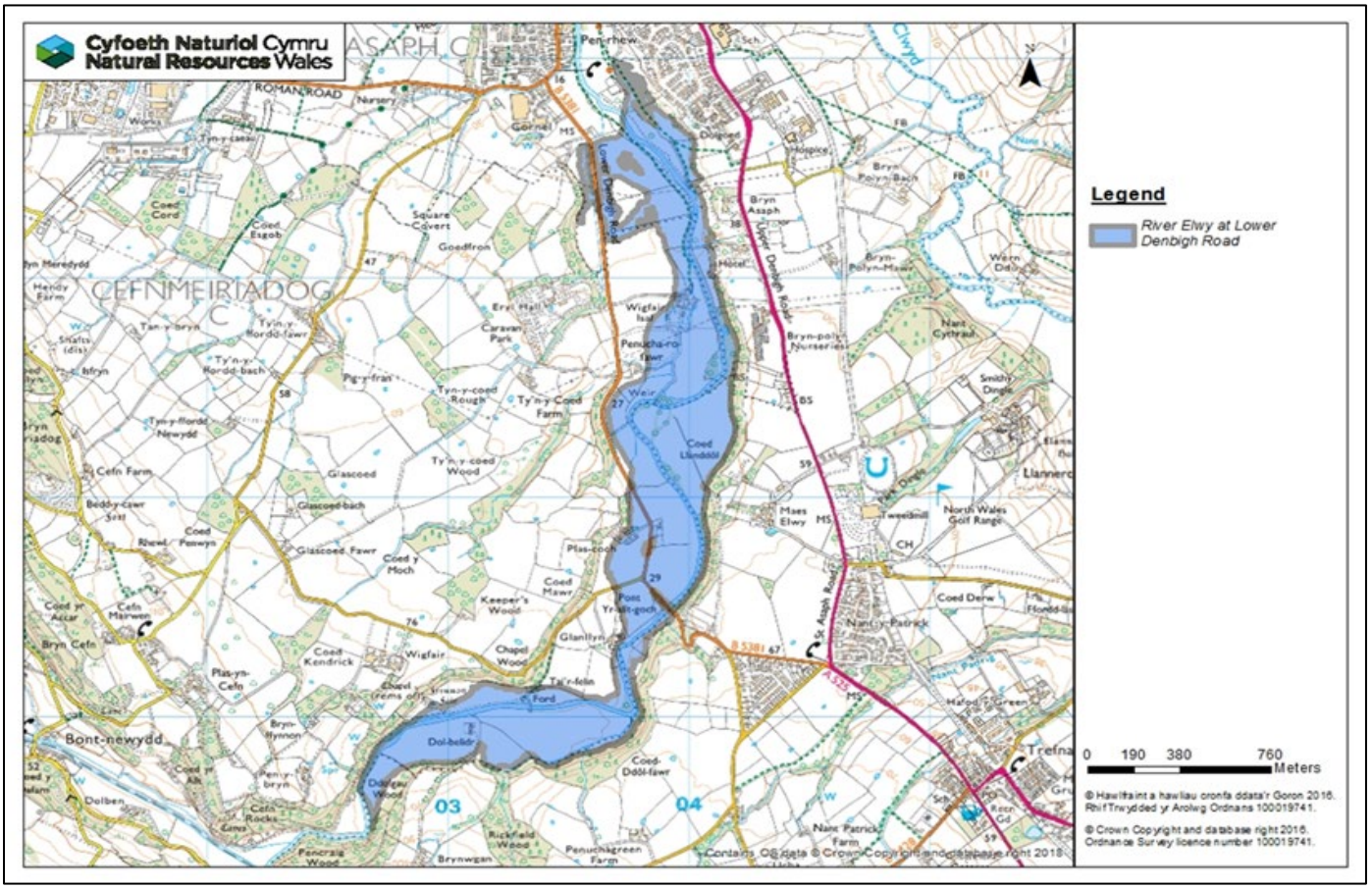
The Elwy at St Asaph (Figure 8) Flood Warning covers parts of St Asaph from Glascoed Road downstream to Roe Parc, including Spring Gardens, Roe Parc, Hen Waliau, The Roe, Tan-y-Bryn, Ashly Court and Dean's Walk.

Figure 8: Flood Warning area for The Elwy at St Asaph



The River Elwy at Lower Denbigh Road (Figure 9) Flood Warning covers the area of Elwy floodplain from Chapel Wood just upstream of the B5381 to Glan Elwy just upstream of Glascoed Road, St Asaph. The warning area includes Dol-Belidr, Pen Rhewl, Wigfair, Pont yr-Allt-Goch, Lower Denbigh Road and Cwrt Wigfair.

Figure 9: Flood Warning area for River Elwy at Lower Denbigh Road.



The village of Llanfair TH is impacted by flooding from the Elwy and the Nant Barrog (Figure 10), rainfall events generally impact both watercourses but exhibit different runoff characteristics and subsequent flow regimes. Properties located on the upper section of Water Street are within the Barrog flood zones whereas properties in the vicinity of School Lane and lower sections of Water Street are also within the Elwy flood zone. Parts of Llanfair TH village are covered by a flood alert for the Elwy and Gele Catchments (Figure 11), no Elwy specific flood warnings cover this area. The flood alert extends through the upper and middle reaches of the Elwy.

Figure 10: Flood zone 2 for Llanfair TH

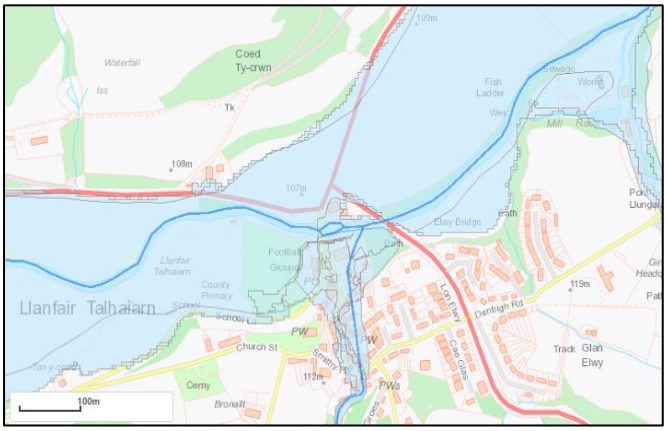
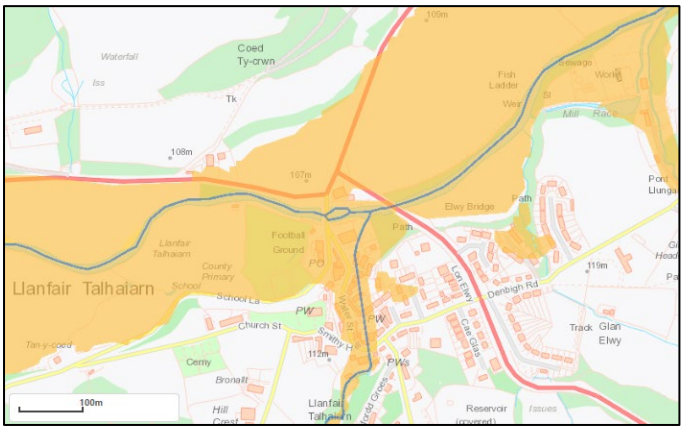


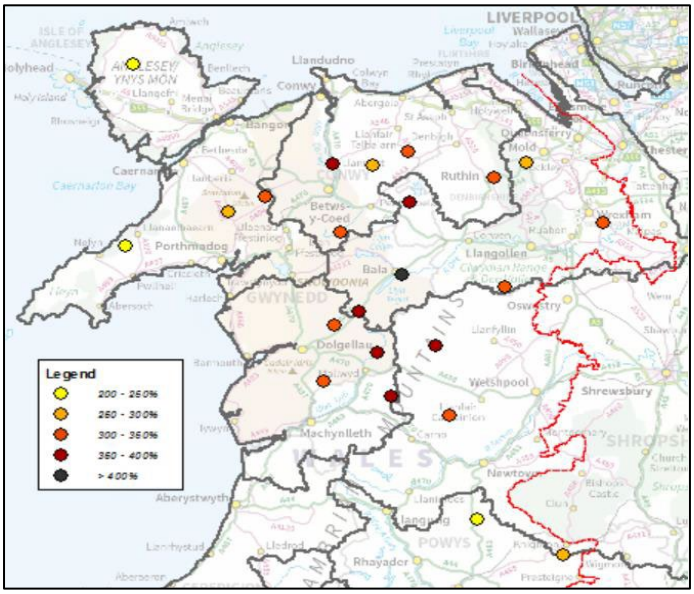
Figure 11: Flood Alert area for Llanfair TH



4. Precipitation & River Flow Analysis

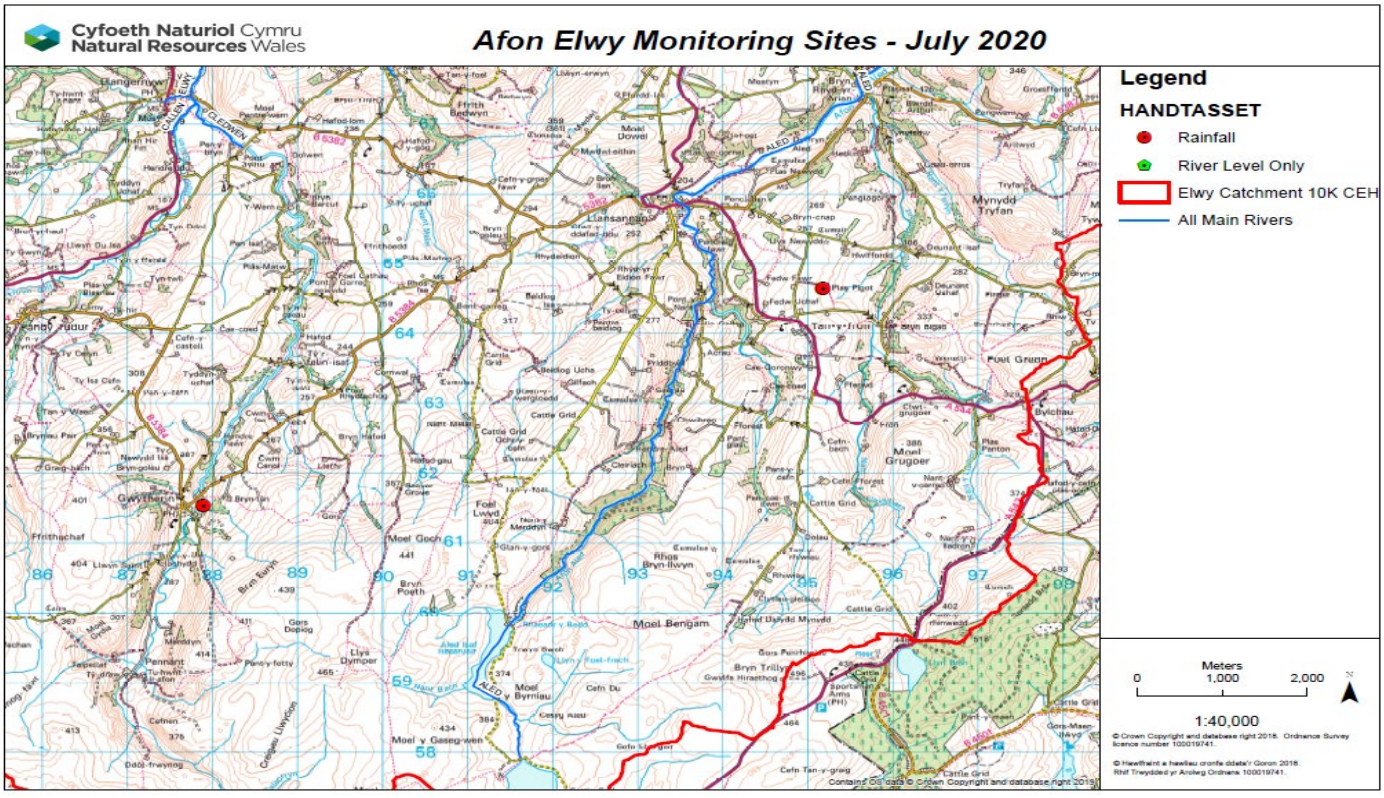
The month of February 2020 was one of the wettest on record for parts of North and Mid Wales. A series of successive weather fronts including storms Ciara (8th – 10th February), Dennis (15th – 16th February), Jorge (29th February to 1st March) and the un-named event through the weekend of 21st – 24th February, saw most raingauges recording over 200% of their February Long Term Average (LTA) (Figure 12).

Figure 12: Rainfall as % of Feb LTA (NRW, 2020)



As the Risk Management Authority (RMA) responsible for flood warning & informing on main rivers, NRW operate and maintain various monitoring sites within the Elwy catchment including rainfall gauges and river level gauges. There are currently two active rain gauges which service the Elwy catchment (Figure 13); Gwytherin is located to the extreme south west of the catchment and Plas Pigot in the mid catchment just south of Llansannan.

Figure 13: Elwy Monitoring Sites (NRW, 2020)



For the period preceding Storm Ciara (Oct 2019 to Jan 2020), with the exception of Oct 2019 for Gwytherin, observed rainfall was below average for both rain gauges with Plas Pigot recording -53% and -49% for October and November 2019 respectively (See Figure 16 & Figure 15). In the period immediately preceding Storm Ciara (7th & 8th February 2020) observed rainfall was again observed to be below the monthly average. However, as Storm Ciara approaches the rainfall figures increase significantly (Figure 14). Gwytherin rain gauge recorded 77mm of rainfall over a 16-hour period, which equates to 66% of the monthly average. Plas Pigot rain gauge recorded 58mm of rainfall over a 16-hour period, which equates to 76% of the monthly average. This trend continues for both gauges through February as Storm Ciara is followed less than 7 days later by Storm Dennis. The final observed rainfall data for February 2020 is 194% and 242% of the long-term average for the month of February from Gwytherin and Plas Pigot respectively.

Figure 14: Short term rainfall (NRW, 2020)

Date	Station Name	
	Gwytherin	Plas Pigot
07-Feb-20	-31%	-38%
08-Feb-20	-2%	9%
09-Feb-20	181%	225%
10-Feb-20	167%	204%
11-Feb-20	148%	183%

Figure 15: Gwytherin Rainfall Feb 2020 (NRW, 2020)

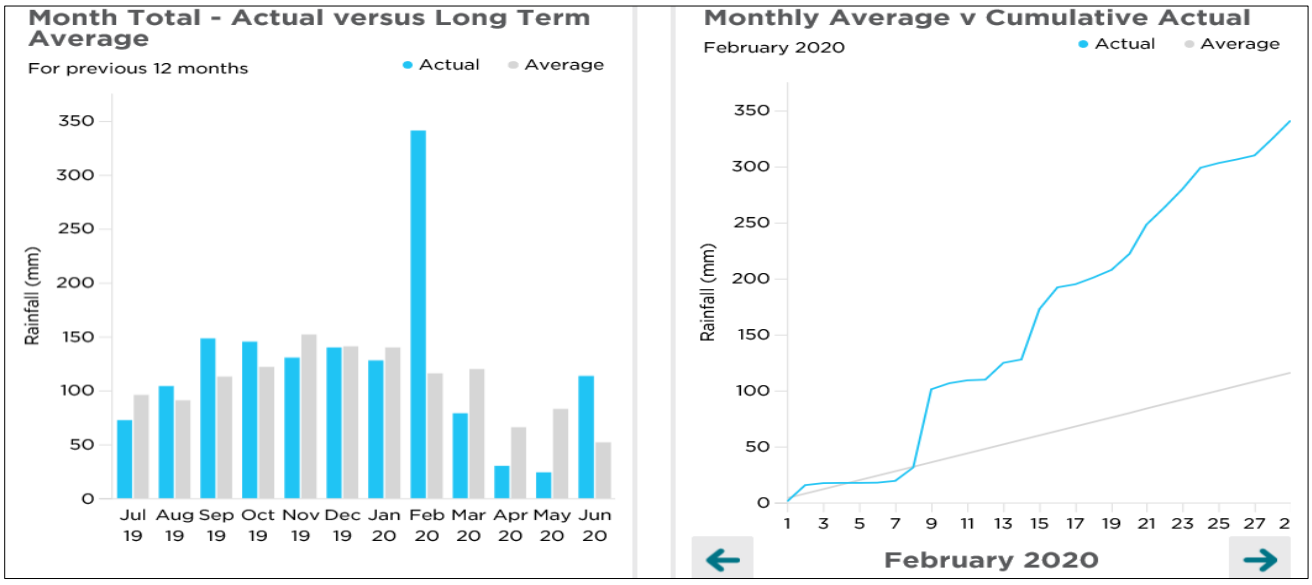
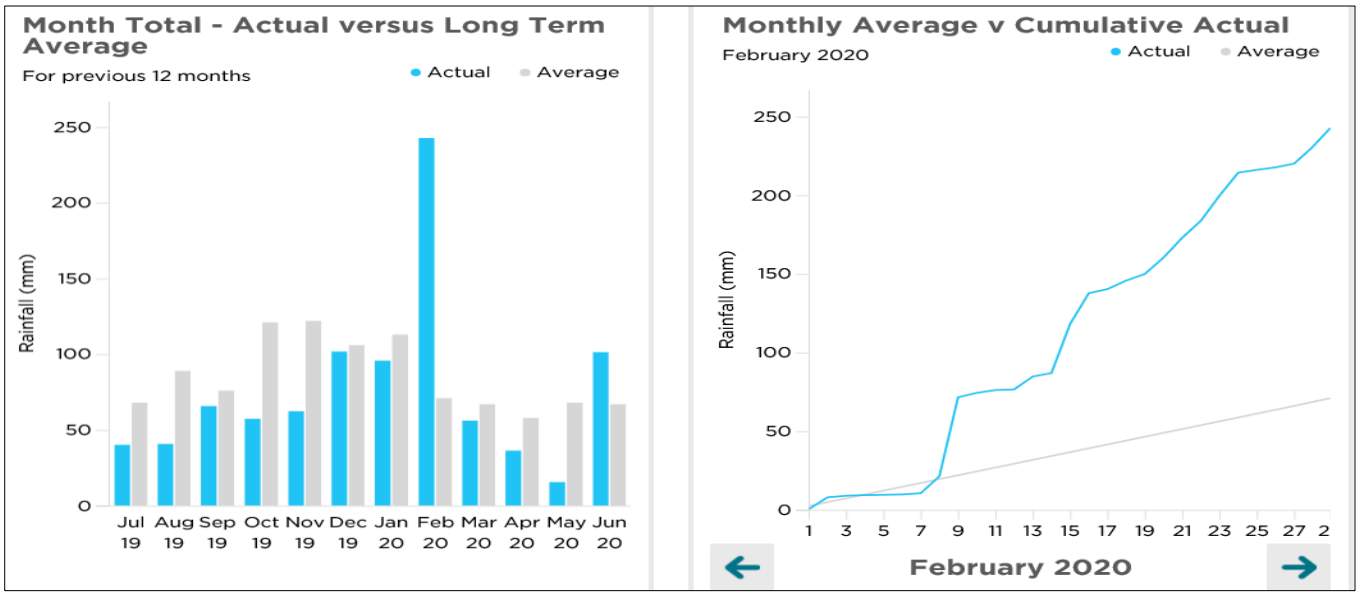


Figure 16: Plas Pigot Rainfall Feb 2020 (NRW, 2020)



In addition to the rain gauges, NRW also operate a number of river flow gauges in the Elwy Catchment (Figure 18). The main river gauge for issuing flood warnings for St Asaph is located on the Afon Elwy, 300m downstream of the confluence with the Afon Aled at Pont Y Gwyddel. Pre-set thresholds are detailed in incident response procedures which initiate discussions between flood duty officers in NRW as to whether to issue various operational messages, flood alerts and warnings dependent on wider catchment precipitation and operational considerations.

The Elwy experienced its highest river level since the start of record in 1974 (Figure 17) as Pont y Gwyddel reached its highest peak on record of 3.652m at 11:30 on 9th February 2020, which is 0.17m higher than the November 2012 event. Unfortunately, the level gauge at St Asaph failed and missed the peak, but the data does suggest it was the highest peak on record here also (corroborated by the Pont y Gwyddel peak upstream). Furthermore, on-site observations both during and after the event suggest the peak at St Asaph was in excess of 4.8m.

Further information on Precipitation and River Flow Analysis can be found in the February 2020 Floods in Wales: Flood Event Data Summary report.

Figure 17: River levels and flows over 9th & 10th Feb 2020

Gauging Station	River	Date/Time of peak	Peak stage (m)	Rank	Peak Flow (m3/s)	Rank	Record Start
Pont Y Gwyddel	Elwy	09/02/2020 11:30	3.652	1	220	1	1974
St. Asaph	Elwy	09/02/2020 15:30	Gauge failed and data suspect. But likely the highest peak on record, exceeding the previous maximum of 4.352m in Nov 2012.				
Ruthin Weir	Clwyd	09/02/2020 16:30	1.129	3	22.7	7	1971
Pont Y Cambwll	Clwyd	10/02/2020 00:15	2.792	6	59.3	18	1973

Figure 18: Elwy River Level Stations (NRW, 2020)

Cyfoeth Naturiol Cymru
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Afon Elwy Monitoring Sites - July 2020

Legend

HANDTASSET

- Rainfall
- River Level Only
- Elwy Catchment 10K CE
- All Main Rivers

Meters
0 750 1,500

N

1:32,000

5. Flood Risk Assets and Property Level Protection

Flood defences were built in and around St Asaph in the 1960s and raised again in the 1970s along both banks of the Elwy to protect the city from flooding between the 2% Annual Exceedance Probability (AEP) or the 1 in 50-year return period event flood and the 1% AEP or the 1 in 100-year return period. However, the city of St Asaph experienced devastating flooding in 2012, at which time flood risk management infrastructure was in place and in fair condition. A full review of flood risk along the Afon Elwy was undertaken after the 2012 event, this led to increased maintenance activities in the short term.

A detailed scheme design was initiated from the initial findings and between 2017 and 2018 flood defences in the area were extensively improved, both in structural integrity and standard of protection (SOP). Raised flood defences from the Elwy meadows upstream to the confluence with the Afon Clwyd at Elwy Crossing (Figure 20 & included in Appendix 1) provide an SOP of 0.5% AEP or the 200-year return period event at present day observations of flows on the Afon Elwy.

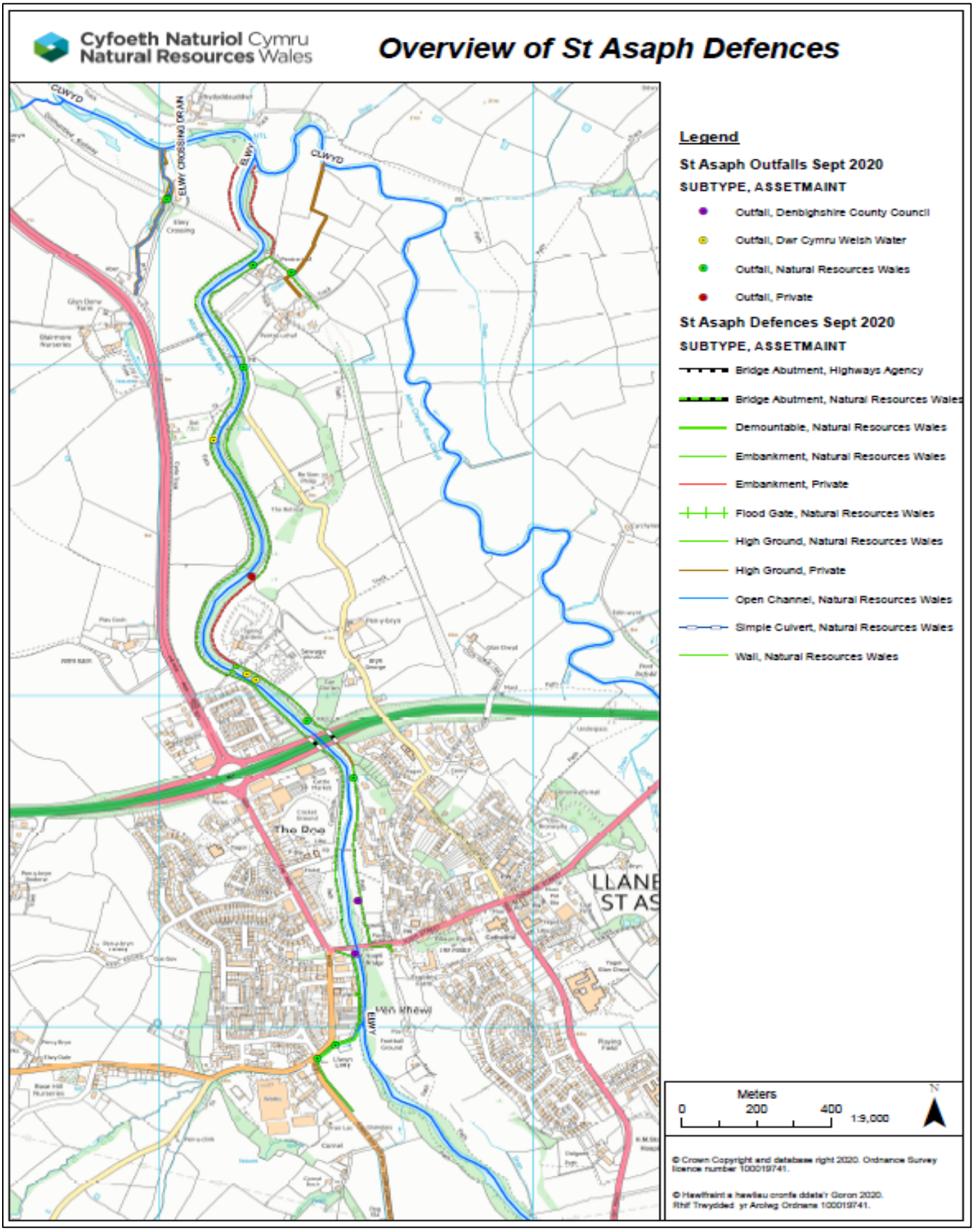
As part of the 2018 improvement scheme, significant lengths of defence wall were constructed along existing earth embankments. The majority of defences are earth embankments with a clay core, usually with either tarmac or gravel paths along the crest. All hard and soft Flood Defence Levels (FDL) are designed to contain the 0.5% AEP modelled water levels plus an inclusion of 300mm freeboard allowance. There are a number of outfalls present on both banks, along the full length of the Elwy which vary in maintainer between Dwr Cymru Welsh Water, Local Authority, NRW and private.

All raised defences in the St Asaph area are visually inspected on a 12-month schedule, various flood risk management assets in the mid and upper Elwy reaches are inspected at between 12- and 24-month schedules. All assets have a condition score allocated in reference to the 2012 Condition Assessment Manual (Figure 19). At the time of the February 2020 storm event the majority of flood risk management assets in the Elwy catchment were performing at or above their target condition.

Figure 19: Extract from CAM12 detailing condition scores (EA, 2012)

Grade	Rating	Description
1	Very Good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce the overall performance of the asset
3	Fair	Defects that could reduce performance of the asset
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation needed
5	Very Poor	Severe defects resulting in complete performance failure

Figure 20: Overview map of St Asaph flood defences



Further details on a sub-set of defences contained in the St Asaph flood risk management system and perceived to have been impacted by the storm event in February 2020, are included below (Figure 21). Further details on flood defence infrastructure in Wales can be found on the Lle Geo-Portal website here.

Figure 21: Visual inspection record 2019

Asset				Last Inspection			
AMX ID	Name	Description	Target Condition	Date	Current Condition	Comments	Recommendations
EMB1800067	St Asaph STW Embankment	Trapezoidal Clay Embankment tying into high ground.	3 - Fair	16/10/2019	2 - Good	Refurbished embankment with good grass cover, just been cut	Routine grass cut
EMB1800014	Glas Coed Stream Outfall	Top hung HDPE flap	3 - Fair	17/10/2019	1 - Very Good	New large plastic flap, new box culvert being put under the road	
WALL1500995	Roe Parc Wall	Sheet pile Reinforced Concrete flood wall with brickwork cladding and cast stone copings, butted joints. Full length is fenced, steel mesh at the southern end and timber feather board on the northern section.	3 - Fair	16/10/2019	1 - Very Good	Brick clad wall	
EMB1500412	Elwy Fisherman's Bridge Embankment	Trapezoidal Clay Embankment	3 - Fair	15/10/2019	2 - Good	Grass cover a bit long and could do with cutting	Cut the Embankment
EMB1501406	Elwy Mount Embankment	Trapezoidal Clay Embankment tying into high ground.	3 - Fair	15/10/2019	5 - Very Poor	Top 1/3 of the defence totally overgrown and a tree has fallen over the embankment, the other 2/3 is well maintained although some minor damage from horses and motorcycles, override condition of 5 as full inspection cant be done for the fourth time running	Shrub and tree clearance needed at the top end of the defence, then an accurate assessment of the embankment can be done

EMB1500412 Elwy Fishermans Bridge Embankment

The Elwy Fisherman's Bridge Embankment (Figure 22) was not raised during the scheme as modelling showed the crest levels were sufficient to contain the 0.5% AEP flood. At the time of the last inspection in October 2019 the embankment was in Good condition. Subsequent post-event (February 2020 & February 2021) and (May 2020) routine inspections record the embankment condition as Fair with comments "*is stable and only suffered minor erosion damage*".

Figure 22: Elwy Fishermans Bridge Embankment (NRW, 2019)

EMB1501406 Elwy Mount Embankment

The right bank embankments from high ground at Spring Gardens Caravan Park down to the fisherman's bridge were not raised during the 2018 St Asaph Scheme as they were deemed adequate to contain the design flood event. A short section of embankment just upstream and

downstream of the fisherman's bridge was raised to design standard using pre-cast concrete blocks as constrictions from the highway disallowed earth embankment widening and raising.

A short section of the embankment was in Very Poor condition during the October 2019 asset inspection due to excessive vegetation growth and motorcycle damage. NRW are currently working with landowners in the area to refurbish and maintain flood risk management assets to a good condition.

Figure 23: Elwy Mount Embankment (NRW, 2019)

WALL1500995 Roe Parc Wall

The Roe Parc section of raised defence (Figure 24) was formally a grass covered earth embankment. In 2012 extensive overtopping was observed along this section. The 2018 scheme significantly improved the standard of protection along this section by construction of a steel sheet pile wall with brick cladding. A vertical wall was favoured to the original earth embankment due to space availability. The wall was designed to contain the 0.5% AEP event.

Figure 24: Roe Parc Wall (NRW, 2019)

Figure 25: Roe Parc wall& embankment transition post-construction (NRW, 2018)

Post-event topographic survey completed by NRW confirmed that the as-built levels for Elwy left bank Roe Parc defences were within engineering tolerances for hard and soft defences (Figure 26).

Figure 26: Roe Parc as-built levels comparison (NRW, 2020)

Location Detail		Required level m AOD	As-built level m AOD
Roe Parc Wall	Upstream	13.98	14.11
	Downstream	13.35	13.50
Roe Parc embankment	Upstream	14.06	14.10
	Downstream	13.07	13.08

EMB1800067 St Asaph STW Embankment

During the 2018 St Asaph scheme the right bank of the Elwy at St Asaph sewage treatment works was raised by up to 400mm over its 175m length of original embankment. The landward face of the embankment was widened to accommodate the increased height and to facilitate future raising if required. The full length was surfaced with a 2.4m wide gravel path along the crest, although this does not form part of the FDL. The upstream end of the embankment ties into high ground at the A55 flyover with a finished ground level of 14.06m AOD which forms FDL for the 0.5% AEP event.

Figure 27: St Asaph STW Embankment Visual Inspection 2019 (NRW)

Post-event topographic survey completed by NRW confirmed that the as-built levels for Elwy right bank sewage treatment works defences were within engineering tolerances for hard and soft defences (Figure 28). There was a short length, less than 5m which was approximately 100mm lower than the design crest level.

Figure 28: Elwy STW as-built levels comparison (NRW, 2020)

Location Detail		Required level m AOD	As-built level m AOD
St Asaph STW Embankment	Upstream	14.06	14.08
	Downstream	13.07	12.97

OUTFALL1800014 Glas Coed Stream Outfall

The Glascoed Stream upstream of the Lower Denbigh Road bridge is an ordinary watercourse, downstream of the road bridge is designated main river and within the Afon Elwy floodplain. As part of the 2018 St Asaph scheme the first section of concrete culvert was placed, and a concrete headwall was cast into the wall to hold a non-return flap (Figure 29). The non-return flap stops water from the Afon Elwy flowing up the Glascoed Stream which otherwise would potentially causing flooding to properties along Glascoed Road. At a later date, circa autumn October 2019, Denbighshire County Council undertook refurbishment of the road bridge by continuing placement of concrete culvert sections.

Figure 29: Glascoed Stream non-return flap (NRW, 2019)

6. Event Observations & Flow Routes

The mapped flood extents and flow routes shown in the figures below are derived from a number of different sources including;

- Onsite visits,
- Discussions with residents,
- Social media content which can be verified,
- Photographic evidence provided by residents,
- Log sheets from duty officers,
- NRWs incident reporting system.

Main rivers are usually larger streams and rivers but also include some smaller watercourses, which in Wales, are legally designated by Natural Resources Wales. In the majority of areas, NRW does not own the river or surrounding land but has permissive powers to consent and undertake works on main rivers to manage flood risk. This includes any structure or appliance for controlling or regulating the flow of water in, into or out of a main river. A map of all designated main rivers in Wales can be found on the Lle Geo-Portal website at: https://lle.gov.wales/catalogue/item/MainRivers/?lang=en

All other watercourses not designated main river are referred to as ordinary watercourses for which the local authority has similar powers to consent and undertake works. Again, the local authority are not generally the watercourse owner for ordinary watercourses. Further information on watercourse responsibility can be found in A guide to your rights and responsibilities of riverside ownership in Wales.

All the maps included below utilise a consistent colour scheme (Figure 30);

- **Light blue** flood extents are primarily derived from designated **main river**,
- **Light yellow** flood extents are primarily derived from **ordinary watercourse**,
- **Solid blue** lines signify the approximate route of a designated **main river**,
- Coloured lines show observed flood mechanisms,
- **Red circles** denote affected property, either residential or commercial.

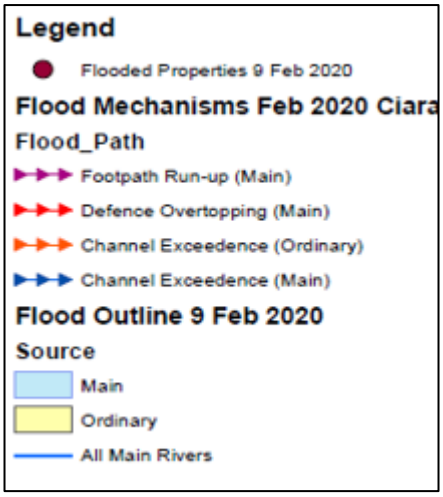


Figure 30: Generic legend for maps

Lower St Asaph Community

Initial reports from NRW operatives on site stated that flooding began to occur just downstream of Spring Gardens Bridge on the left bank (See Figure 34, Figure 35& Figure 36), but based on observed water levels (Figure 31) it is possible other areas of raised defence in the lower reaches (downstream of Spring Gardens Caravan Park) of the Elwy started to overtop before this. Multiple sources later confirmed that during the event significant lengths of the Elwy Fishermans Bridge Embankment (EMB1500412) experienced overtopping, >200mm for approximately 1.5 hours (see Figure 32 & Figure 33 below).

Figure 31: Afon Elwy levels looking D/S from SGB (NRW, 2020)

Figure 32: Extensive embankment overtopping at Dol Afon (Elwy resident, 2020)

Figure 33: Extensive embankment overtopping at Dol Afon (Elwy resident, 2020)

Figure 34: Phase 2 - Reducing overtopping at EMB1500412 (NRW 2020)

Figure 35: Phase 1 - Extensive overtopping at EMB1500412 (NRW 2020)

Figure 36: Phase 3 – Minimal overtopping at EMB1500412 (NRW 2020)

Local residents have regularly observed surcharging of the storm overflow chamber located on the left bank downstream of Spring Gardens Caravan Park, when the outfall is closed by high river levels. Although this was not observed to be the primary mechanism of flooding to Lower St Asaph, surcharging did contribute to flood depths and anecdotal evidence suggests poor quality water was discharged for a significant period of time. The outfall is maintained by DCWW but no further technical details are available to NRW at present.

The surcharging of the DCWW chamber was again observed in November 2020 during the rainfall brought to North Wales by the remnants of Hurricane Zeta. Details of the surcharging were passed to DCWW at the time, DCWW confirmed they had visited site and will undertake an internal condition and asset survey at a later date.

Recommendation 1.1 - DCWW – Review performance of the underground system in the Lower St Asaph area.

The right embankment, Elwy Mount Embankment (EMB1501406) was also overtopped (see Figure 38, Figure 37 & Figure 39) but it is unclear to what extent and for what time period this occurred. The property known as “The Retreat” was reported as flooded internally. Other residential properties were not reported as flooded internally but all residents of the Mount would have experienced significant impacts due to the single access road flooding to a significant depth.

Recommendation 1.2 – NRW – Work with the landowners of Elwy Mount embankment to restore the flood risk management asset back to good condition.

Figure 37: Wrack & debris deposits signifying overtopping location (NRW, 2020)

Figure 38: Wrack & debris deposits showing line of overtopping (NRW, 2020)

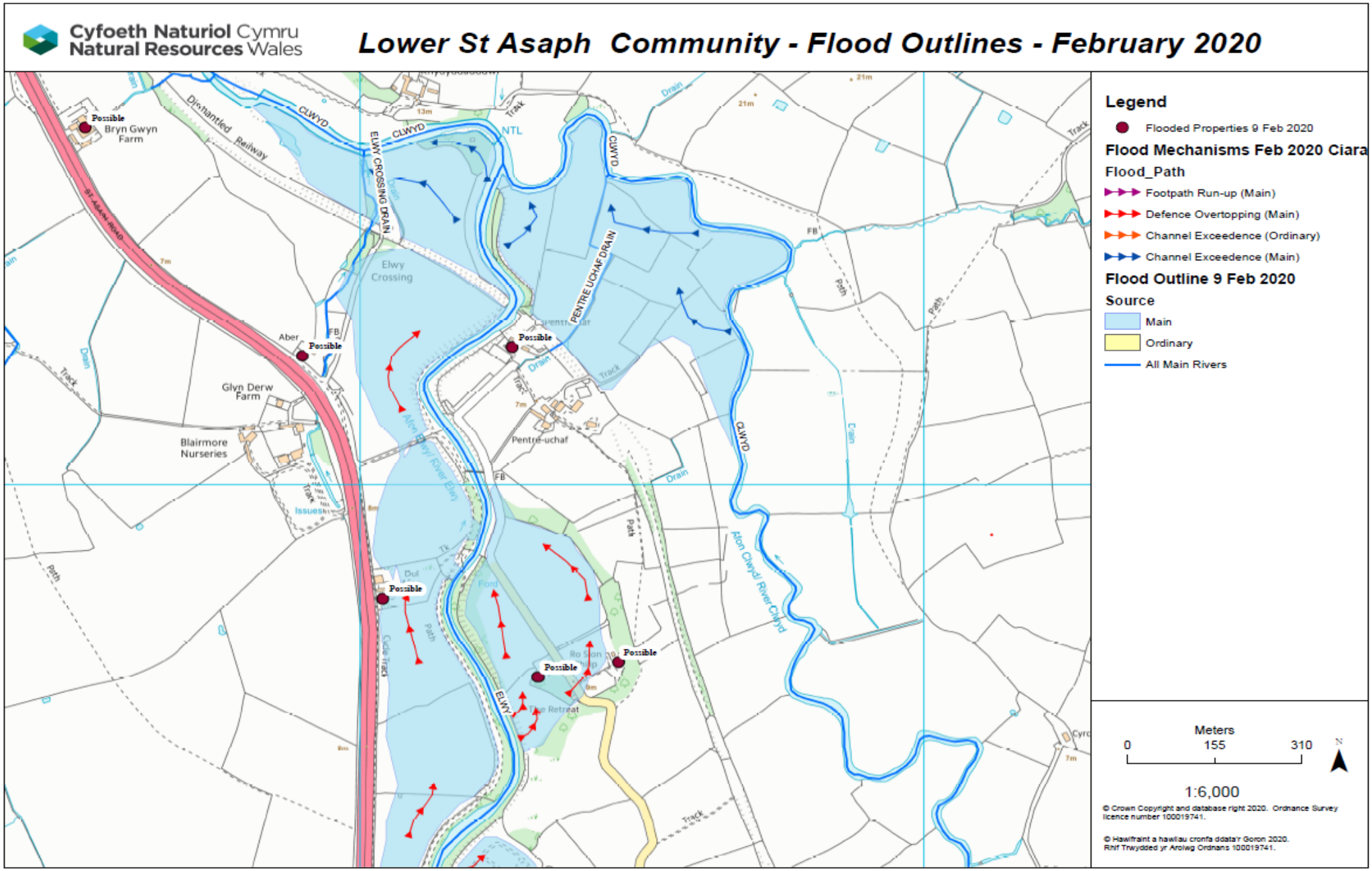
Figure 39: Wrack & debris deposits on the riverside face (NRW, 2020)

During a flood event lots of information is received by risk management authorities (Local authorities, NRW, Fire & Rescue service etc.); information is prioritised and acted on where individual organisation and multi-agency priority dictates. It is often highlighted in post-event investigations that anecdotal evidence received during an event is very difficult to validate due to geographical anomalies, communication issues and inaccurate information. Photographs are an extremely useful tool for post-flood validation and risk management authorities should strive to record and catalogue associated information.

Recommendation 1.3 – NRW – All photos taken during formal NRW duties (inspection, maintenance, incident response etc.) should be time and date stamped.

The primary mechanism of flooding in the Lower St Asaph Community is deemed to be main river flooding as a result of river levels exceeding the standard of protection of earth embankment flood defences due to significant rainfall events impacting the catchment.

Figure 40: Lower St Asaph community flood mechanisms - Feb 2020



St Asaph Community - Right bank

Significant overtopping, between 100-150mm over 150m for approximately 1.0 hour was observed on the right bank St Asaph STW Embankment (EMB1800067). A private residential dwelling (Figure 41) and 3 static caravans were inundated by flood water in the Spring Gardens Caravan Park (Figure 42). Significant amounts of water which overtopped the right bank flowed through the sewage treatment works, following the topography and filling the land of Spring Gardens Caravan Park. As the overtopping water could not exit the caravan park because of downstream embankments, depths within the park rose considerably. Although there is a small, privately owned pumping station on-site to drain surface water, there is no permanent infrastructure on site to evacuate the volume of water observed.

Figure 41: Residential property flooded on Elwy RB (NRW, 2020)

Figure 42: Spring Gardens Caravan Park flooding (NRW, 2020)

Figure 43: Spring Gardens Caravan Park flooding (NRW, 2020)

Initial investigations into the factors which caused the overtopping at this location pointed to the main reason being channel exceedance (Figure 44) due to a significant storm event affecting the upper catchment. It is probable that hydraulic afflux (localised raising of water levels) occurred in the immediate vicinity of the STW embankment due to the dense, mature trees on the riverbank berm. Water levels may also have increased locally due to super elevation caused by the volume of water passing around a slight bend in the river channel at this location. A build-up of debris in the channel profile impacting available cross-sectional area and reducing conveyance efficiency may also have exacerbated water levels but it is difficult to ascertain the full impact due to the high debris loading already in the system during high flow events.

Figure 44: Elwy river levels 09-02-2020 (NRW, 2020)

Recommendation 2.1 – NRW – Undertake a performance review for the 2018 St Asaph Flood Risk Management scheme.

Recommendation 2.2 – NRW – Using the hydraulic model, investigate the flow mechanisms and sensitivity of various parameters which may be impacting water levels at St Asaph STW Embankment.

Overtopping of the St Asaph STW Embankment started after the defences in Lower St Asaph had been overtopping for a period of time (Figure 45). During the post-event topographic survey, a low spot (approx. 100mm) was identified over a short length, less than 5m, of the right bank. Information and photographs obtained through the subsequent investigation have found evidence to show that overtopping occurred along a significant length of the right bank (Figure 46). Although observed to be extensive and prolonged, the overtopping was not deemed to pose a significant risk of defence failure during the event based on age, build quality and current condition. Post-event asset inspections (Figure 49) confirmed that the embankment structure had performed well under considerable hydraulic and debris loading.

Figure 45: Water levels looking u/s from SGB (Resident photo)

Figure 46: Overtopping of RB EMB1800067 (Resident Photo)

Figure 47: Localised scour caused by overtopping at the discrete low spot (NRW, 2020)

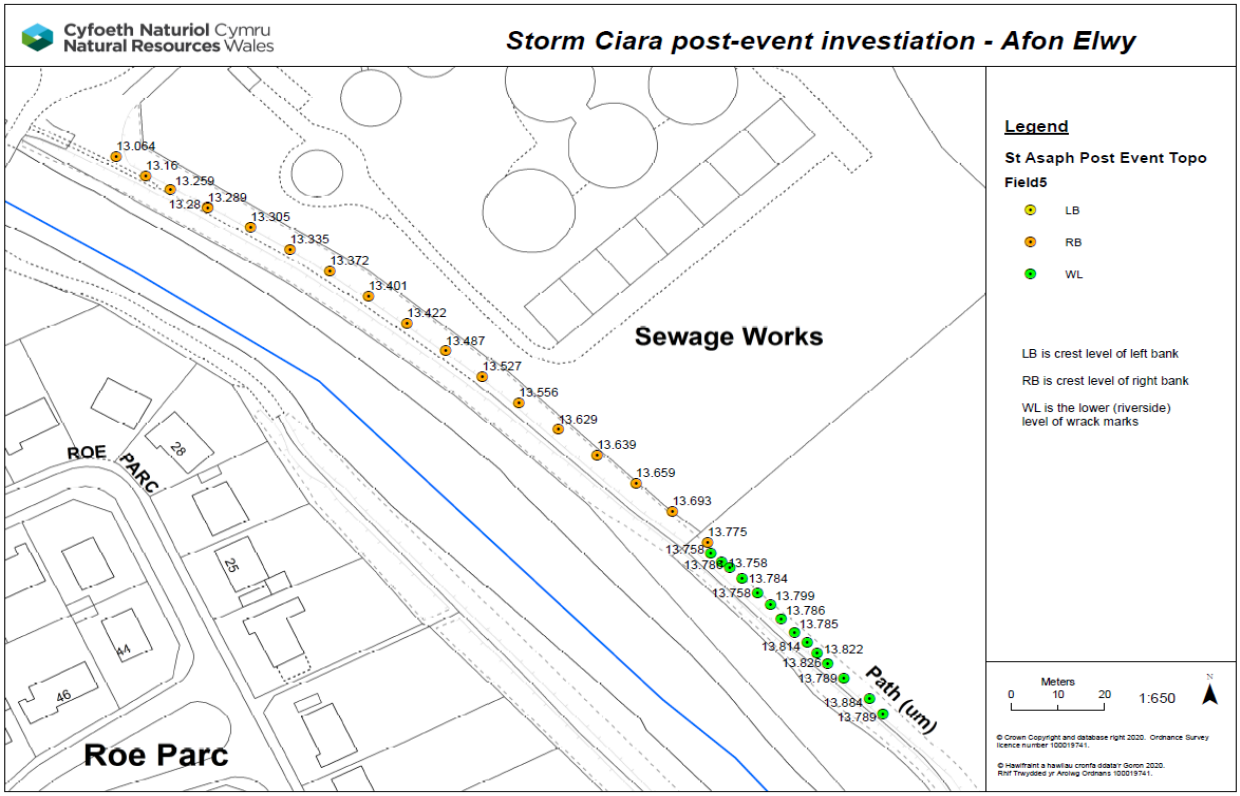
Figure 48: Line of wrack on RB STW emb (NRW, 2020)

There was one area of minor scour (Figure 47), later observed to be in the approximate location of the low spot. The scour observed only at this specific location and not on the embankments is likely due to a concentrated flow route, turbulence caused at the base of the hedge and lack of grass revetment.

Figure 49: Post Event Inspection RB EMB1800067 (NRW, 2020)

Investigations and survey collected in the days after the event found a number of wrack (flood debris) marks, silt lines and flattened vegetation which allows for anecdotal evidence obtained during the event to be validated. Wrack marks on the right bank show a clear line at which overtopping occurred (Figure 48). Post-event topographic survey showed that overtopping started at approximately 13.693m AOD on the right bank (Figure 50). The map shows green dots where wrack was deposited on the riverside slope or crest of the embankment and orange dots are embankment crest levels at which overtopping was confirmed to have occurred.

Figure 50: Post-event topographic survey (NRW, 2020)



Completion of full topographic survey undertaken for NRW by an external contractor, allowed for validation of the post-event topographic survey (Figure 51) and the assumptions derived from it. This further investigation highlighted possible deficiencies in the finished crest level of the Elwy right bank embankment. The design crest level is 14.06m AOD just downstream of the A55, a section through the down ramp has a design FDL of 13.95m AOD plus 100mm topsoil and a section at the DCWW headwall has a design FDL of 13.80m AOD plus 100mm topsoil. The design crest level at the downstream extent of defence is 13.07m AOD.

Figure 51: Elwy St Asaph STW embankment as-built levels comparison (NRW, 2020)

St Asaph STW Emb					
Section Name	Design FDL (m AOD)	Finished Ground Level (FGL) (m AOD)	As-built level (m AOD) *(analysis undertaken at nearest collected point)*		Difference between FDL & As-built (m)
			Post-event wrack survey	Post-event topo survey	
Upstream	14.06	14.06	No data	14.08	0.02
T-T	13.95	14.05	No data	13.83	-0.22
U-U	13.80	13.90	13.63	13.64	-0.26
Downstream	13.07	13.07	13.06	12.97	-0.10

Standard flood risk management design procedure incorporates an allowance into all hard and soft defences to account for modelling, hydrology and engineering uncertainties, this is known as freeboard. In the St Asaph scheme, freeboard allowance is included as an increase of 300mm height onto the modelled design height of all hard and soft defences. Although the right bank defences are within engineering tolerance there is a section along it which has lower than 300mm freeboard incorporated into the as-built level.

Failure of the St Asaph river level gauge during the event caused difficulties for duty staff within incident rooms. The significant benefits of having trained and competent operational staff and flood wardens on site during an event are highlighted by this incident. More robust monitoring equipment or locally available resource on site to relay information to duty offices should be considered.

Recommendation 2.3 - NRW – Consider the current incident response plans and address the resource & resilience shortfalls during such events.

The primary mechanism of flooding of the right bank communities in St Asaph Community is deemed to be main river flooding as a result of river levels exceeding the standard of protection of earth embankment flood defences due to significant rainfall events impacting the catchment. There are possibly other hydraulic mechanisms which caused raised water levels locally but these are very difficult to predict and quantify by both computational modelling and post event analysis.

St Asaph Community – Left bank

Properties in Roe Parc on the left bank of the Elwy were not flooded but minor overtopping of earth embankments was observed at two locations. Full topographic survey of defences (Figure 52) confirmed that all Roe Parc defences are at or above required FDL but some short sections have inconsistent freeboard allocation.

Figure 52: Elwy St Asaph Roe Parc embankment as-built levels comparison (NRW, 2020)

Roe Parc Defences				
Section Name	Design FDL (m AOD)	Finished Ground Level (FGL) (m AOD)	As-built level (m AOD) *(analysis undertaken at nearest collected point)*		Difference between FDL & As-built (m)
			Post-event wrack survey	Post-event topo survey	
Upstream Emb A55 (L1)	14.03	14.03	13.98	14.12	0.09
Upstream Emb Ramp (L2)	13.98	14.08	13.83	14.10	0.02
Roe Parc Wall Middle (LL)	13.90	14.08	No data	14.03	-0.04
Roe Parc Wall D/S (MM)	13.70	13.88	No data	13.82	-0.05
Downstream Emb	13.07	13.07	No data	13.08	0.01

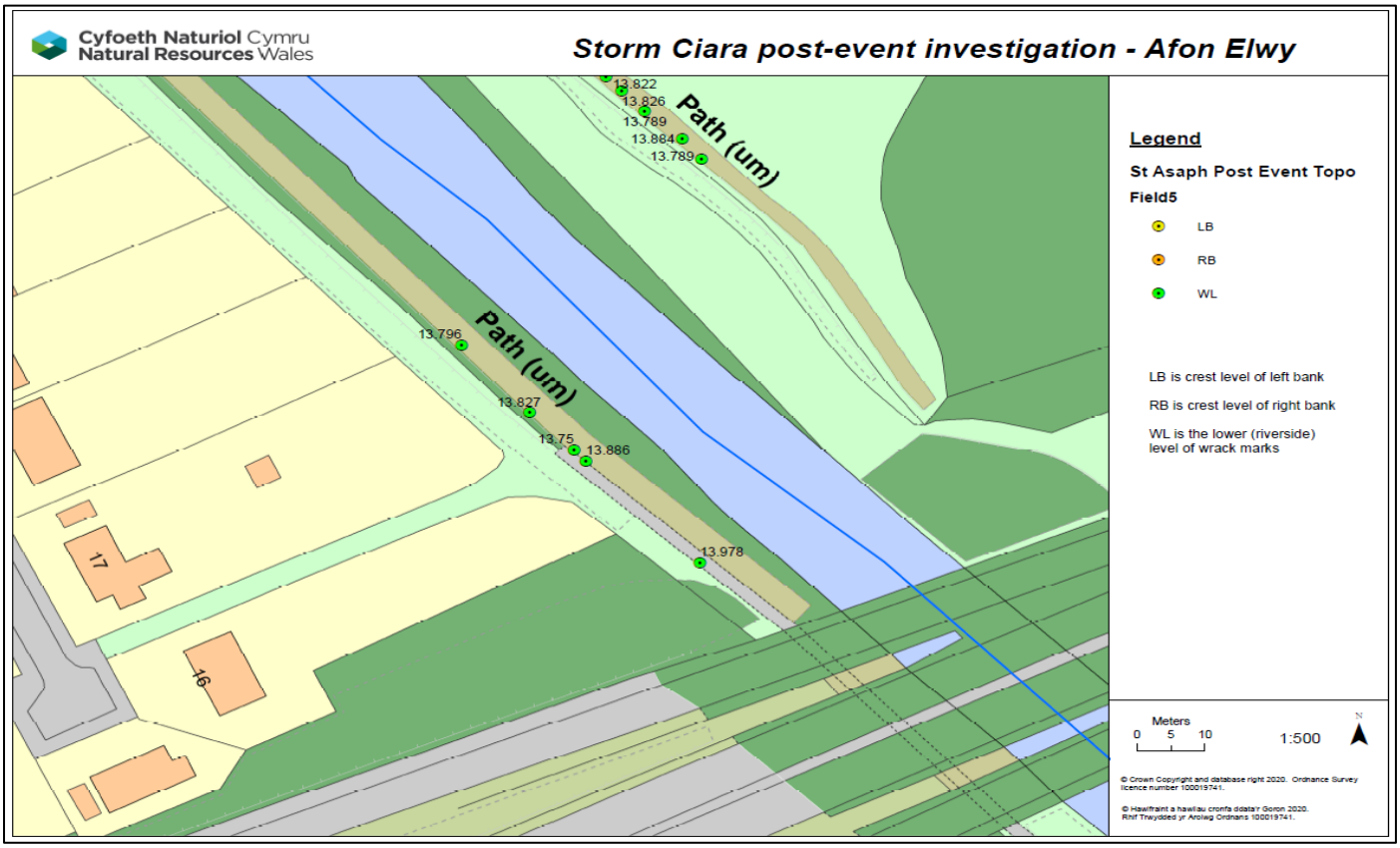
Water levels on the left bank (Figure 56) just downstream of the A55 flyover reached 13.978m AOD as the velocity of water pushed up the smooth surface of the tarmac footpath. Water levels on the left bank at the upstream end of Roe Parc Wall reached 13.886m AOD. Residents deployed sandbags (Figure 53) to stop water being pushed up the tarmac path and over the bank towards Roe Parc. Based on evidence provided by residents and flood wardens and validated by post-event survey, it is unlikely that river levels (Figure 54) would have overtopped the Roe Parc embankment just downstream of the A55 bridge.

Figure 53: Sandbags placed at Roe Parc by residents looking downstream (NRW, 2020)

Figure 54: Water levels at u/s end of Roe Parc Wall (Resident photo)

Figure 55: Sandbags placed at Roe Parc by residents looking upstream (Resident photo, 2020)

Figure 56: Left bank recorded wrack marks (NRW, 2020)



A Roe Parc resident estimated overtopping at the downstream end of Roe Parc Wall started when the manual river gauge located on the A55 bridge was reading 4.6m. Post-event investigation showed that overtopping started downstream of Spring Garden Bridge and was later observed to be pushing up smooth surfaces causing minor overtopping at Roe Parc when the manual river gauge was reading circa 4.8m. The photo below (Figure 58) was taken at the height of the flood when the manual river gauge under the A55 bridge was reading 4.9 metres. Overtopping was observed to be minimal before residents deployed sandbags (Figure 57). The role of flood wardens is highly valued and this incident shows the resilience provided by their presence on site but health, safety and wellbeing must be priority during potentially hazardous situations.

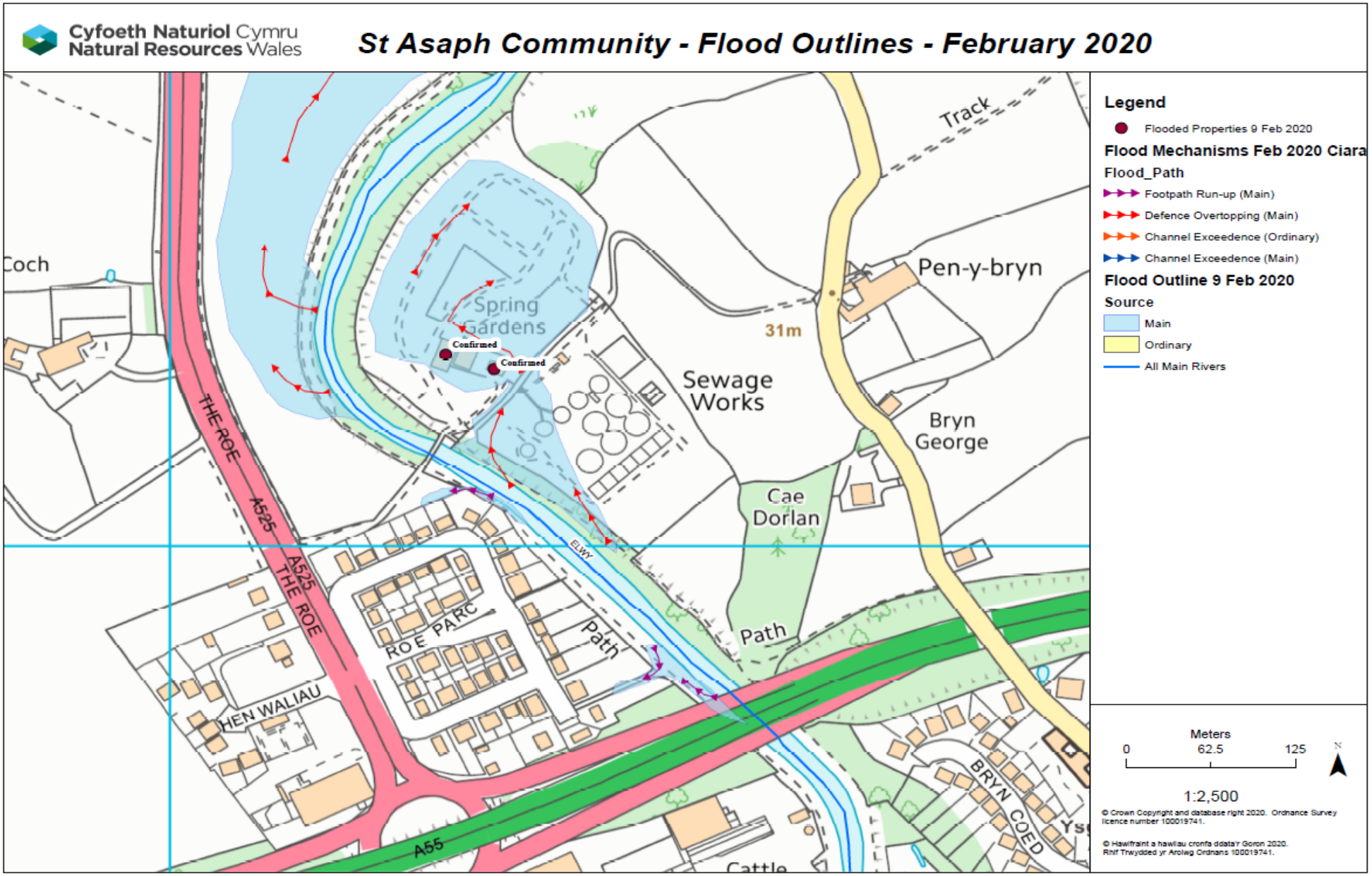
Figure 57: Sandbags placed at Roe Parc wall by residents (NRW, 2020)

Figure 58: River levels looking upstream from Spring Gardens Bridge (Source: Roe Parc Resident)

Recommendation 3.1 – NRW – Review policy and procedure regarding the roles and responsibilities of flood wardens both in an incident and during normal working times.

The primary mechanism causing overtopping of the left bank of the Elwy in St Asaph Community is deemed to be main river water levels exceeding the standard of protection of flood defences due to a significant rainfall event impacting the catchment.

Figure 59: St Asaph community flood mechanisms - Feb 2020



Glascoed Stream Community

The residential and light industrial area adjacent to the roundabout between Lower Denbigh Road and Glascoed Road was significantly impacted by water from multiple locations during the Storm Ciara, February 2020 event. Multiple sources; high water levels in the main river and ordinary watercourse, overland flow from agricultural land and exceedance of surface water drainage systems were all observed mechanisms. A number of residential properties were impacted, and four residential properties and three commercial properties were confirmed to have flooded internally.

Water levels in the Glascoed Stream were observed to be high early in the event and residents reported that debris was cleared and the stream was flowing freely, although it is not known what debris consisted of and who cleared it. When the Elwy rose and the non-return flap closed, the Glascoed Stream started to back up and eventually spilt out of left bank onto Glascoed Road. There was also water observed to be running overland off the agricultural land at the back of the former Honeywell factory, impacting residential and commercial property and flooding the Lower Denbigh Road and Glascoed Road.

Water flowed over the left bank of Glascoed stream and spread across the road impacting highways and properties and flooding one residential property internally. The water continued to flow down the B5381, over the ramp and into the New Inn car park where depths increased (Figure 60) due to the Elwy embankments not allowing water back into the river. The Oaks residential property was flooded internally to approximately 50-100mm. The lower, uninhabited floors of the New Inn Public House were inundated from floodwaters which flowed down the road from Glascoed Stream causing damage to appliances and stock. The lower floors of the gym building were inundated but the depth of water and extent of damage is unknown at the time of writing.

The Glascoed Stream road culvert has an access chamber installed in the first pre-cast unit, which is designed to allow operatives to enter the culvert should blockage removal or internal inspection be required. Incorporation of the access chamber also provides opportunity for over-pumping to dry the culvert if internal works are required. The access chamber is not designed to

accommodate high volume pumps during storm conditions. Considering the large volumes of water conveyed by the culvert during flood conditions, pumping water out of the culvert, over the flood wall and into the Afon Elwy is not a viable option.

Figure 60: Water accumulation behind embankment at New Inn (NRW, 2020)

Post event inspection of the Glascoed Stream by representatives of NRW and DCC highlighted the high-water levels (Figure 63). During the event residents utilised available material to divert flood water away from property and into road gulleys and surface water systems (Figure 61 & Figure 62).

Figure 61: Residents diverting flood waters from Llwyn Elwy during Storm Ciara (Resident Photo, 2020)

Figure 62: Residents diverting flood waters on Lower Denbigh Road during Storm Ciara (Resident Photo, 2020)

Figure 63: Silt mark Glascoed Stream (NRW, 2020)

Previous flood investigation reports show that properties in Caradoc Terrace, Ruby Terrace and The Roe were impacted by floods in 2012 and 2017. It is understood that on multiple occasions during February 2020 many residential properties in Caradoc Terrace, Hoel Esgob and Tan Y Bryn were again impacted by flooding to varying extents caused by overland flow from agricultural land and surcharging of highway drainage.

This flood investigation report is compiled by NRW to cover main river impacts, details of impacts from non-main river have been passed to the relevant authorities for further investigation should they deem it necessary.

At some time during the event, unauthorised opening of the flap valve took place (Figure 64), and although water levels within the Glascoed Stream were high, backflow from the Afon Elwy would have exacerbated the situation. It must be understood that flood defence assets are designed to a specification with strict operating regimes, and any unauthorised operation of such assets can be extremely detrimental to people, property and infrastructure and potentially life threatening.

Figure 64: Unauthorised opening of non-return valve (NRW, 2020)

If you have concerns about flood defences please contact Natural Resources Wales:

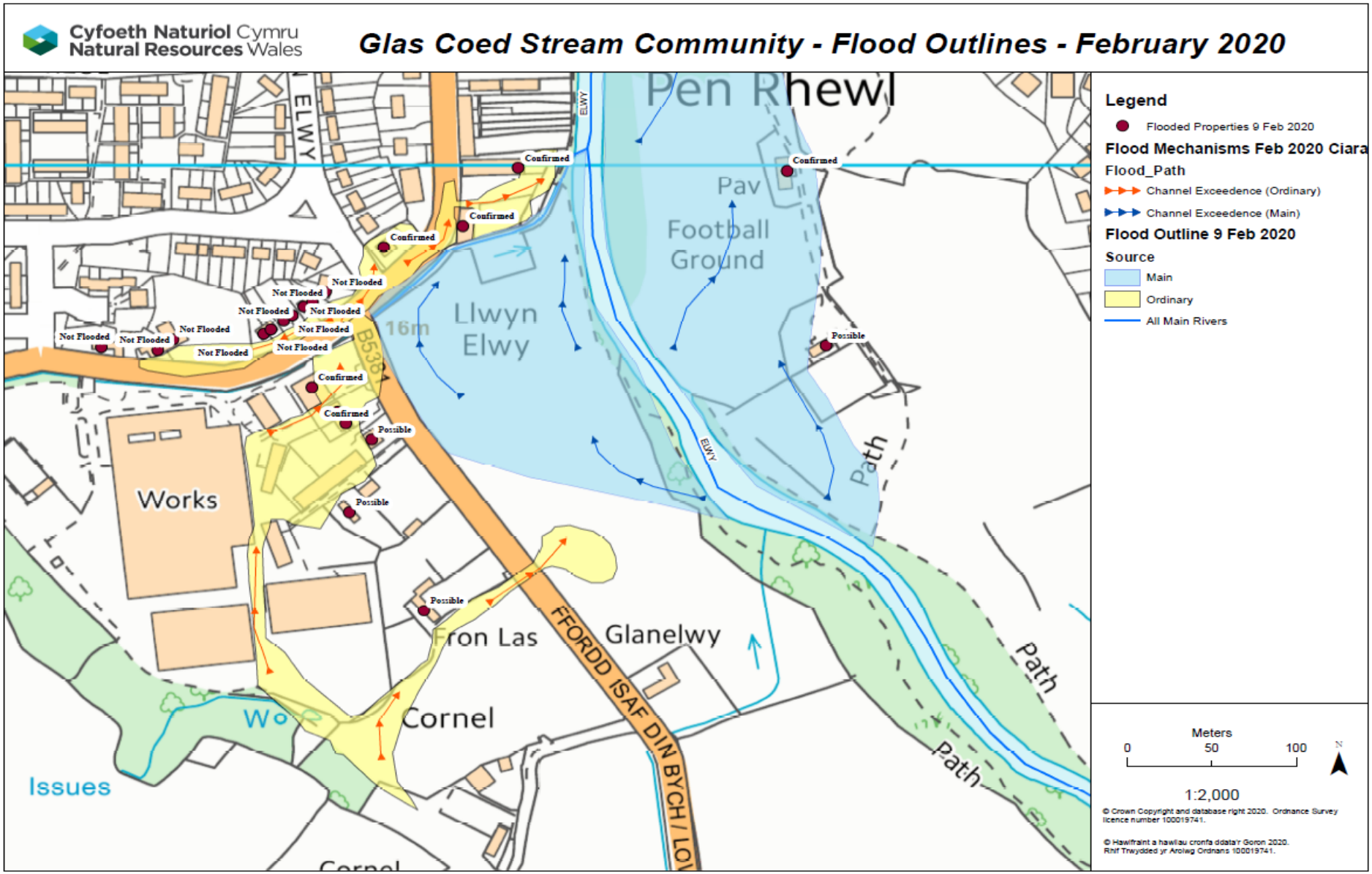
For incidents 24 hours day - 0300 065 3000
Or for general enquiries email - enquiries@naturalresourceswales.gov.uk

Recommendation 4.1 – NRW – Model the effects of non-return flap operation on water levels in the Glascoed Stream.

Recommendation 4.2 – DCC – Undertake a Flood Investigation Report for all non-main river flooding in the St Asaph and Glascoed Communities.

There were multiple flooding mechanisms which impacted and flooded property and infrastructure in the Glascoed Stream area. The Afon Elwy main river back flowed up the Glascoed Stream due to unauthorised opening of the non-return flap. The Glascoed Stream ordinary watercourse exceeded channel capacity and spilt out of left bank immediately upstream of the road culvert. Multiple properties were also impacted by overland flow from agricultural land and surcharging of highway drainage caused by a significant rainfall event impacting the catchment and local area.

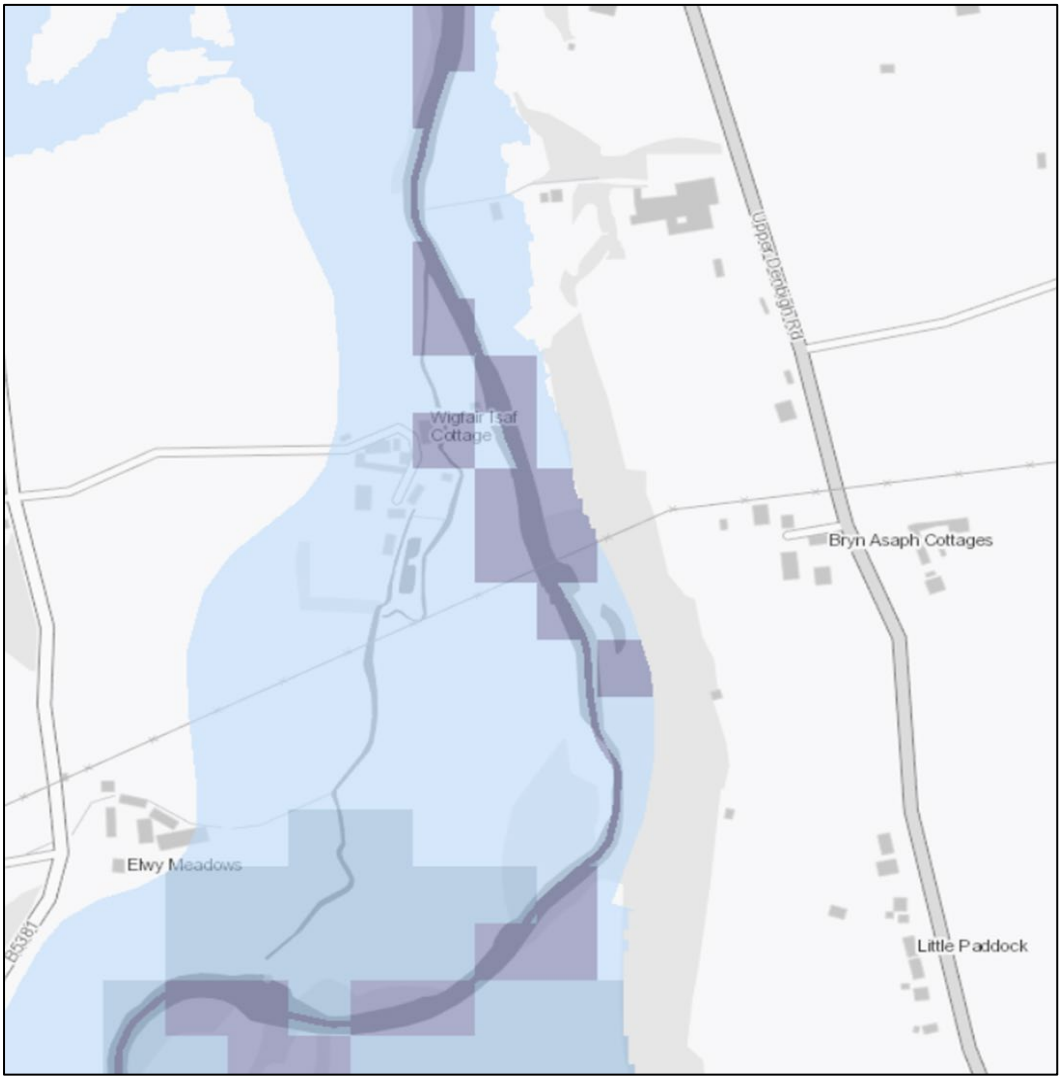
Figure 65: Glas Coed community flood mechanisms - Feb 2020



Wigfair Isaf Community

The Wigfair community has been impacted by high river levels historically but NRW hold no reports of confirmed internal flooding. A garage located in the grounds of Wigfair Fach was flooded to about 100mm depth and water got close to entering the back-patio door of the main house, but floor levels are raised by approximately 200mm above surrounding ground. As no internal flooding has been observed in this event and multiple previous high flow events it is possible the published flood map is overestimating extents in this area (Figure 66).

Figure 66: Extract from the published flood map covering Wigfair Community (NRW, 2020a)



Recommendation 5.1 – NRW – Review the published flood map data for Wigfair Isaf Community.

The primary mechanism of flooding in Wigfair Isaf Community is deemed to be main river inundation of the floodplain as a result of river levels exceeding the level of natural riverbanks in the area.

Figure 67: Wigfair Isaf community flood mechanisms - Feb 2020

Cyfoeth Naturiol Cymru
Natural Resources Wales

Wigfair Isaf Community - Flood Outlines - February 2020

Legend

Flooded Properties 9 Feb 2020

Flood Mechanisms Feb 2020 Ciara

Flood_Path

Channel Exceedence (Main)

Flood Outline 9 Feb 2020

Source

Main

Ordinary

All Main Rivers

Meters

0 50 100

N

1:2,000

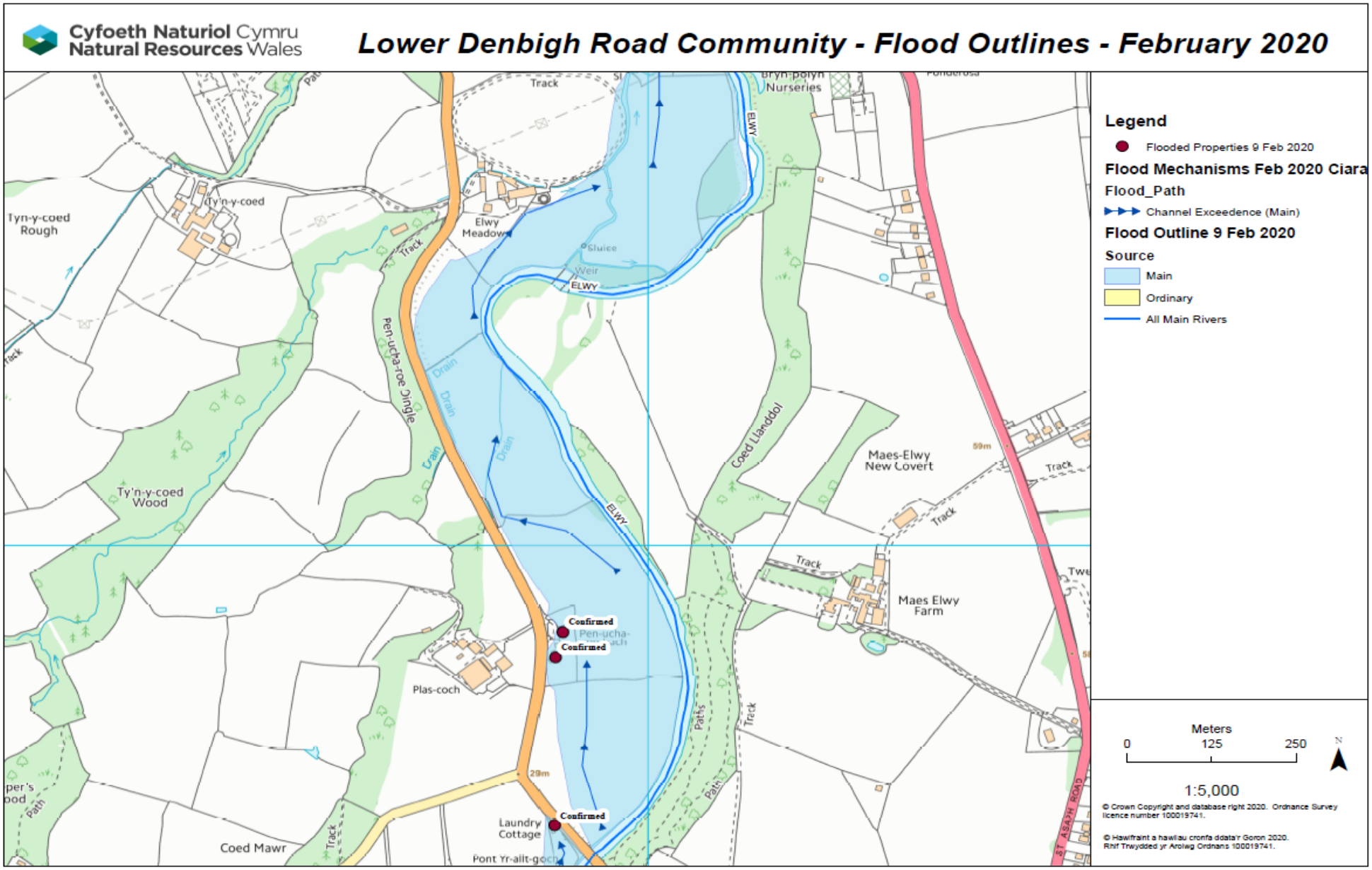
Lower Denbigh Road Community

Various properties along the Lower Denbigh Road have historically been impacted by high river levels with at least two documented events (2012 & 2015) impacting property to varied degrees. After the 2012 event a small bund was constructed around the south of Pen Ucha Roe to divert floodplain water away from residential property, although the bund was not designed to contain events of the magnitude of Storm Ciara. The properties were visited during post-event investigations, but contact could not be made. The presence of sandbags at Pen Ucha Roe was noted but, other than this, there was no other Property Level Protection (PLP) present at the dwelling and it was unclear as to the extent of internal flooding. Later communications confirmed that the property was impacted but implementation of Property Level Resilience (PLR) in the form of tiled floors after previous events had confined the damage to domestic appliances only.

Recommendation 6.1 – NRW – Provide advice on Property Level Protection and Property Level Resilience measures for residential property in affected communities in the upper and middle reaches of the Afon Elwy catchment which do not benefit from a defence scheme.

The primary mechanism of flooding at Lower Denbigh Road Community is deemed to be main river inundation of the floodplain as a result of river levels exceeding the level of natural riverbanks in the area.

Figure 68: Lower Denbigh Road community flood mechanisms - Feb 2020



Chapel Wood Community

Laundry Cottage is located just upstream of the B5381 road bridge over the Afon Elwy and does have a history of flooding. During the February 2020 event Laundry Cottage was unfortunately flooding internally to a significant depth. The residential property at Glan Llyn did not flood internally during the event but the grounds were significantly affected by erosion (Figure 69). The residential property located at Glan Llyn farm was not flooded internally during the event but river levels did come close to outbuildings and affected agricultural land and crops.

Figure 69: Erosion to private garden, showing historic riverbank revetment (NRW, 2020)

Dolbelydr was not visited after the flood but it is possible that the property was impacted by high river levels as the property is shown in the flood map outline. There is also a history of flooding detailed in the 2012 Denbighshire County Council Flood Investigation Report, when the property flooded internally to approximately 50mm but only causing minor damage to the interior.

The Elwy at Mill Cottage community has a wide floodplain contained on the left bank by high ground, flood depths through this section can be significant (Figure 70). There are four residential properties at Mill cottages, all having slightly different floor levels due to historic construction of the building and later conversion to residential use. All properties were close to inundation but unaffected by overland flow. Lower rooms in some properties were observed to have ground water rising through tile or slate floors but depths were observed to be shallow and impacts minimal.

Figure 70: Wrack mark on gate showing height of flood (NRW, 2020)

Recommendation 6.1 is also applicable to this community.

The impacts on Chapel Wood Community are deemed to be main river inundation of the natural floodplain and groundwater impacts due to a rise in the water table caused by high river levels and underlying strata.

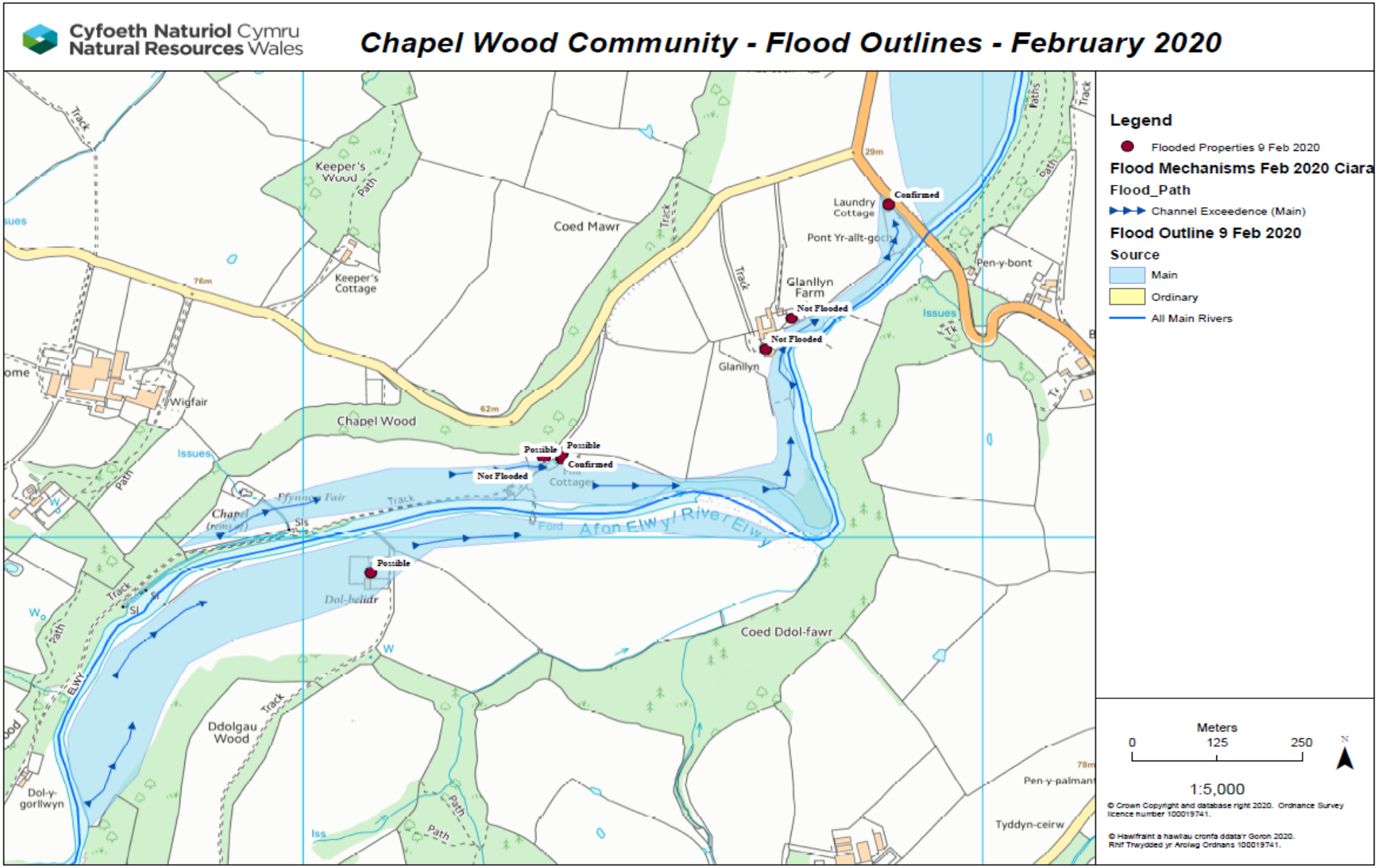
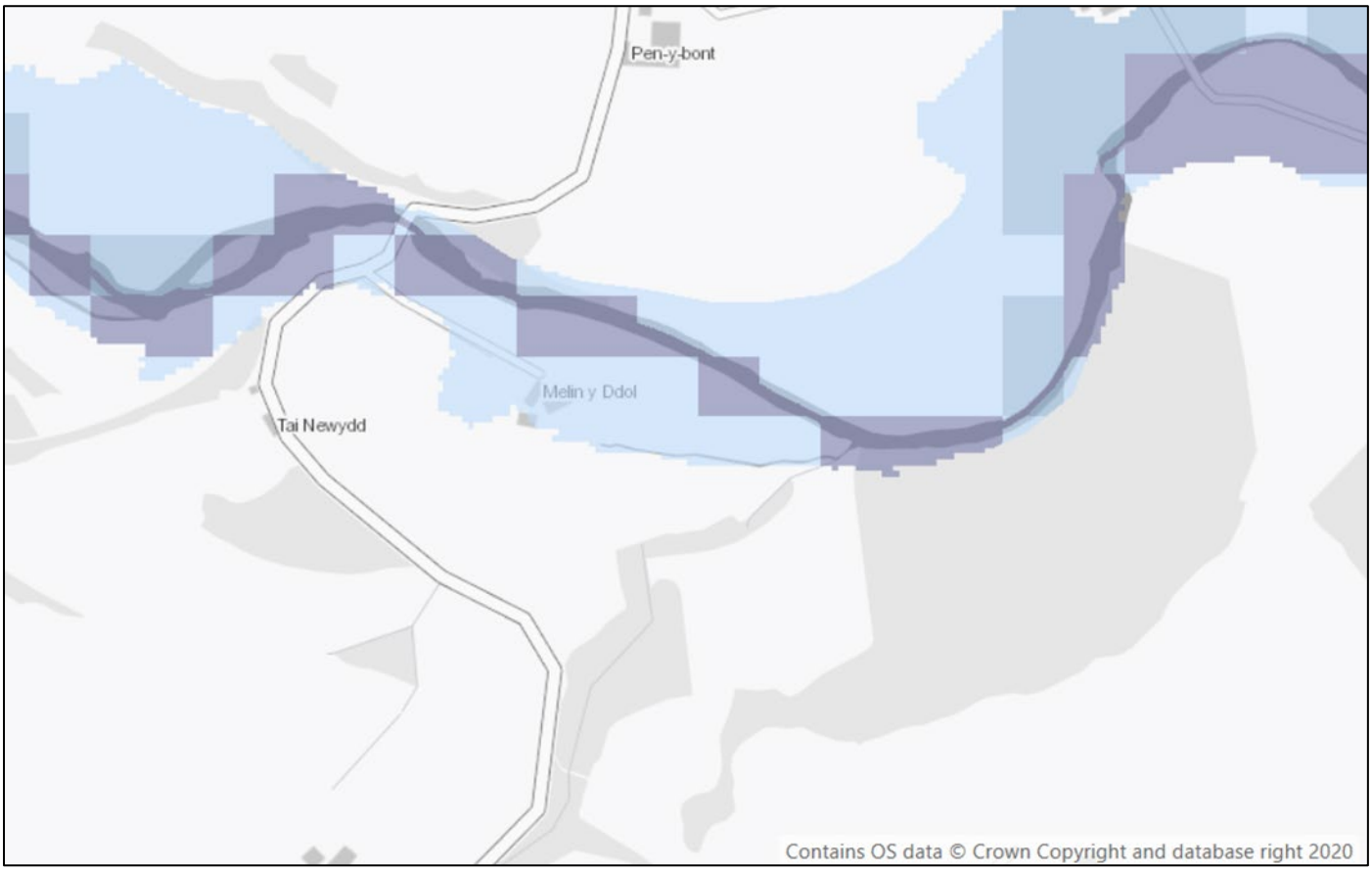


Figure 71: Chapel Wood community flood mechanisms - Feb 2020

Pont Y Ddol Community

Pont Y Ddol was not visited after the flood but it is possible that the property known as Melin Y Ddol was impacted by high river levels as the property is shown in the flood map outline (Figure 72).

Figure 72: Extract from the published flood map (NRW, 2020a)



Recommendation 6.1 is also applicable to this community.

The impacts on Pont Y Ddol Wood Community are deemed to be main river inundation of the natural floodplain caused by a significant rainfall event centred over the catchment.

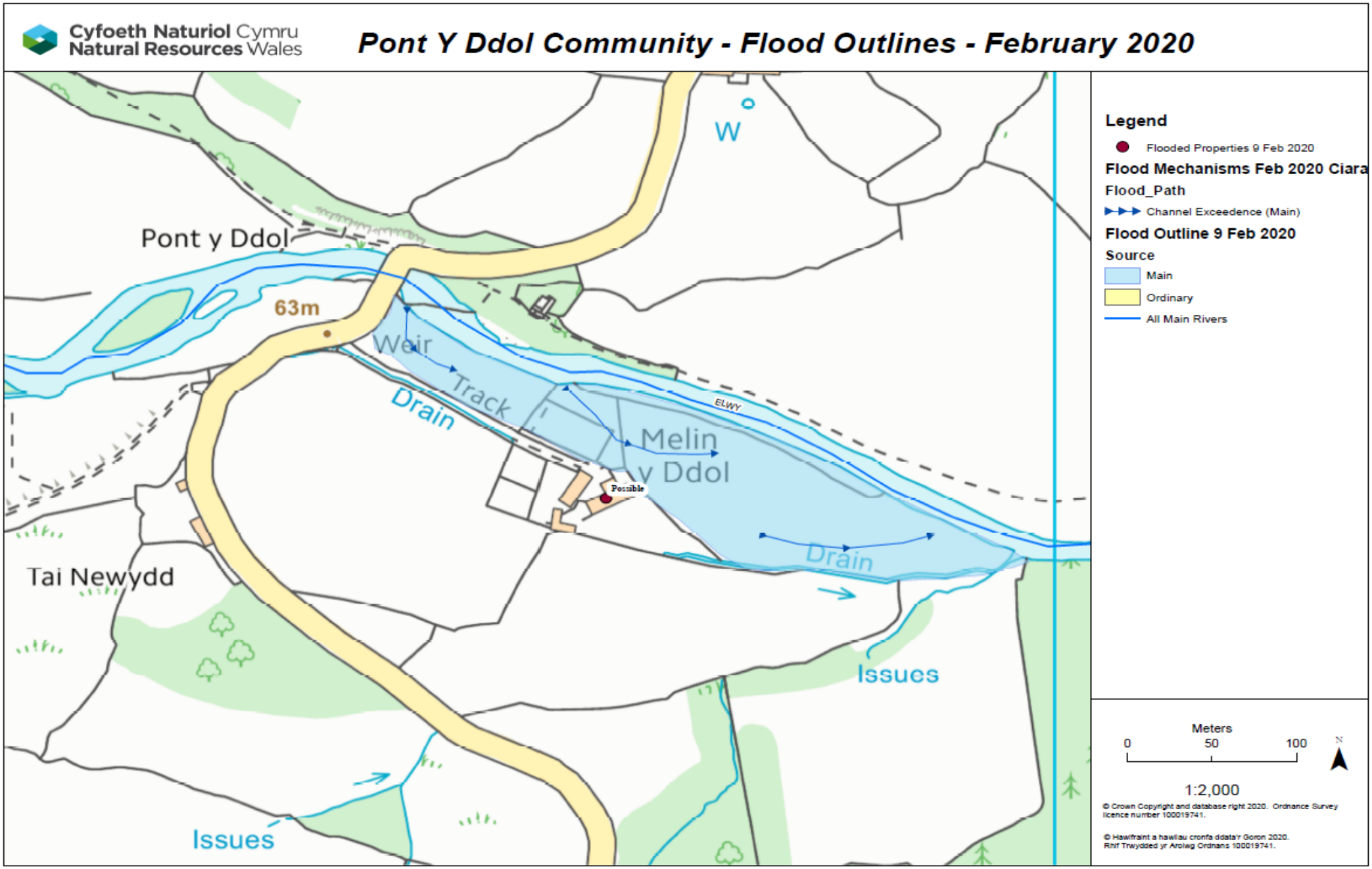


Figure 73: Pont Y Ddol community flood mechanisms - Feb 2020

Pont Meredydd Community

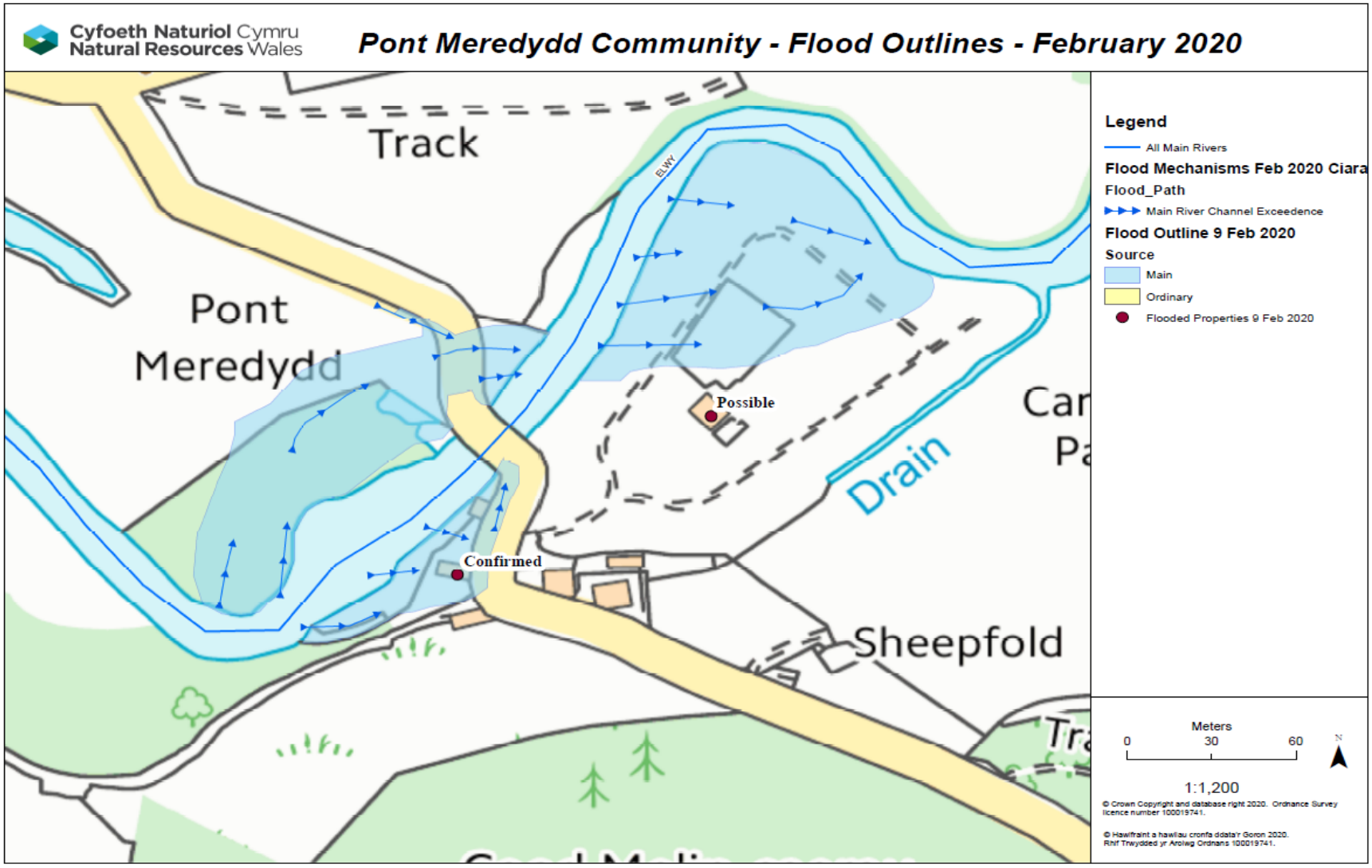
Pont Meredydd community has experienced significant flooding in 2012 when earth embankments were overtopped due to river levels exceeding the standard of protection of defences. On the south east bank of the Elwy, upstream of the road bridge, there are earth embankments which are deemed to provide a standard of protection in the region of 1 in 100 (1% AEP) based on historic observations. The embankment was refurbished in 2016 after which maintenance responsibility was accepted by the homeowner. Downstream of the bridge are reveted riverbanks with interspersed trees.

Residents of Caerau Cottage do have moveable PLP and it is expected that it was deployed prior to high levels on the Elwy. However, due to the significant rainfall recorded in the upper catchment and the river levels recorded downstream, it is presumed that PLP measures would be inadequate to protect against such depths as would be present in this area.

In previous events the caravan park has been affected by water from the Elwy entering over the riverbank, but it is assumed no caravans have been damaged. However, due to the water levels observed in this event it is possible that water overtopped riverbanks and over the road from Caerau Cottage side into the caravan park, possibly inundating residential property.

The mechanism of flooding in Pont Meredydd Community is deemed to be main river flooding as a result of river levels exceeding the standard of protection of earth embankment flood defences and natural riverbanks due to a significant rainfall event impacting the catchment.

Figure 74: Pont Meredydd community flood mechanisms - Feb 2020



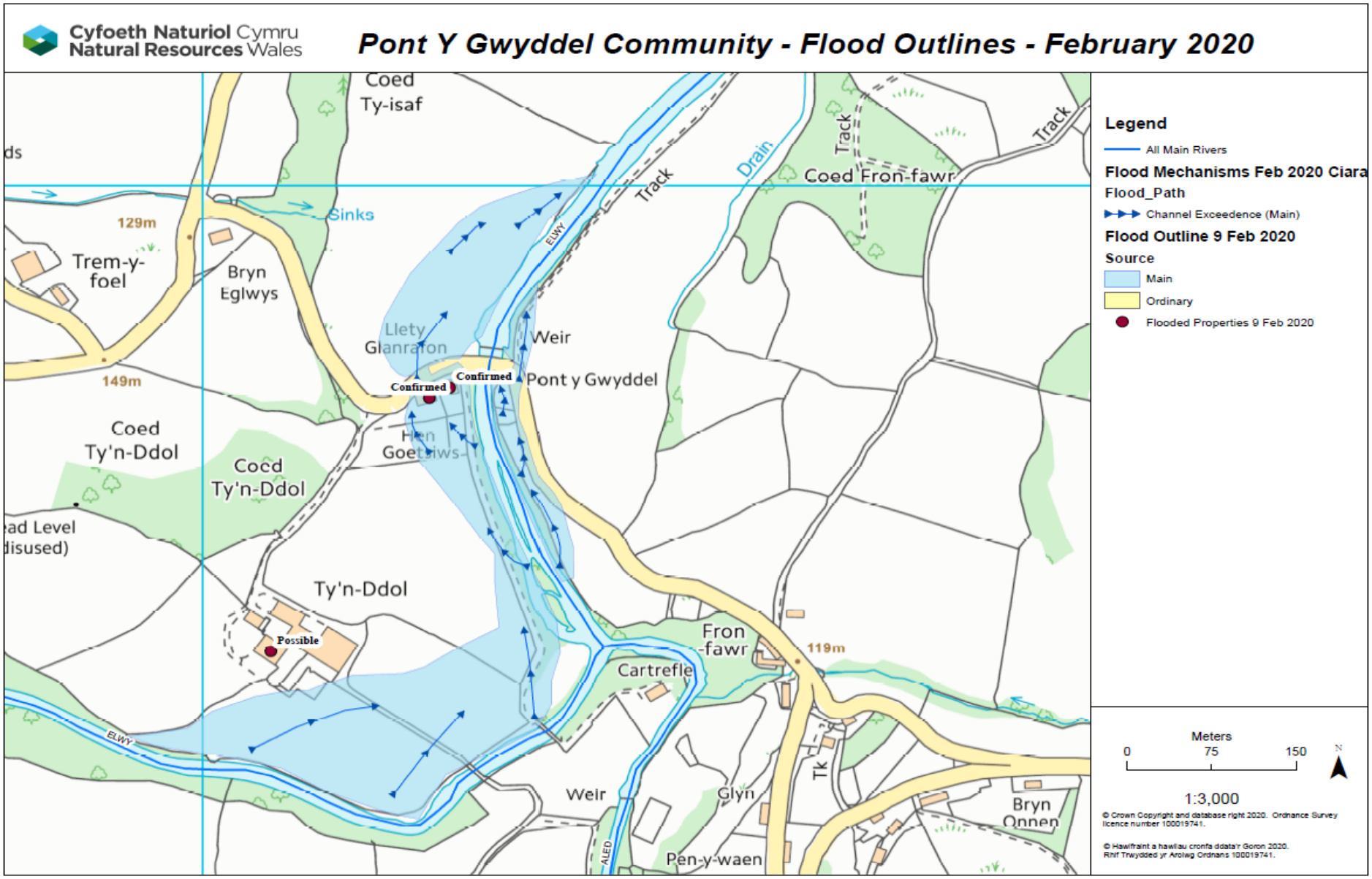
Pont Y Gwyddel Community

Pont Y Gwyddel community has experienced significant flooding on multiple occasions; as the Afon Elwy rises above its natural banks, flow routes across agricultural land are initiated which impact two properties. During the February 2020 event river levels at the gauging station adjacent to the residential properties recorded its highest ever flow. Due to the substantial water levels, floodplain flow routes bypassed the gauge impacting the recorded data. Overland flow caused damage to residential property, road surfaces and agricultural land.

Recommendation 6.1 is also applicable to this community.

The primary flooding mechanism impacting Pont Y Gwyddel Community is deemed to be main river inundation of the natural floodplain caused by a significant rainfall event centred over the catchment.

Figure 75: Pont Y Gwyddel community flood mechanisms - Feb 2020



Llanfair TH Community

Lanfair Talhaiarn community has historically experienced flooding on multiple occasions, with more recent significant events impacting property and highways in 2012 and 2015. The community is impacted by flooding from the Nant Barrog and on larger events can be impacted by the Afon Elwy too. During the Storm Ciara February 2020 event, flooding to Llanfair community was initially derived from water exceeding the capacity of the Nant Barrog culvert and flowing down Water Street, impacting many residential properties (Figure 78). A separate flood investigation covering flooding to Llanfair community from the Nant Barrog is ongoing at the time of writing but has not been published.

The river levels on the Elwy recorded downstream at Pont Y Gwyddel were the highest ever observed, along with significant rainfall totals recorded at Gwytherin rain gauge upstream of Llanfair TH, point to a significant event on the Afon Elwy (Figure 77) which exacerbated flood water levels in lower areas of the Llanfair community. During the 2012 flood event, anecdotal evidence highlighted a flow route from the Afon Elwy crossing agricultural land (natural floodplain) and entering Llanfair community along School Lane from west to east. This same flow route was observed by a Llanfair resident and flood warden during the 2020 event. Based on this information and the location and height of flood defences, it is surmised that this flow route is only initiated during flow events significantly greater than 1 in 100 year (1% AEP) on the Afon Elwy. Flood levels in the lower village were significant, greater than 1m in areas, as a result of culvert exceedance of the Nant Barrog and natural channel exceedance of the Afon Elwy. The significant flood levels are demonstrated by Figure 76 which shows flood water in lower Llanfair overtopping the Elwy embankments back into the Elwy floodplain. The wall in front of the Black Lion Hotel was also overtopped by flood water back into the Elwy.

The Black Lion Hotel and Glyndwr Hall were flooded to significant depths by the Nant Barrog and exacerbated by inundation from the Afon Elwy. A number of other residential and commercial properties along Water Street were also flooded by flows from the Nant Barrog.

Figure 76: Overtopping Llanfair TH Elwy embankments back into the Elwy (Resident photo)

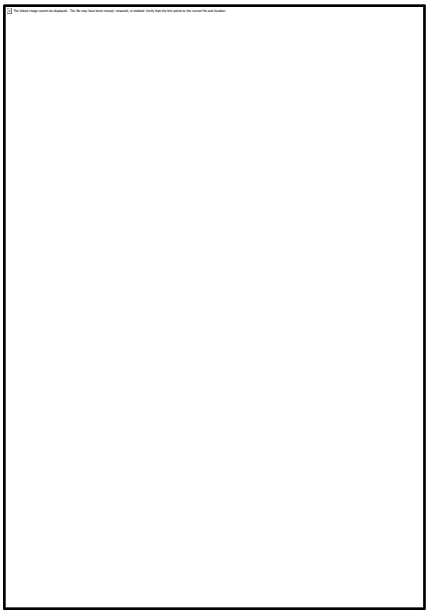


Figure 77: Flooding in Llanfair TH (Resident photo)

Figure 78: Flooding in Llanfair TH exacerbated by Elwy river levels (Resident photo)

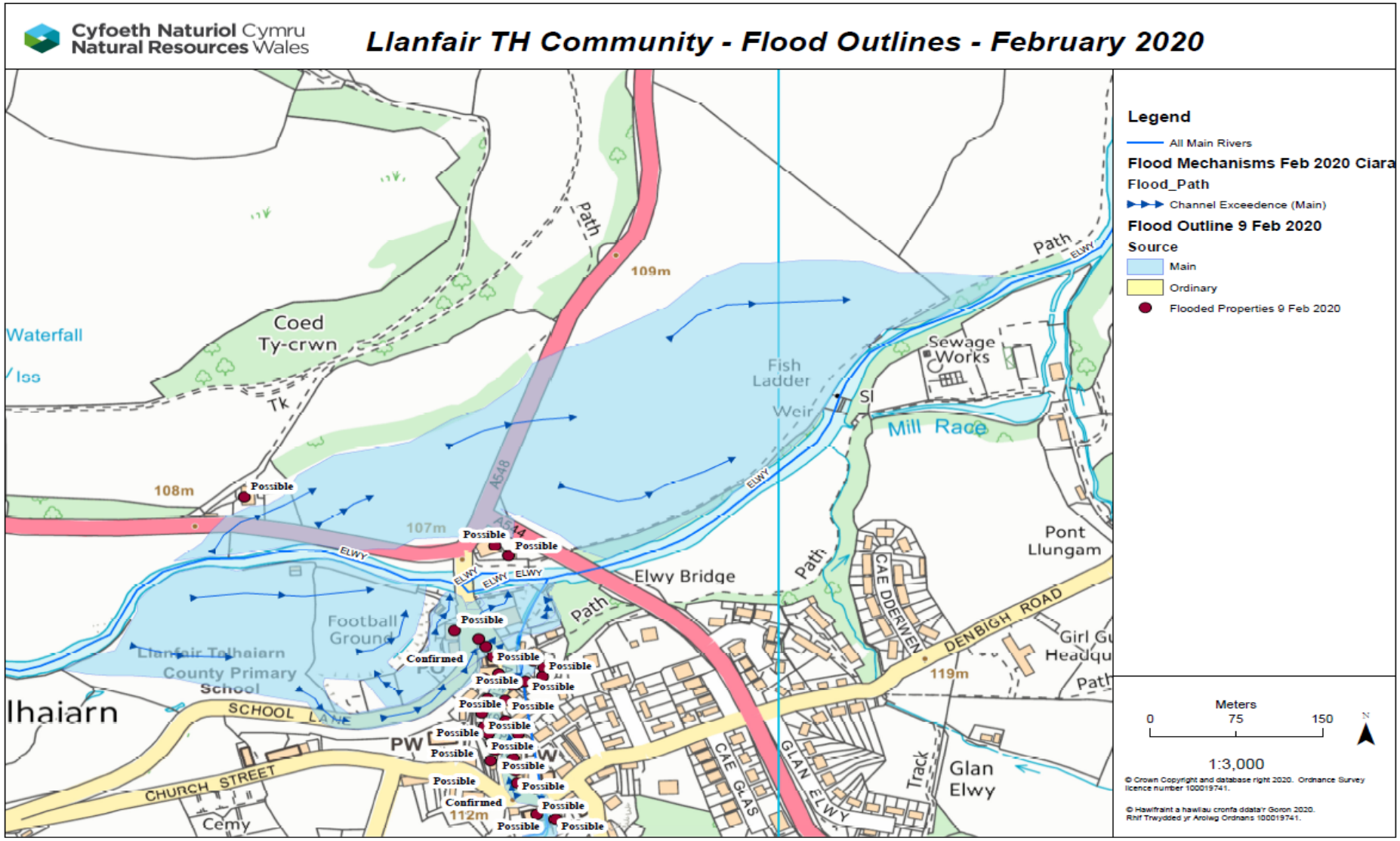
Recommendation 6.1 is also applicable to this community.

Recommendation 7.1 – NRW – Investigate through computational modelling the flow mechanisms from both the Nant Barrog and Afon Elwy, impacting Llanfair Talhaiarn Community in significant flood events.

The primary mechanism of flooding of Llanfair Talhaiarn Community is deemed to be main river flooding as a result of river levels exceeding the standard of protection of the culvert on the Nant Barrog due to a significant rainfall event impacting the catchment. Flood water levels in the lower community, School Lane and Black Lion Hotel, were exacerbated by water levels in the Afon Elwy exceeding natural riverbank levels and flowing along School Lane caused by a significant rainfall event centred over the catchment.

A separate flood investigation covering flooding to Llanfair community from the Nant Barrog is ongoing at the time of writing but has not been published.

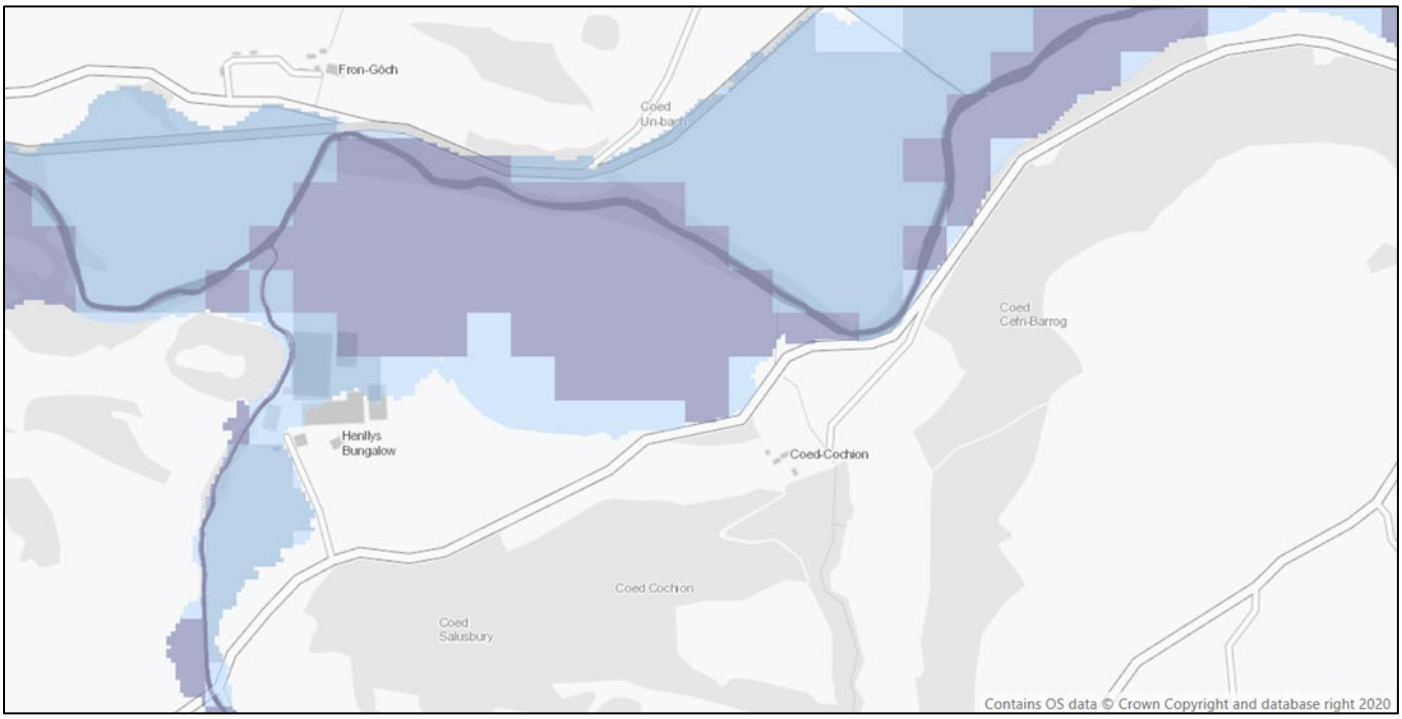
Figure 79: Llanfair TH community flood mechanisms - Feb 2020



Henllys Farm

No reports of residential property flooding were received by NRW for this area, but post-event inspections highlight potential flooding impacts to agricultural land and possibly commercial and/or agricultural premises. A large proportion of the land in this area is natural floodplain for the Afon Elwy and the Nant Melai.

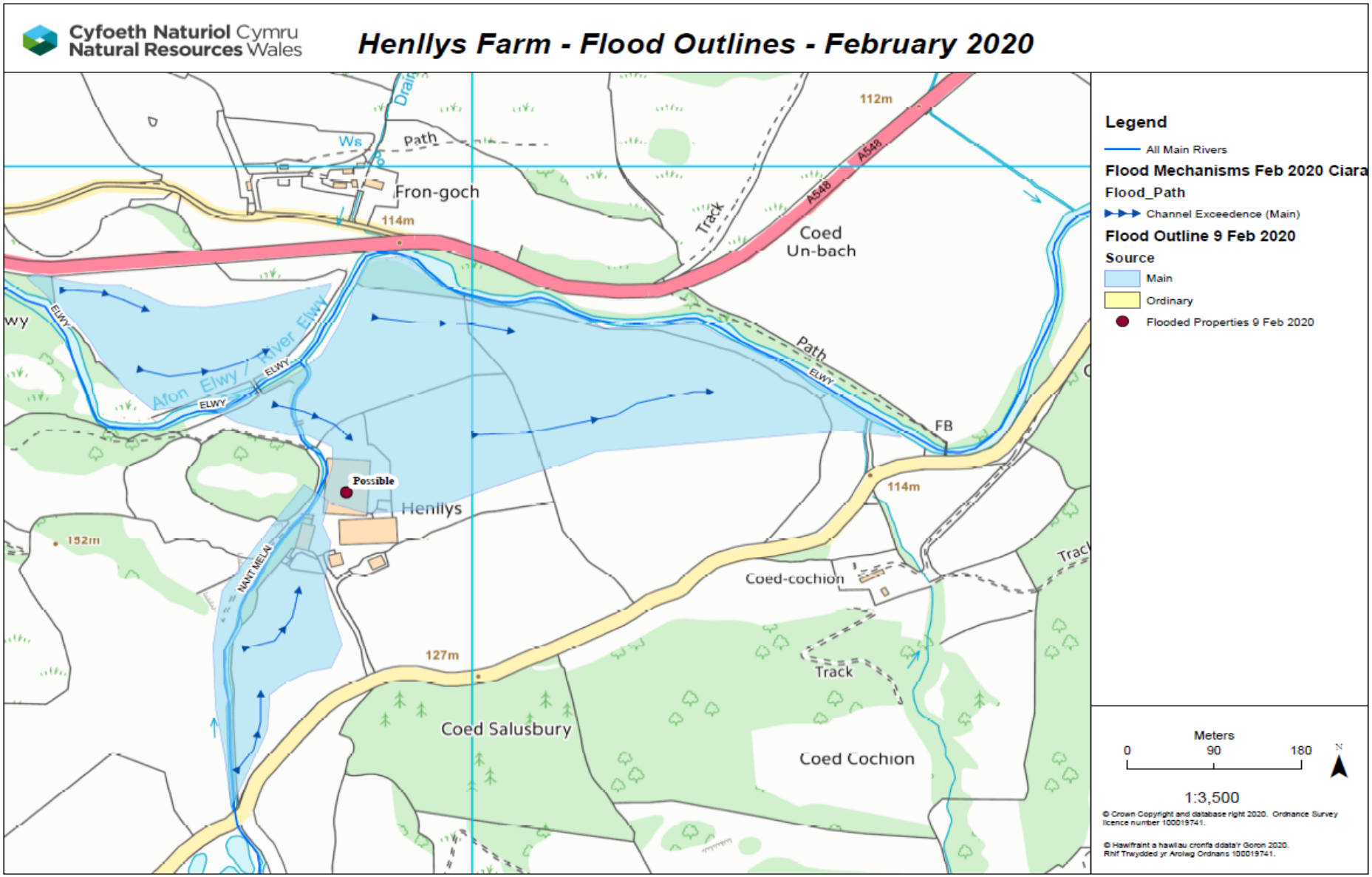
Figure 80: Extract from the published flood map showing Henllys Farm (NRW, 2020a)



Recommendation 6.1 is also applicable to this community.

The primary impacts on Henllys Farm are deemed to be main river inundation of the natural floodplain from the Afon Elwy and Nant Melai caused by a significant rainfall event centred over the area.

Figure 81: Henllys Farm flood mechanisms - Feb 2020



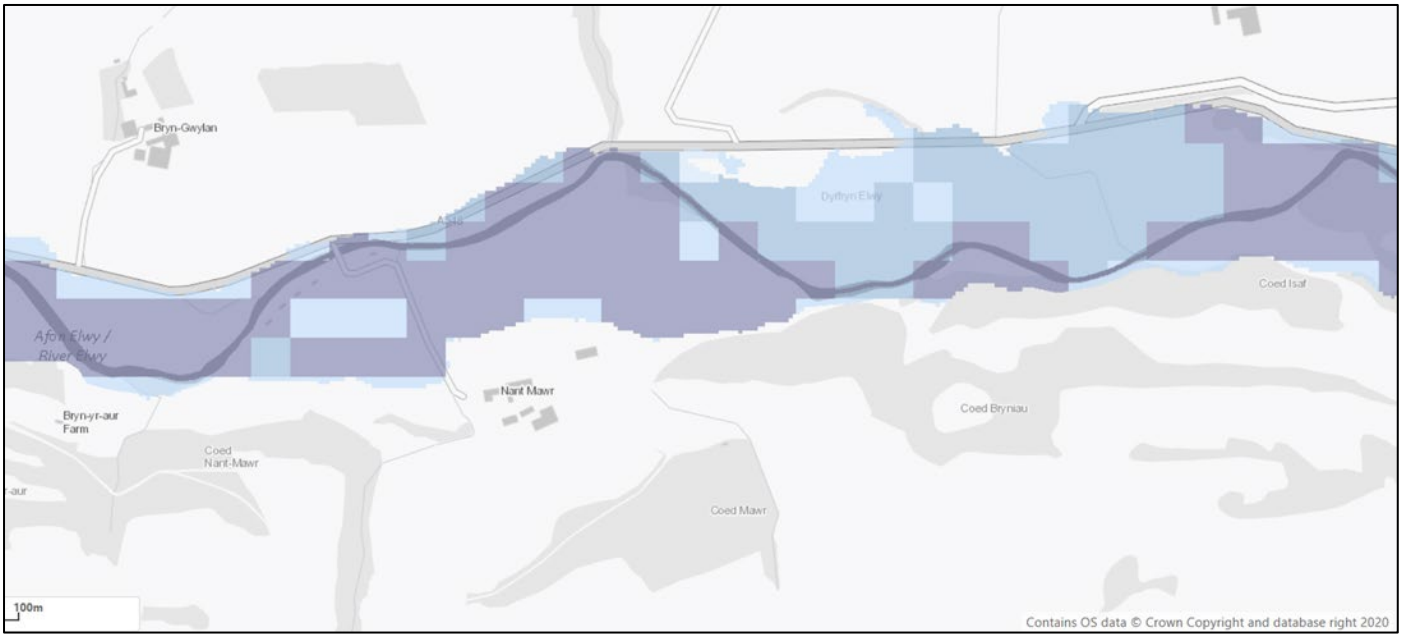
Nant Mawr Caravans

Post-event investigation found that at least 4 static caravans located on the banks of the Afon Elwy were impacted by the Storm Ciara event in February 2020. At least one caravan was dislodged from its fixings, carried downstream by flood waters, broken up and debris deposited within the floodplain. Another caravan was partially dislodged from its fixings but remained intact and on site.

Recommendation 8.1 – Nant Mawr Caravan Park Residents - Nant Mawr Caravan Park to be directed to NRW advice and guidance for site owners and operators who have sites at flood risk.

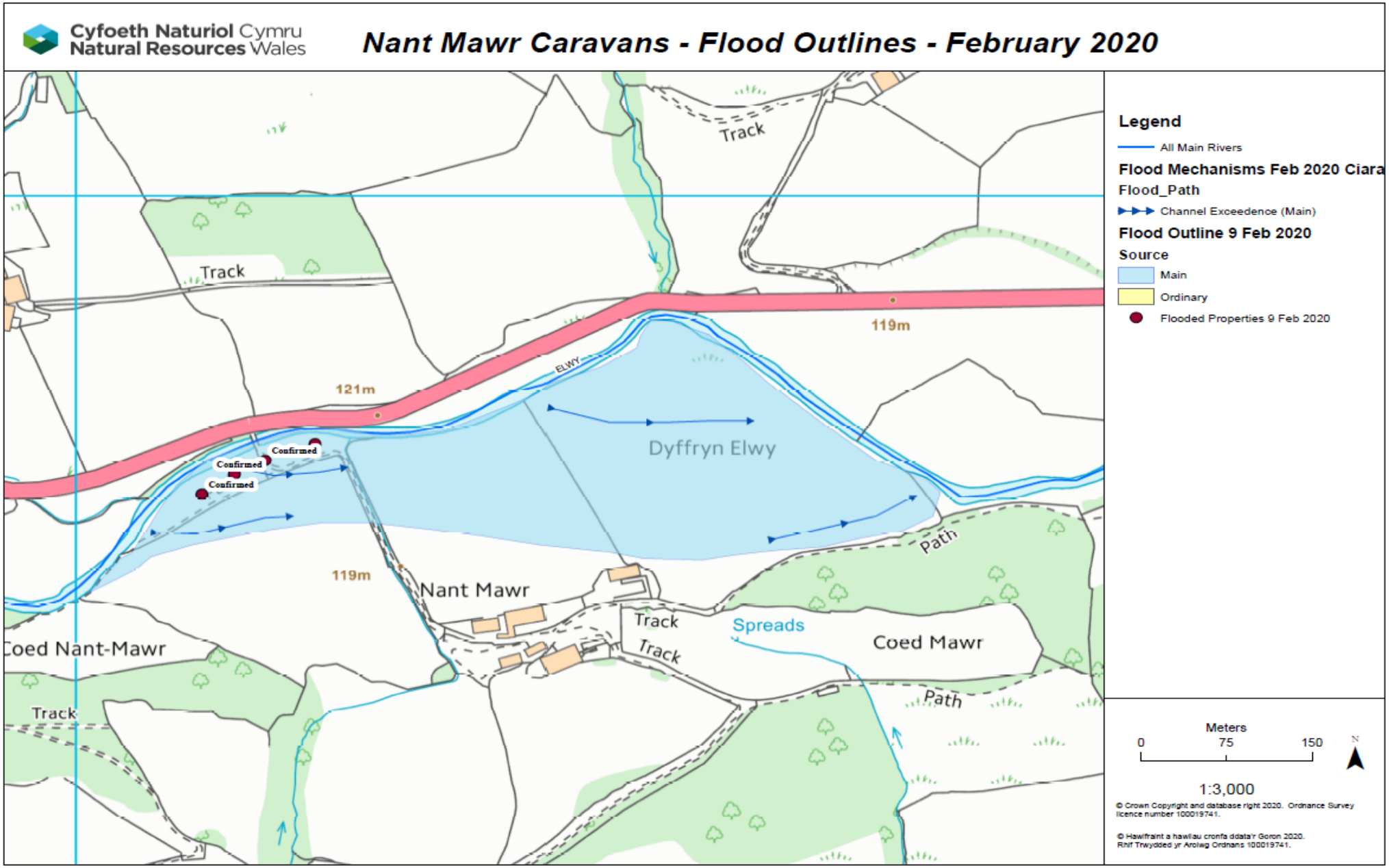
https://naturalresources.wales/flooding/guidance-for-caravan-and-campsites-owners-and-operators-1/?lang=en

Figure 82: Extract from the published flood map showing Nant Mawr Caravans (NRW, 2020a)



The primary mechanism of flooding on Nant Mawr Caravans is deemed to be significant depths and velocity of main river flow in its natural floodplain and inappropriate land-use within the floodplain.

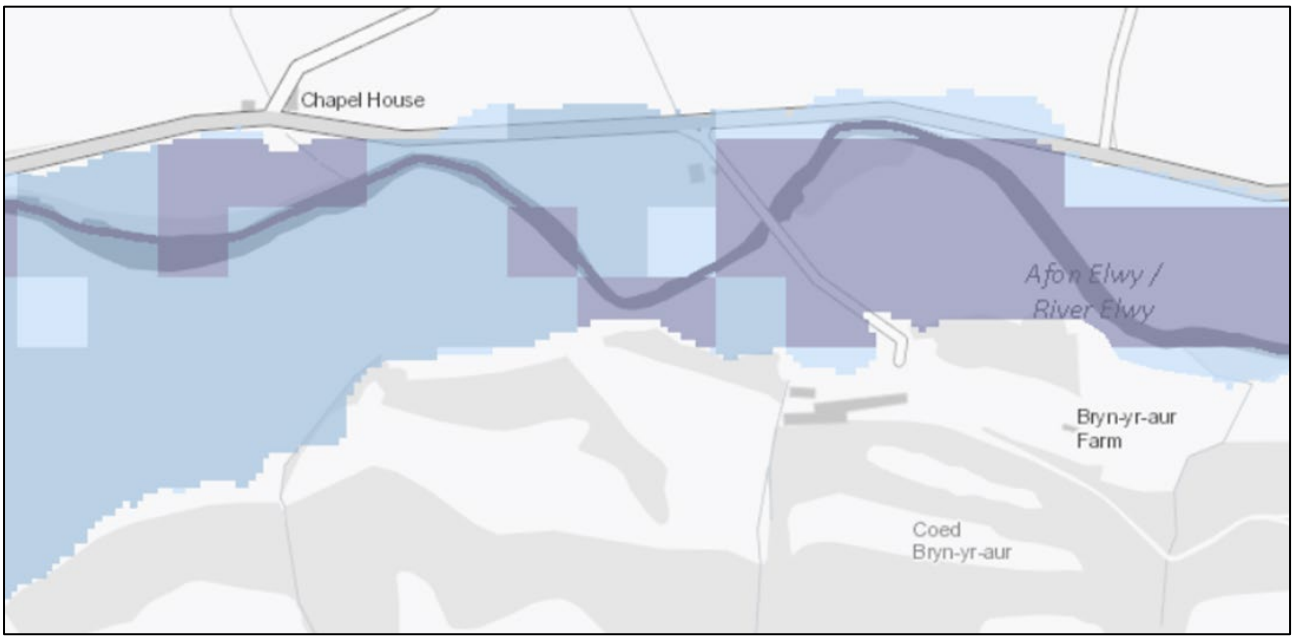
Figure 83: Nant Mawr Caravans flood mechanisms - Feb 2020



Bryn Yr Aur Community

The three properties in the Bryn Y Aur community were not visited post-event but anecdotal evidence and published flood maps (Figure 84) suggests all properties were impacted and Bryn y Aur Bungalow possibly being flooded internally. The A548 road was impacted in various locations by both the Elwy and various ordinary watercourses. Post-event inspection highlighted that at this location, significant amounts of water and debris had impacted the highway.

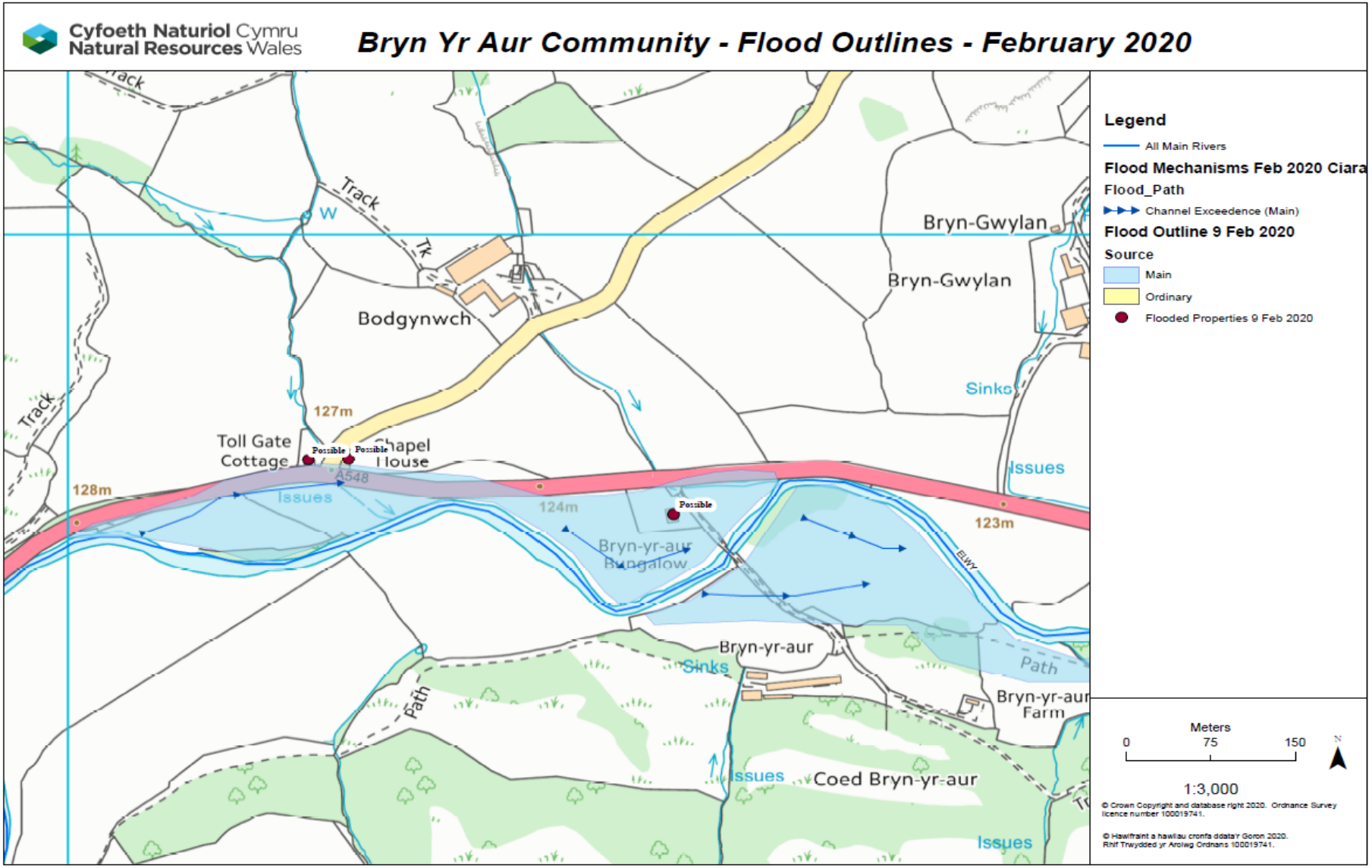
Figure 84: Extract from the published flood map showing Bryn Yr Aur community (NRW, 2020a)



Recommendation 6.1 is also applicable to this community.

The impacts on Bryn Yr Aur Community are deemed to be main river inundation of the natural floodplain caused by a significant rainfall event centred over the catchment.

Figure 85: Bryn Yr Aur Community flood mechanisms - Feb 2020

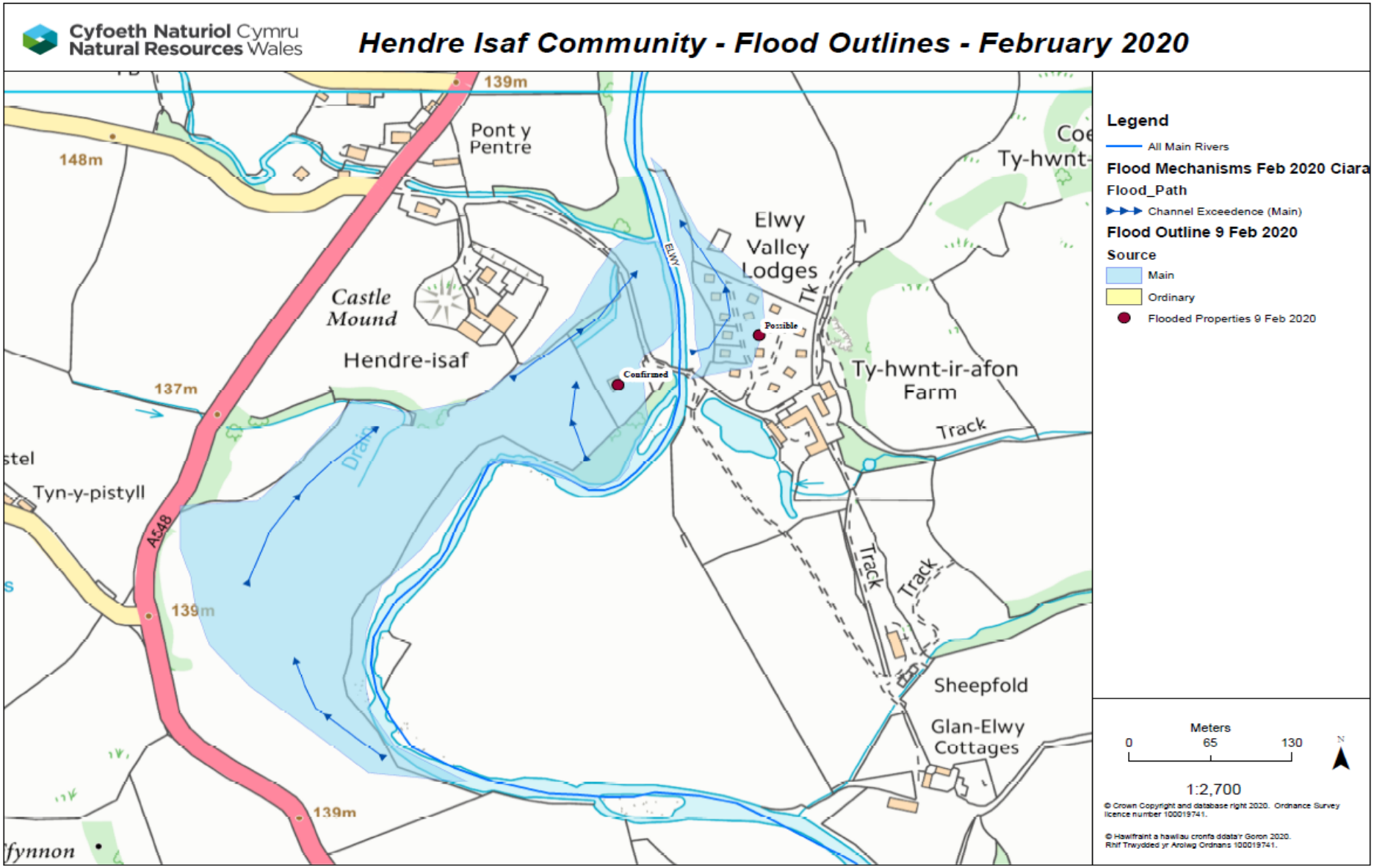


Hendre Isaf Community

The landscape of Hendre Isaf has historically been developed by river processes with some signs of historic industry and land-use still evident. The residential property Ty-hwnt-ir-afon on left bank and the caravan park on right bank have been impacted by flooding on many occasions. Considering the location of development within the floodplain and placement of a road bridge, river inundation of the floodplain and impacts to property and infrastructure is expected to continue.

The impacts on Hendre Isaf Community are deemed to be main river inundation of the natural floodplain caused by a significant rainfall event centred over the catchment and initiation of flow along historic channels due to high river levels.

Figure 86: Hendre Isaf Community flood mechanisms - Feb 2020

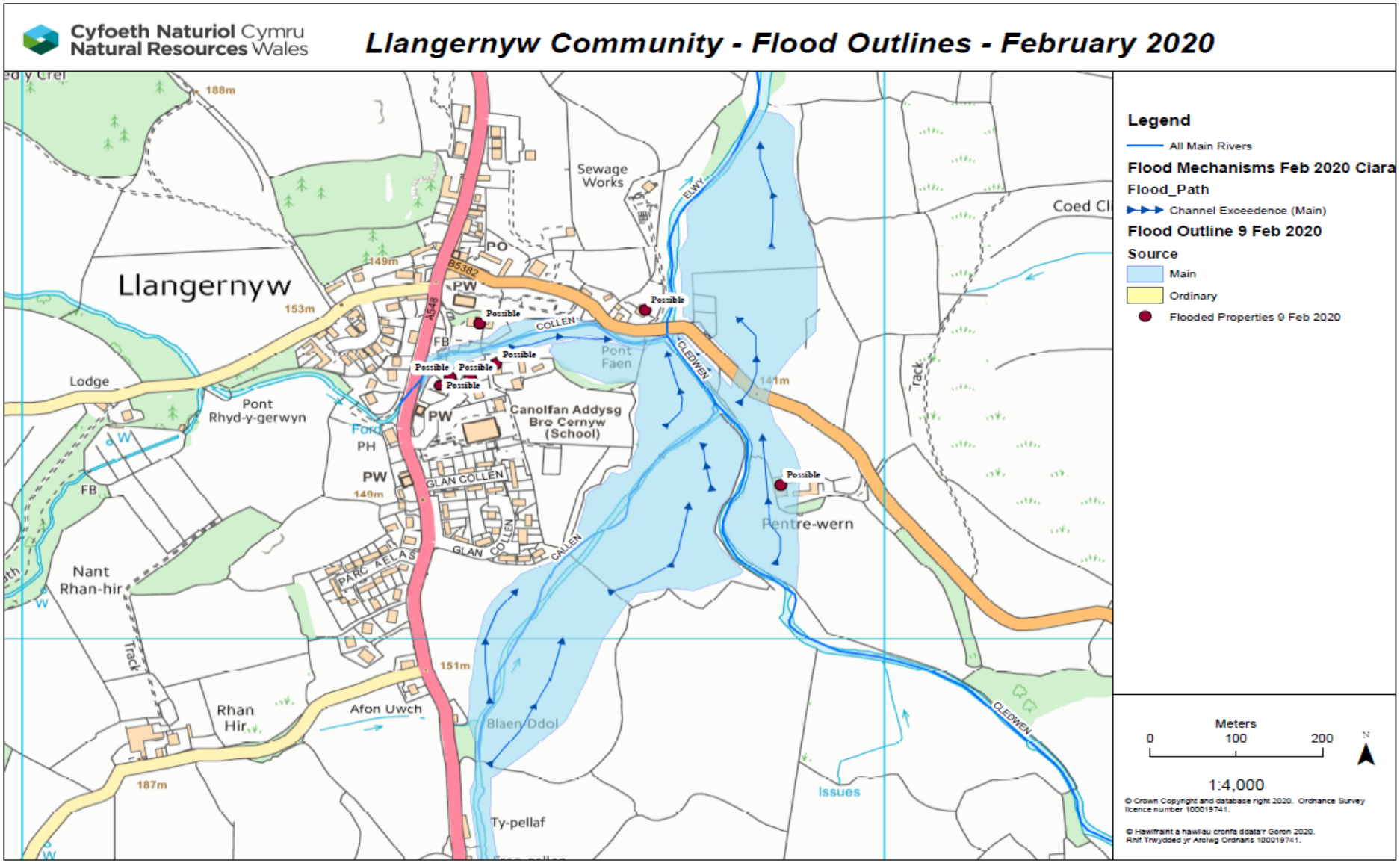


Llangernyw Community

Llangernyw community is located at the confluence of three designated main rivers; Afon Collen, Afon Cledwen and Afon Callen which converge to form the head of main river of the Afon Elwy. The whole area of floodplain had significant depths of water. During post-event investigation it was noted that a large agricultural trailer had been moved through the floodplain and lodged on the right abutment of the road bridge. Significant flow from the Afon Cledwen crossed the road on the right bank, possibly impacting agricultural buildings and ripping up hedges to move downstream below the road bridge.

The impacts on Llangernyw Community are deemed to be main river inundation of the natural floodplain caused by a significant rainfall event centred over the catchments.

Figure 87: Llangernyw Community flood mechanisms - Feb 2020



7. Response

During an event NRW undertake a number of incident response procedures both pre-, during and post-event. Over the days and weeks following the Elwy flood event, officers from NRW gathered information, completed surveys and spoke to affected residents for collation of the flood investigation report.

The Flood Warning System for St Asaph worked as expected with the Flood Forecasting Model performing well and providing appropriate lead time for professional partners. The river level gauge at St Asaph did show erroneous readings for a period, possibly due to debris obstructing the equipment, but operatives and flood wardens on site were extremely helpful in relaying situation reports. It is possible that the failure of the automatic river level gauge at St Asaph hampered Duty Officers in issuing a Severe Flood Warning but based on outputs from the Flood Forecasting Model, the Flood Warning was issued early with a view to preparing resource and residents.

A list of Flood Alerts and Warnings issued, downgraded and removed for the Storm Ciara event is detailed in Figure 88.

Figure 88: Flood Warnings issued February 2020.

Date	Time	Target Area	Action	Message Type	Duration	Contacts		
						Successful	Unsuccessful	Total
09-Feb-20	08:55:15	Elwy & Gele Catchment	Issue	Flood Alert				0
09-Feb-20	08:58:01	Elwy at Lower Denbigh Road	Issue	Flood Alert				0
09-Feb-20	09:01:56	Elwy at St Asaph	Issue	Flood Alert				0
09-Feb-20	09:08:13	Elwy Spring Gardens Bridge to Rhuddlan	Issue	Flood Alert				0
09-Feb-20	09:12:55	Elwy at Lower Denbigh Road	Issue	Flood Warning				0
09-Feb-20	11:07:33	Elwy Spring Gardens Bridge to Rhuddlan	Issue	Flood Warning	00:20:13	387	60	447
09-Feb-20	12:37:25	Elwy at St Asaph	Issue	Flood Warning	00:22:59	1420	236	1656
09-Feb-20	16:08:04	Elwy at Spring Gardens	Issue	Severe Flood Warning	00:18:26	382	70	452
09-Feb-20	16:14:02	Elwy at St Asaph	Issue	Severe Flood Warning	00:21:10	1429	244	1673
09-Feb-20	18:33:53	Elwy at St Asaph	Update	Severe Flood Warning to Flood Warning	00:20:46	1450	255	1705
09-Feb-20	19:45:33	Elwy at Spring Gardens	Update	Severe Flood Warning to Flood Warning	00:19:47	391	61	452
10-Feb-20	10:02:31	Elwy Spring Gardens Bridge to Rhuddlan	Remove	Flood Warning				0
10-Feb-20	10:04:20	Elwy at St Asaph	Remove	Flood Warning				0
10-Feb-20	11:26:20	Elwy at Lower Denbigh Road	Remove	Flood Warning				0
10-Feb-20	11:28:01	Elwy & Gele Catchment	Remove	Flood Alert				0

8. Conclusions

The event experienced on the Afon Elwy on 9th February 2020 was a significant storm event with catchment rain gauges recording 194% and 242% of long-term average rainfall in the upper and mid reaches respectively which resulted in the highest ever recorded flow at the Pont Y Gwyddel gauge station. The river flow recorded at Pont Y Gwyddel and peak water levels observed at locations in and around St Asaph by NRW operatives and residents, were both confirmed to be higher than those observed during the devasting 2012 event.

Considering the observed river levels on the Afon Elwy at Pont Y Gwyddel gauging station were significantly higher than those observed during the 2012 event, the flood risk management scheme at St Asaph performed well providing benefit to over 370 properties. However, many residential properties, commercial premises and caravan parks did flood, many of which were outside the defended area for the St Asaph scheme. NRW have initiated a formal review of scheme performance, are continuing to work with professional partners to manage flood risk and will continue to work with communities to understand the mechanisms of flooding.

The pattern of weather observed across Wales highlights the continual risk which flooding poses. NRW is constantly working to increase understanding of flood risk and will continue to engage with communities such as St Asaph to manage flood risk. There are lessons to be learnt by all Risk Managment Authorities and Elwy residents in-order to continually improve how flood risk is manged in all parts of the Afon Elwy catchment. The recommendations contained within this report go some way to capturing the lessons learnt but require positive action by all stakeholders to continually manage flood risk on the Afon Elwy.

9. Recommendations

A number of recommendations are made based on observations from public, professional partners and duty officers involved, with a view to continually improving the way flood risk is managed across Wales.

Recommendation 1.1 - DCWW – Review performance of the underground system in the Lower St Asaph area.

Recommendation 1.2 – NRW – Work with the landowners around the Afon Elwy to maintain the flood risk management assets back to Fair condition.

Recommendation 1.3 – NRW – All photos taken during formal NRW duties (inspection, maintenance, incident response etc.) should be time and date stamped.

Recommendation 2.1 – NRW – Undertake a performance review for the 2018 St Asaph Flood Risk Management scheme.

Recommendation 2.2 – NRW – Using the hydraulic model, investigate the flow mechanisms and sensitivity of various parameters which may be impacting water levels at St Asaph STW Embankment.

Recommendation 2.3 - NRW – Consider the current incident response plans and address the resource & resilience shortfalls during such events.

Recommendation 3.1 – NRW – Review policy and procedure regarding the roles and responsibilities of flood wardens both in an incident and during normal working times.

Recommendation 4.1 – NRW – Model the effects of non-return flap operation on water levels in the Glascoed Stream.

Recommendation 4.2 – DCC – Undertake a Flood Investigation Report for all non-main river flooding in the St Asaph and Glascoed Communities.

Recommendation 5.1 – NRW – Review the published flood map data for Wigfair Isaf Community.

Recommendation 6.1 – NRW – Provide advice on Property Level Protection and Property Level Resilience measures for residential property in affected communities in the upper and middle reaches of the Afon Elwy catchment which do not benefit from a defence scheme.

Recommendation 7.1 – NRW – Investigate through computational modelling the flow mechanisms from both the Nant Barrog and Afon Elwy, impacting Llanfair Talhaiarn Community in significant flood events.

Recommendation 8.1 – Nant Mawr Caravan Park Residents - Nant Mawr Caravan Park to be directed to NRW advice and guidance for site owners and operators who have sites at flood risk.

https://naturalresources.wales/flooding/guidance-for-caravan-and-campsites-owners-and-operators-1/?lang=en

10. Useful information

Natural Resources Wales publish a wide range of information on flooding, useful web links include;

Long term flood risk maps - https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en

River Levels, Rainfall and Sea Data - https://rivers-and-seas.naturalresources.wales/

The Blue Pages is a directory of property level flood products and services put together to advise and inform people of what is available to help reduce the risk of flooding to homes and businesses.

http://bluepages.org.uk/

The National Flood Forum provides wide-ranging advice and support for individuals and communities affected by flooding.

https://nationalfloodforum.org.uk/

The “What 3 Words” mobile application divides the world up into 3 metre squares and gives each square a unique 3-word combination allowing exact locations to be established quickly and communicated effectively to emergency services.

https://what3words.com/daring.lion.race

11. References

Centre for Ecology and Hydrology, 2020. *National River Flow Archive.* [On-line]. Available from; https://nrfa.ceh.ac.uk/data/station/spatial/66006

Environment Agency, 2012. *Condition Assessment Manual (CAM)* Bristol: Environment Agency

Denbighshire County Council, July 2013. *Investigation into the November 2012 Floods Flood Investigation Report - Part 1.* Accessed June 2020. Available from: https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi6turFtJ_sAhURUxUIHbVWAycQFjAEegQIARAC&url=https%3A%2F%2Fmoderngov.denbighshire.gov.uk%2Fdocuments%2Fs8537%2FFlood%2520App%25201.pdf%3FLLL%3D0&usg=AOvVaw3hjiHCuwpQ_wrUWMH0m7gm

Dŵr Cymru Welsh Water, 2019. *Environmental Assessment of Aled Isaf - Llyn Aled Drought Permit* [On-line]. Accessed June 2020. Available from: *https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwitrbOy7Z7uAhVHa8AKHTT0AdIQFjAAegQIAhAC&url=https%3A%2F%2Fwww.dwrcymru.com%2F-%2Fmedia%2FProject%2FFiles%2FPage-Documents%2FCorporate%2FEnvironment%2FWater-Resources%2FRevised-Draft-Drought-Plan-2020%2FEnvironmental-Assessment-Reports%2FAppendix-12--Environmental-Assessment-Report-for-Llyn-Aled-Option-no-80126.ashx&usg=AOvVaw0LQegnATYDn9GcV2gkaohS*

Elwy residents, 2020. *Various photographs taken during the storm event by Elwy residents.* Not published.

Natural Resources Wales, 2019. *Photographs taken during routine asset inspections.* Not published.

Natural Resources Wales, 2020. *Various photographs taken during the storm event.* Not published.

Natural Resources Wales, 2020a. *Risk of flooding from Rivers and Sea – Online maps.* Available from:

https://maps.cyfoethnaturiolcymru.gov.uk/Html5Viewer/Index.html?configBase=https://maps.cyfoethnaturiolcymru.gov.uk/Geocortex/Essentials/REST/sites/Flood_Risk/viewers/Flood_Risk/virtualdirectory/Resources/Config/Default&layerTheme=1

12. Appendices

Event photos

Lower St Asaph Photographs

Figure 89: River levels d/s of fishermans bridge (NRW, 2020)

Higher St Asaph Photographs

Figure 90: Sandbags deployed at Roe Parc Wall (Resident photo, 2020)

Figure 91: River gravel deposit on Foxons Ramp (NRW, 2020)

St Asaph Photographs

Figure 92: Overtopping location RB STW emb (NRW, 2020)

Figure 93: Location of overtopping Roe Parc Wall (NRW, 2020)

Figure 94: Overtopping location RB STW emb (NRW, 2020)

Figure 95: Overtopping location RB STW emb (NRW, 2020)

Figure 96: Overtopping location RB STW emb (NRW, 2020)

Figure 97: Progression of overtopping RB STW emb (NRW, 2020)

Figure 98: River levels 09-02-2020 compared to bridge deck (NRW, 2020)

Figure 99: Wrack marks cattle market emb u/s section (NRW, 2020)

Figure 100: Water levels at SGB (Resident photo)

Figure 101: Post event debris (Resident photo)

Figure 102: Wrack marks u/s library wall (NRW, 2020)

Figure 103: Wrack marks cattle market emb d/s section (NRW, 2020)

Figure 104: Wrack marks Dr Emb (NRW, 2020)

Figure 105: Flood debris at the rear of Ruby Terrace (NRW, 2020)

Figure 106: Wrack mark in relation to crest height common emb (NRW, 2020)

Figure 107: Wrack mark common emb (NRW, 2020)

Figure 108: Wrack mark common emb (NRW, 2020)

Figure 109: Overtopping location RB STW emb (NRW, 2020)

Figure 110: Wrack marks at Roe Parc emb (NRW, 2020)

Figure 111: Wrack marks at Roe Parc emb ramp (NRW, 2020)

Figure 112: Wrack marks at Pont Begard wall (NRW, 2020)

Figure 113: Wrack mark common emb (NRW, 2020)

Figure 114: Water mark d/s Pont Begard (NRW, 2020)

Figure 115: Prior to peak water levels at u/s end of Roe Parc Wall (Resident photo)

Figure 116: River levels looking d/d from city bridge (NRW, 2020)

Figure 117: Prior to peak water levels at u/s end of Roe Parc Wall (Resident photo)

Figure 118: Prior to peak water levels at A55 birdge (Resident photo)

Figure 119: River levels at confluence of Glascoed & Elwy (NRW, 2020)

Figure 120: Water levels at the U/S end of Ruby Terrace (NRW, 2020)

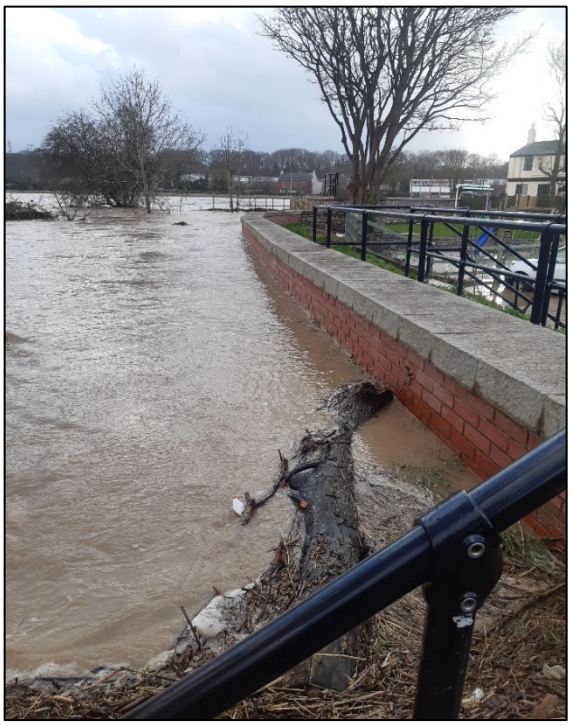


Figure 121 Water levels at the U/S end of Ruby Terrace (NRW, 2020)

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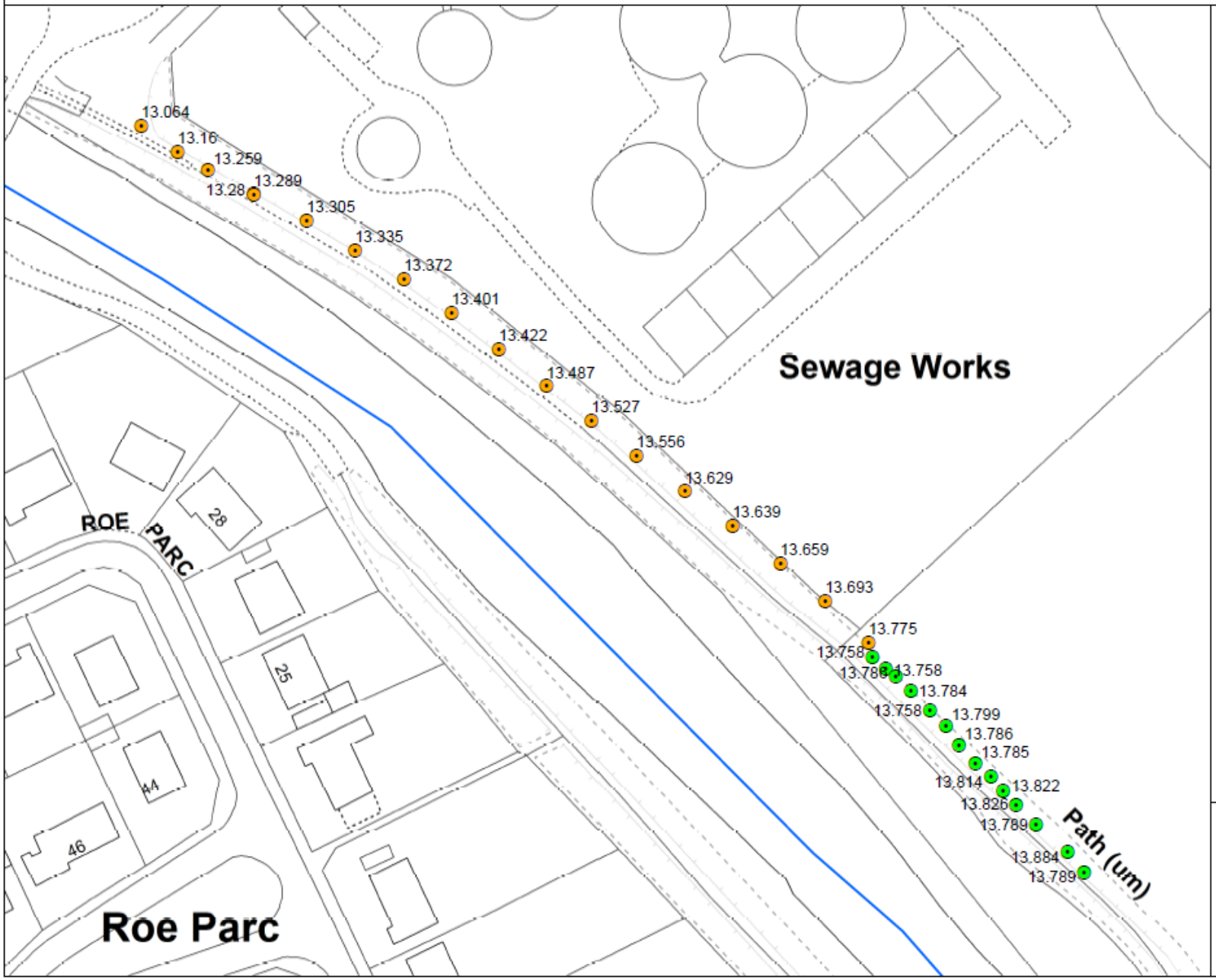
Natural Resources Wales

Storm Ciara post-event investiation - Afon Elwy



Legend

St Asaph Post Event Topo

Field5

- LB
- RB
- WL

LB is crest level of left bank

RB is crest level of right bank

WL is the lower (riverside) level of wrack marks

Meters 0 10 20 1:650

N

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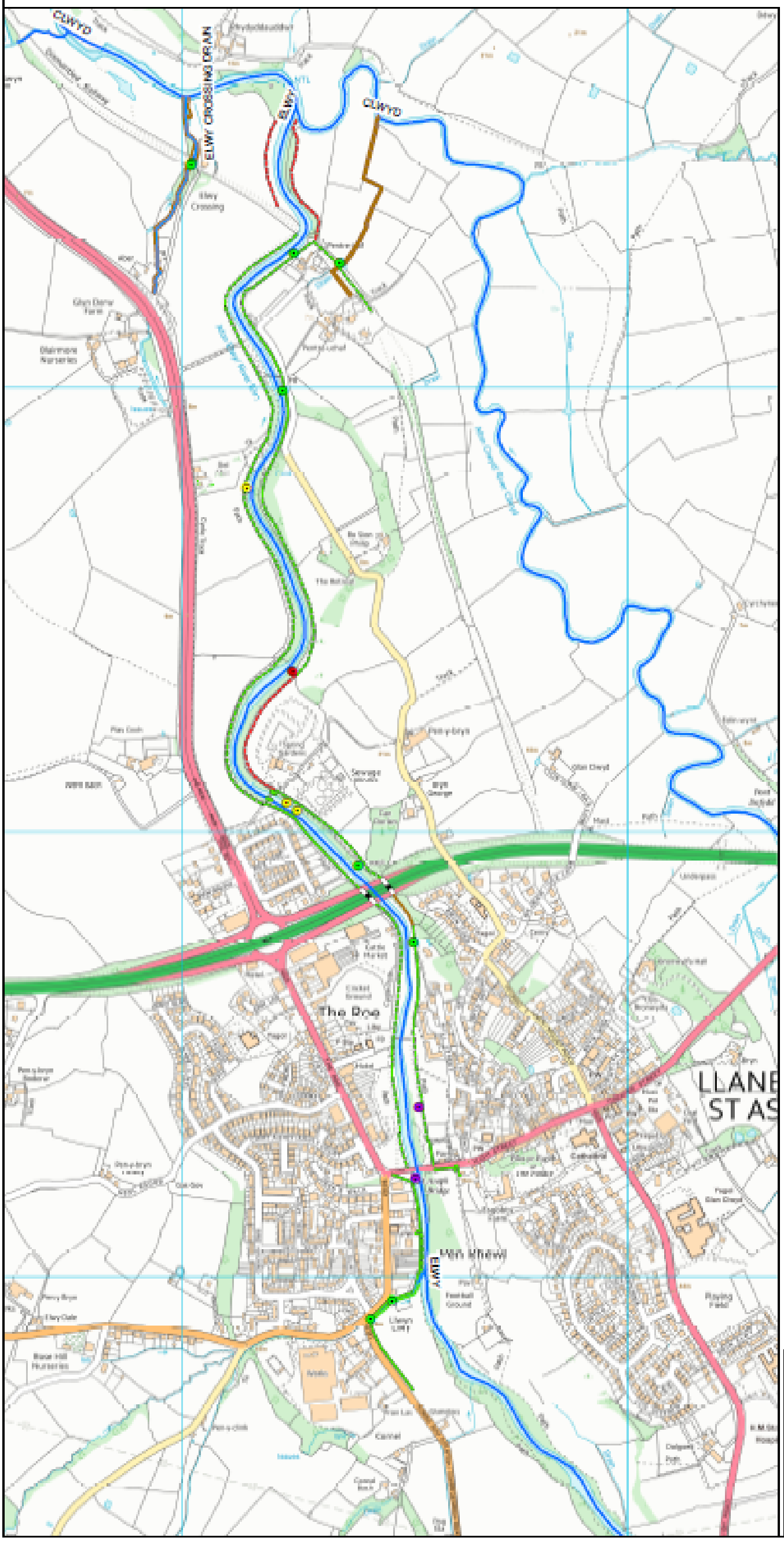
Natural Resources Wales

Overview of St Asaph Defences



Legend

St Asaph Outfalls Sept 2020

SUBTYPE, ASSETMAINT

- Outfall, Denbighshire County Council
- Outfall, Dwr Cymru Welsh Water
- Outfall, Natural Resources Wales
- Outfall, Private

St Asaph Defences Sept 2020

SUBTYPE, ASSETMAINT

- Bridge Abutment, Highways Agency
- Bridge Abutment, Natural Resources Wales
- Demountable, Natural Resources Wales
- Embankment, Natural Resources Wales
- Embankment, Private
- Flood Gate, Natural Resources Wales
- High Ground, Natural Resources Wales
- High Ground, Private
- Open Channel, Natural Resources Wales
- Simple Culvert, Natural Resources Wales
- Wall, Natural Resources Wales

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