

# The Flash Floods of 11 and 12 August 2020 in Central and Eastern Scotland

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## Summary

The flash floods of the 11 and 12 August caused by widespread thunderstorms across Central and Eastern Scotland resulted in severe disruption to infrastructure and significant property flooding.

The rainfall measured during the evening of the 11 August and morning of the 12 August 2020 suggests that the rainfall was an extreme event compared to historical records and can be considered rare. Hourly rainfall of greater than 50 mm (Dunnottar raingauge in Aberdeenshire), daily rainfall of 106 mm (Fife airport raingauge) and the equivalent of a month's worth of rain in short duration across a wide geographical area is more significant than some recent notable summer flash floods including those experienced in Glasgow in 2002 and in Elgin as part of Ex. Tropical Storm Bertha in 2014.

Scotland has historically observed similar, if not higher rainfall totals as presented in this report, but nevertheless the intensities recorded between the 11 and 12 August were exceptional. What also makes these convective-driven thunderstorms unique is the relatively widespread nature of the event affecting large parts of Central and Eastern Scotland, rather than being isolated to a single location or urban centre.

The event needs to be considered in the context of recent climate trends. Recent research has highlighted that in the United Kingdom we are experiencing wetter summers with the most recent decade being significantly wetter than the preceding five decades<sup>1</sup>. Estimating the rarity of such an event is challenging given relatively limited historical records on which to compare and a non-stationary climate, however this report attempts to place the thunderstorms and flash flooding in context.

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<sup>1</sup> Kendon, M., McCarthy, M., Jevrejeva, S., Matthews, A., Sparks, T. and Garforth, J. (2019) State of the UK Climate 2019. *International Journal of Climatology*, the Royal Meteorological Society Journal of Climate Science, Vol. 40, 1.

## **The Thunderstorms and Flash Floods of 11 and 12 August 2020**

The aim of this report is to present information on the thunderstorms of the 11 and 12 August 2020 and resulting flash floods. This largely factual report is to help communicate important hydrological data from the event and to help those interested in the scale of this extreme and notable rainfall. The report is intended to inform future knowledge and understanding of extreme short duration flood events in Scotland.

The report is structured by first presenting the weather scenario that led to the extreme rainfall and flooding and attempts to put the recorded hydrological data into context of previous short duration floods in Scotland. The report also details the impacts of the flooding, how forecasting services highlighted the risk and presents a more detailed flooding analysis on the areas most affected.

It is important to note that all data in this report are subject to uncertainty. Whilst every effort has been made into ensuring the hydrological data presented is as accurate as possible, it must be recognised that measuring extreme rainfall is uncertain in nature and that it was not possible to visit all sites to undertake full quality control checks immediately after the event due to the restrictions associated with Covid-19.

### **The Hydrometeorological Situation**

Hot continental airmass was the predominant weather type over the United Kingdom for several days from 7 August leading up to the 12 August.

During the evening and overnight period of Tuesday 11 August and the morning of Wednesday 12 August, a cluster of thunderstorms formed and tracked northwards across the eastern half of Scotland before clearing into the North Sea. These brought significant amounts of rain and lightning, with the intensity of the rain resulting in large accumulations in a short period of time<sup>2</sup>.

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<sup>2</sup> Met Office (2020) 11th August 2020 Flash Flood Assessment Timeline, Met Office, Exeter, 9pp.

The heavy rainfall associated with the convection started across the Lothians and Fife in the late evening of Tuesday 11 August and progressed north across Perth and Kinross overnight. Other parts of eastern Scotland remained dry at this time.

By early-morning on the 12 August the thunderstorm activity began to move north-eastwards with some very heavy, thundery rainfall reaching south east Aberdeenshire. This heavy, thundery rain then continued for around four or five hours, giving some notable rainfall totals within relatively short periods of time.

Due to the physical characteristics of the atmosphere and uncertainty associated with these types of convective weather situations, it can be very difficult to provide advance forecast detail for specific locations.

Figure 1 illustrates the distribution of rainfall recorded across Scotland during the thunderstorms. The figure shows the maximum 24-hour accumulation for all SEPA's raingauges. Further detail is provided later in the report on short duration rainfall totals. However, the highest 24-hour maximum rainfall values can be seen across central and eastern Scotland such as Fife (106 mm), Clackmannanshire (89 mm), Perth (86 mm), Aberdeenshire (78 mm) and Falkirk (73 mm).

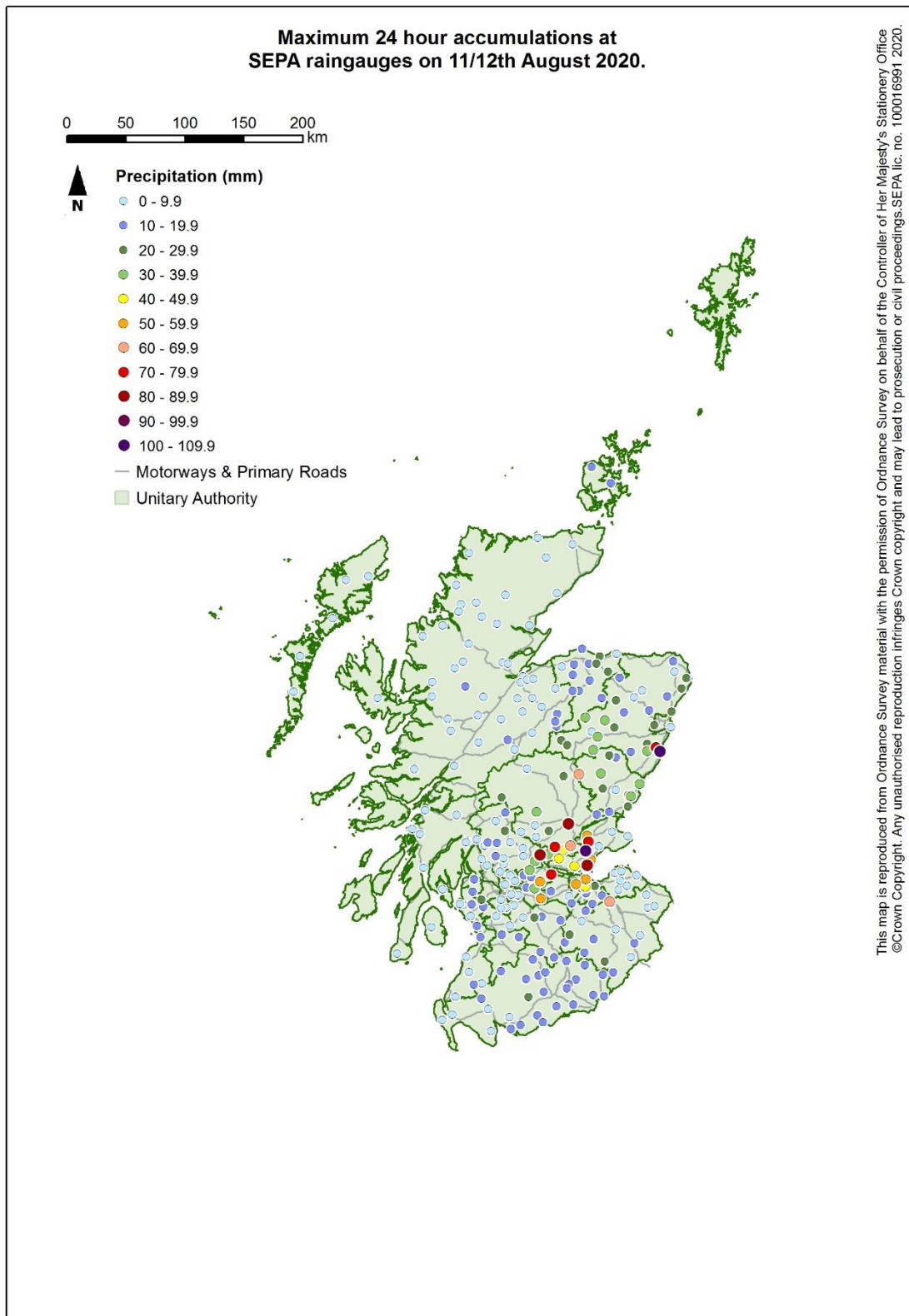


Figure 1: Maximum 24-hour rainfall recorded over 11<sup>th</sup> and 12<sup>th</sup> August 2020

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## The Flash Floods in Context

The following section presents the August 2020 flooding in the context of other historical and short duration rainfall events to illustrate whether the recorded rainfall was extreme.

Similar severe thunderstorms and flash floods in Scotland have resulted from what has been considered extreme rainfall. The flood of 25 July 1983 on the Hermitage Water in Roxburghshire saw 65 mm of rainfall being recorded in 75 minutes causing significant disruption and impact on the natural environment<sup>3</sup>.

There are several examples rainfall events which have caused transport infrastructure failures in recent years. These include the Glen Ogle A84 landslide of 2004 which measured 47 mm in 15 minutes and the disruption to the rail line north of Dunblane in 2012 which saw 65 mm in 6 hours, although this was estimated from radar given the lack of raingauge data.

Some of the areas affected by the August thunderstorms have historically been impacted by floods. For example, Perth experienced a flash flood event in the summer of 2002 caused by similar convective short-duration rainfall which affected many properties which were flooded from the Craigie Burn. For this flash flood 30 mm in 1 hour was estimated to have fallen<sup>4</sup>.

Figure 2 plots a series of historical short duration rainfall events and an extreme rainfall threshold for Scotland. The DEFRA extreme rainfall threshold is a series of rainfall depths for different durations that should be considered as extreme rainfall. The original work had only a limited number of historical Scottish cases but was adjusted from a UK profile<sup>5</sup>.

A study in 2007 more focused on Scotland identified 44 extreme rainfall events and classified these as convective, frontal or orographic<sup>6</sup>. The events collated as part of this study have been plotted in Figure 2 alongside the extreme rainfall threshold.

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<sup>3</sup> Acreman, M. (1991) The flood of July 25<sup>th</sup>, 1983 on the Hermitage Water, Roxburghshire Scottish Geographical Magazine, 107:3, 170-178

<sup>4</sup> Cargill, A, MacConnachie, A. M. and Perrett, J. C. (2004) Flash flood on the Craigie Burn, Perth, Scotland. Weather, January 2004, Vol. 59, No. 1.

<sup>5</sup> Collier, C. G., Fox, N. I., and Hand, W. H. (2002) Extreme Rainfall and Flood Event Recognition. DEFRA/Environment Agency, Technical Report, FD2201.

<sup>6</sup> Met Office (2007) Extreme Event Analysis. Final Report to the Met Office by Envirocentre.

What can be illustrated by the figure is:

- The rainfall recorded by several raingauges in the recent event (presented as ▲ on the figure) are close to the DEFRA extreme rainfall values for Scotland, or in some cases exceed these, i.e. 57.8 mm in an hour at Dunnottar and 79 mm in just over three hours at Cheyne.
- The rainfall recorded for the 11 and 12 August in some locations exceeded the rainfall depth recorded for some recent and very notable flash flood events in Scotland, including Glasgow 2002, Ex Tropical Storm Bertha and the Perth floods from 2002 highlighted above, when 30 mm was recorded in an hour compared with 41 mm on the 11 August.
- Whilst historical extreme rainfall events (presented as ■ on the figure) may include events which have recorded greater rainfall at short durations, these events are small in numbers (19 convective events from records dating back to 1901) and therefore the rainfall recorded during the 11 and 12 August 2020 can be considered rare.



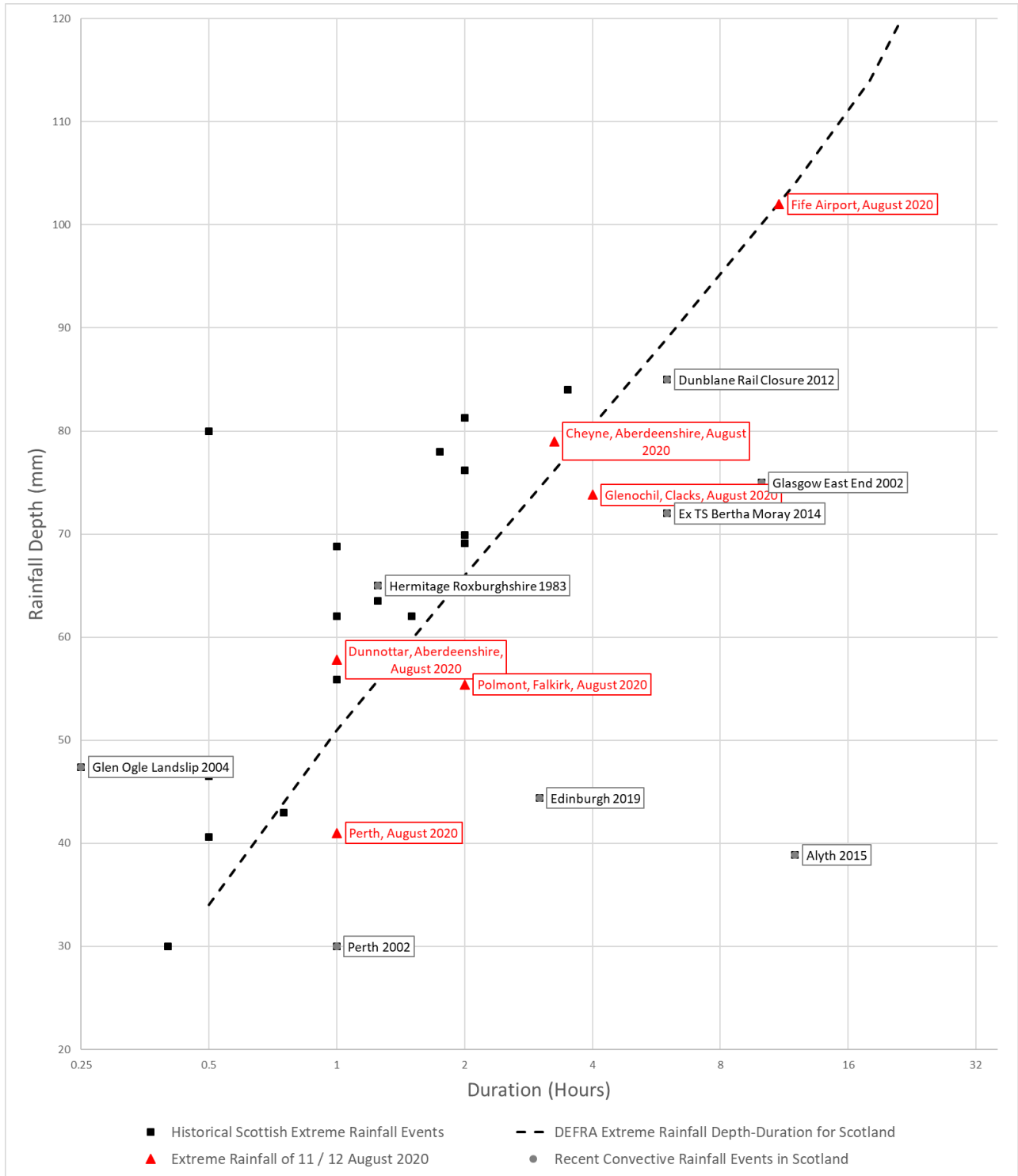


Figure 2: Comparison of the 11 and 12 August rainfall with historically extreme short duration rainfall in Scotland

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## The Impacts of the Thunderstorms and Flash Floods

The extreme rainfall recorded during the thunderstorms of the 11 and 12 August resulted in large scale flash flooding with impacts and disruption across central and eastern Scotland being extensive and severe. Impacts included:

- Flooding in Stonehaven predominantly due to surface water and some minor flooding from the Carron
- Rail derailment at Carmont near Stonehaven
- Over 190 properties flooded across Perth & Kinross
- A breach in the Union Canal near Polmont which meant damage and closure of the Edinburgh-Glasgow railway line
- A major gas pipe exposed due to erosion along the Black Devon in Clackmannanshire
- Extensive flooding in the Falkirk and Grangemouth area
- Extensive surface water flooding and a major incident declared in Fife due to the extensive impacts including at Kirkcaldy hospital and the evacuation of a caravan park due to a landslide
- A carriageway of the A68 in Midlothian being washed away.

SEPA collate information on the impacts of flooding across Scotland through its *Observed Flood Events* database. This information is gathered from members of the public through Floodline and SEPA's Contact Centre, from SEPA staff, partners such as local authorities and Transport Scotland and from digital sources such as social media. For the period of the 11 and 12 August SEPA have since collated 582 records of flooding impacts.

Another useful source of information regarding the impacts of flooding is through SEPA's Report-a-Flood citizen science data gathering tool<sup>7</sup>. Flooding incidents can be reported by anyone in Scotland and the information is presented in a live flood report map. Figure 3 presents a heat map of all the reported flooding incidents observed across the 11 and 12 August highlighting the key areas that were impacted by the floods.

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<sup>7</sup> SEPA. Report-a-Flood. <https://floodlinescotland.org.uk/report-a-flood/>

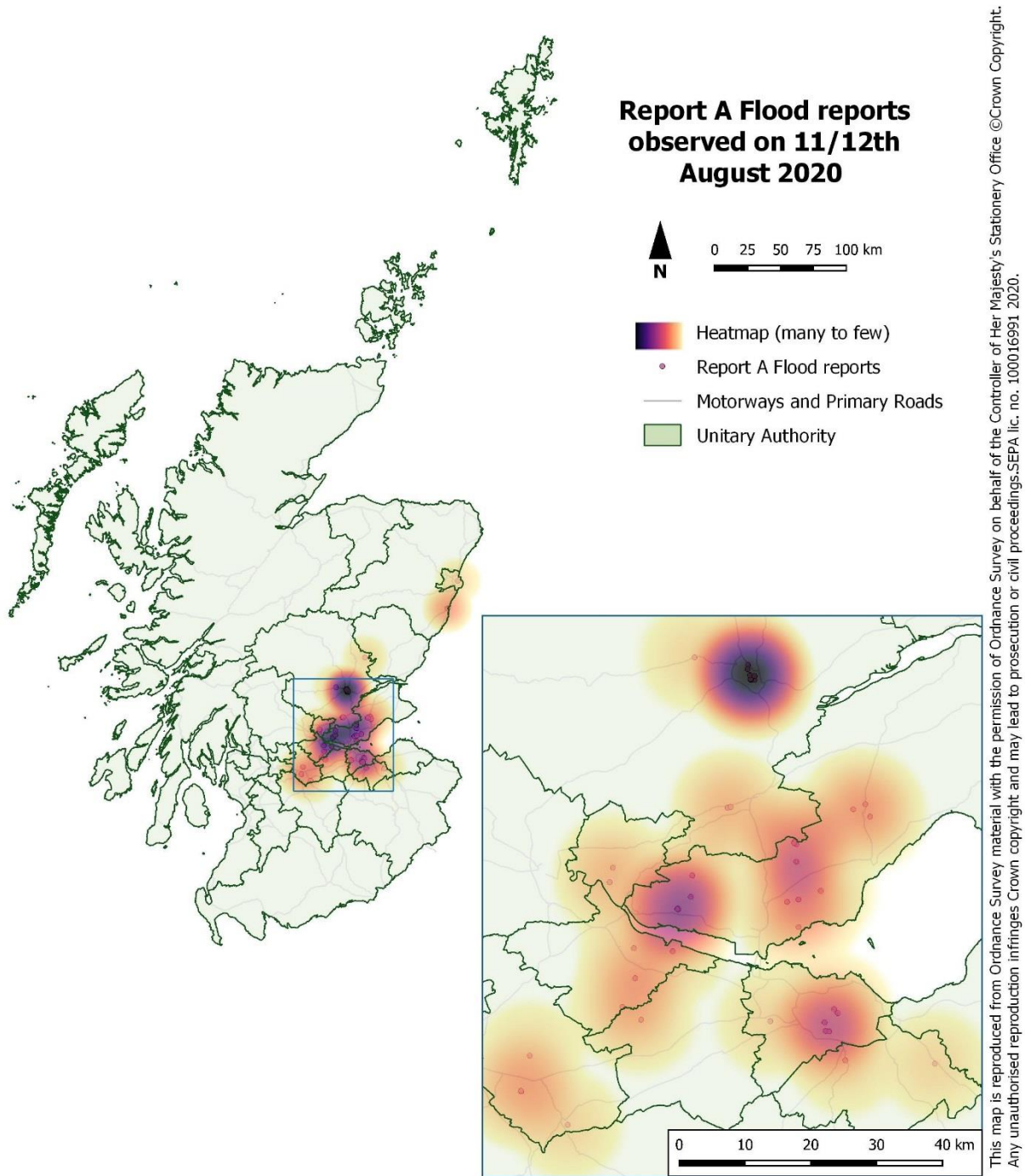


Figure 3: Distribution of reported flooding incidents on the 11 and 12 August 2020 as reported to Report-a-Flood

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## Flood Guidance and Alerts

Working in partnership with the Met Office, the Scottish Flood Forecasting Service provides flood forecasts and guidance on surface water flood risk through a Flood Guidance Statement. This flood outlook is issued daily to flood and emergency responders in Scotland forecasting the potential for flooding.

On Saturday 8 August, it indicated that “property flooding and damage, and disruption to travel and infrastructure are possible” for three consecutive days from Monday 10 August to Wednesday 12 August. At that stage, the risk was highlighted for the whole of Scotland.

Similar and updated guidance on Sunday 9, Monday 10 and Tuesday 11 August in the Flood Guidance Statement were issued highlighting the possibility of significant impacts. On Tuesday 11 August, the flood guidance included an area of concern which covered the area subsequently affected (see Figure 4).

Flood Alerts which are sent to responders and the public by SEPA were issued for large parts of the country during Monday 10 August. For example, a Flood Alert for Aberdeenshire and Aberdeen City was issued at 14:45pm on Monday 10 August stated:

*‘A Flood Alert has been issued for Aberdeenshire and Aberdeen City. From Tuesday morning through to Wednesday heavy thundery showers could cause flooding impacts from surface water and small and fast responding watercourses. Particularly at risk are urban areas and the transport network. There may be difficult driving conditions. Due to the localised nature of the heaviest showers, impacts may be isolated with not all locations being affected. Sudden onset flooding impacts could occur at any time of the day.’*

Updates were issued to the Flood Alerts the following day including this below at 12:35pm on Tuesday 11 August, stating:

*‘Heavy thundery showers during Tuesday and Wednesday could cause flooding impacts from surface water and rivers. Particularly at risk are urban areas and the transport network. There may be difficult driving conditions. Due to the localised nature of the heaviest showers, impacts may be isolated with not all locations being affected. Sudden onset flooding impacts could occur at any time of the day. The greatest risk is during Tuesday evening into early Wednesday morning. Flooding of properties, parts of*



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## Detailed Flood Incident Reports

The following reports provide more detail on specific flash flood incidents during the thunderstorms of the 11 and 12 August 2020. The detailed reports include rainfall analysis and flooding impact information for South East Aberdeenshire, Perth and Kinross, Fife and Falkirk.

Whilst we have presented some selected return period analysis for rainfall recorded during this storm, this needs to be considered with caution.

The Flood Estimation Handbook<sup>8</sup> is currently used to offer guidance on rainfall and river flood frequency estimation across the UK. Rainfall is assessed using the most up to date depth duration frequency (DDF) model which is FEH13. However, the analysis will be limited by the data which the model is based on – both the length of the raingauge records that are available in the model, and the spatial distribution of gauges.

That means that if the nearby raingauges included in the model don't have records long enough to capture other extreme events which have occurred, the statistical analysis of this event against the record will show it as being more extreme than it is. For example, if the DDF model has less than 100 years of rainfall data within it, any estimates of return period which exceed 100 years would be an extrapolation of the available data and so uncertainty increases the higher these values are.

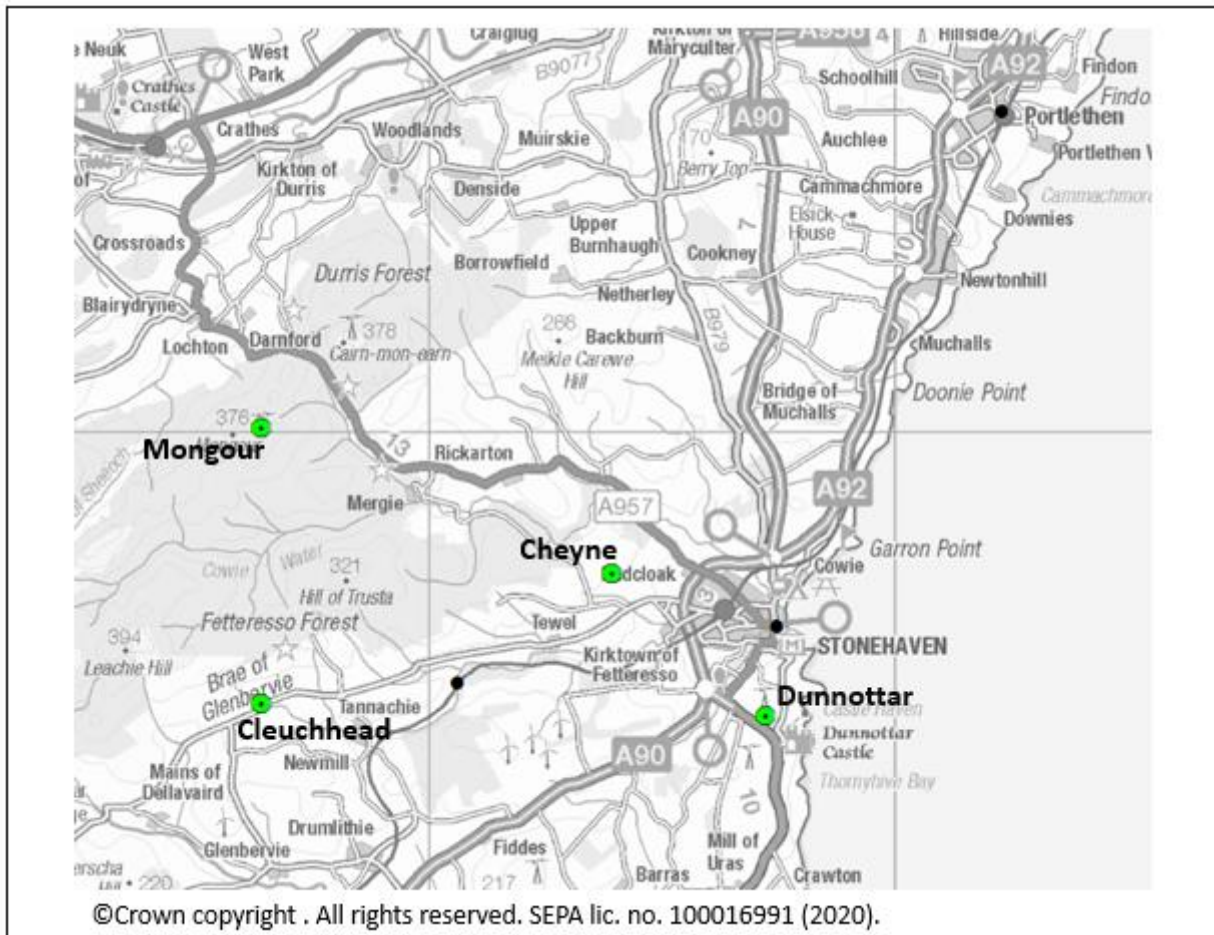
The very rare return periods which are suggested in this analysis is not an accurate reflection of the likelihood of similar events happening again in these locations.

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<sup>8</sup> UK Centre for Ecology and Hydrology. Flood Estimation Handbook: <https://www.ceh.ac.uk/services/flood-estimation-handbook>

## South East Aberdeenshire

Raingauges in the area (see Figure 4) recorded a significant depth of rain falling in a short period of time. In the worst affected areas around the usual monthly rainfall for August fell within 3 hours.



*Figure 4: Raingauges operated by SEPA in South East Aberdeenshire*

As presented in the table below a maximum of 57.8 mm of rainfall was recorded in one hour at the Dunnottar gauge during the morning of the 12 August. As illustrated in Figure 2, this is a historically significant extreme event. This compares to a previous one-hour maximum rainfall of 18 mm measured in July 2015.

The most intense rainfall lasted around 3 hours and delivered the full August monthly average rainfall across much of the affected area. The depth of rain which fell during the thunderstorm was around double the previous maximum totals on record for the same durations, with records dating back some 15 years. Storms with a 1-hour total in excess of

10 mm have occurred every summer since 2013 but not to the magnitude recorded on the 12<sup>th</sup> August.

Raingauge	Max 1-hour total (mm)	Max 3-hour total (mm)	Record from (year)	Average August Monthly Rainfall (mm)
Cheyne	45.0	79.0	2005	82.6
Dunnottar	57.8	78.4	2014	74.7
Cleuchhead	15.8	37.6	2013	96.8
Mongour	15.0	24.0	1995	94.1

*Table 1: Maximum rainfall values recorded for gauges in South East Aberdeenshire on the 11 and 12 August*

As noted above, estimating the return period of the event is difficult given the limitations of the methods available to do that. The current rainfall model in the Flood Estimation Handbook gives an estimate for the event of between 500 and 900 years in the worst affected areas. This is a factor of the limited data that the model is based on and isn't a good indicator of how rare this was, and how likely it is to happen again. This type of intense summer rainfall event seems to be increasing in frequency and how this event compares with past rainfall records might not be a good indication of how likely it is to happen again in future.

It is worth noting that whilst the rainfall intensity recorded was the highest on record (over a period of 15 years), the response in the Carron Water itself was not, being only third highest on record in Stonehaven. Flooding in Stonehaven occurs in a range of scenarios, including those caused by prolonged periods of winter rainfall, and those caused by coastal flooding. The likelihood of this severity of flooding happening is not only related to the rarity of the rainfall, but to a combination of factors including the antecedent conditions.





*Figure 5: Flooding of Barclay Street, Stonehaven on the 12 August. Source: SEPA*

## Perth and Kinross

The table below presents the sub-daily, daily and mean monthly rainfall representative of several communities in Perth and Kinross including Perth (Norwich Union) gauge, Kinkell Bridge (for the Dunning area) and Lathro for Kinross. There is no nearby suitable gauge for Alyth however Forter has been included as the nearest rain gauge.

Raingauge	Max 1-hour total (mm)	Max 3-hour total (mm)	Max 12-hour total (mm)	Average August Monthly Rainfall (mm)
Perth	43.4	56.4	83.4	88.8
Kinkell Bridge	7.8	13.8	18.6	77.9
Forter	18.4	31	50	102.2
Lathro	21.4	29.2	57.2	87.3

*Table 2: Maximum rainfall values recorded for gauges in Perth and Kinross on the 11 and 12 August*

Based on the rainfall analysis that has been undertaken, the event in Perth on the 12 of August is an extreme surface water flood event with nearly a month's rainfall within 12 hours and half of it in 1 hour. The totals may not appear as significant in every area analysed e.g. Kinkell Bridge however the highest rainfall totals may not have been captured by SEPA's rain gauges network in all locations.

Maximum hourly rainfall accumulations for Perth are typically expected to have a return period of a 1 in 150 years. For the longer duration rainfall accumulation these are expected to have a return period in the range of 1 in 75 (3 hours) and 1 in 250 years (12 hours). Communities affected by flooding include Alyth, Kinross, Dunning, Pitlochry and Perth. It has been reported that approximately 192 homes and businesses had been affected by flooding<sup>9</sup>.

<sup>9</sup> Perth and Kinross Council (2020) Flood Bulletin, 5pp.

## Fife

The table below presents the sub-daily, daily and mean monthly rainfall for gauges across Fife. The raingauges selected are those that recorded the most notable rainfall and highlight the exceptional and variable rainfall across the 11 and 12 August.

Raingauge	Max 1-hour total (mm)	Max 4-hour total (mm)	Max 12-hour total (mm)	Average August Monthly Rainfall (mm)
Kinghorn	40.1	69.6	82.8	84.6
Fife Airport	40	73.8	105.6	70.7
Kirkcaldy	35.2	44.8	53	89.4

*Table 3: Maximum rainfall values recorded for gauges in Fife on the 11 and 12 August*

Maximum hourly rainfall accumulations are typically expected to have a return period of a 1 in 100 years.

However, the 4- and 12-hour accumulations for Kinghorn and Fife Airport are expected to have a return period in the range of 1 in 300 and 1 in 1,000 years. The figures should be taken with the caution noted above.

As a consequence of the rainfall, extensive surface water flooding occurred across Fife. A major incident was declared in Fife due to the extensive impacts including at Kirkcaldy hospital and the evacuation of a caravan park due to a landslide

## Falkirk and West Lothian

The table below presents the sub-daily, daily and mean monthly rainfall for gauges across Falkirk. The raingauges selected are those that recorded the most notable rainfall and highlight the exceptional and variable rainfall across the 11 and 12 August.

For Polmonthill, the max 1-hour rainfall occurred between 04:00 and 05:00 on Wednesday morning with the maximum rainfall falling in the 2-hour period from 04:00. The max 1-hour rainfall at Whitburn occurred at 02:00 with the maximum rainfall recorded between 02:00 and 05:00. Finally, the max 1-hour rainfall recorded at Slamannan was at 03:00 with the maximum rainfall occurring in the period between 03:00 and 04:00.

Based on the initial rainfall analysis that has been undertaken, the area around Linlithgow Bridge (using Polmonthill rain gauge which is the closest) experienced about a month's rain in 5 hours, more than a month's rainfall within 12 hours and more than half of it in 1 hour. Slamannan recorded about half of the mean monthly rainfall within a 3-hour period. The totals may not appear as significant in other areas e.g. Whitburn however the highest rainfall totals may not have been captured by the SEPA rain gauge network in all locations.

Raingauge	Max 1-hour total (mm)	Max 3-hour total (mm)	Max 12-hour total (mm)	Average August Monthly Rainfall (mm)
Polmonthill	43.6	57	72.4	64.5
Whitburn	5.6	9.6	10	86.1
Slamannan	17.6	46.6	46.6	81.9

*Table 4: Maximum rainfall values recorded for gauges in Falkirk on the 11 and 12 August*

Using data from the SEPA rain gauge at Polmont Sewage Treatment Works to give an indication of the rarity of the rainfall. The analysis suggests a return period of between 1 in 100 and 1 in 250 years for 1 to 12 hours storm duration.



*Figure 6: Breach of the Union Canal resulting in water from the canal to spread across neighbouring fields and flooded the Edinburgh to Glasgow rail line. Source: Scottish Canals ([www.scottishcanals.co.uk](http://www.scottishcanals.co.uk)).*

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