



Scottish Flood Forecasting Service
Working in partnership

Development of a pilot surface water alerting tool for Glasgow and operational use during the Commonwealth Games

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Scottish Flood Forecasting
Service / SEPA

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Met Office - B. Golding, C. Pierce, B. Wright, N. Roberts, James Hutton
Institute - S. Ghimire, S. Dunn, Deltares – J. Dhandia



Scottish Flood Forecasting Service
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Content

- **Background** – What and why?
- **Pilot application** – Where?
- **Technical set up** – How?
- **Event review** – How well?
- **Conclusions** – What next?

Background

Surface water flood forecasting in Scotland

  Scottish Flood Forecasting Service
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Flood Guidance Statement 10:30hrs 25 July 2013

Our assessment for daily flood risk in Scotland is below. This statement is valid at the time of issue.

10:30 - 23:59hrs Thursday 25 July 2013 00:00 - 23:59hrs Friday 26 July 2013 00:00 - 23:59hrs Saturday 27 July 2013 00:00 - 23:59hrs Sunday 28 July 2013 00:00 - 23:59hrs Monday 29 July 2013

General Overview of Flood Risk

The flood risk is **LOW** across the areas of Scotland coloured yellow on the map on Thursday and Friday due to the possibility of surface water flooding. Small watercourses may also be affected. There is a medium likelihood of minor disruption in these areas, and a low likelihood of significant disruption. In the other areas of the mainland coloured green for Thursday there is still a possibility of minor impacts, however the likelihood is low, and therefore the overall risk is very low.

There is also the potential for disruption going into the weekend; there is still much uncertainty about the detail of this.

Weather Situation

The rather humid airmass will continue to bring a threat of thundery showers and isolated torrential downpours over the next five days. A band of rain over parts of southern and central Scotland on Thursday morning will turn showery as it moves north into the Highlands, then by afternoon much of the mainland away from the far north will be at risk of scattered thundery downpours. This risk continues into Thursday night when some longer spells of heavy rain are possible these extending to the far north and Orkney by Friday morning. Thereafter, each day carries the risk of scattered thundery downpours over the mainland, mainly in the afternoons and evenings, with some respite night and mornings.

Warnings and Alerts in force in Scotland at 10:30hrs

Flood ([click here](#))
0 Severe Flood Warnings / 0 Flood Warnings / 7 Flood Alerts

Severe Weather (relevant to flood risk) ([click here](#))
Warning - Yes / Alert - No

Surface Water Flood Risk
There is a **MODERATE** likelihood of **MINOR** disruption due to surface water flooding across most parts of the country on Thursday and Friday due to thundery downpours. There is also a **LOW** likelihood of **SIGNIFICANT** disruption if the most intense showers fall in vulnerable areas. The main focus of any impacts on Thursday will be central and western areas, and mainly during the afternoon and evening. There is still a low likelihood of minor impacts in the eastern areas coloured green on the map.

On Friday there remains a low risk in all areas.

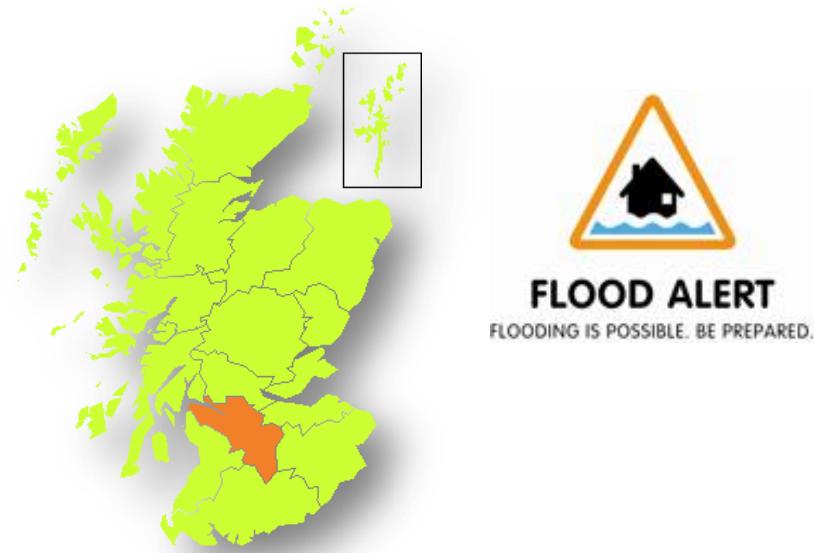
Possible impacts include flooding of low-lying areas, urban areas, built-up rural areas, and the travel network.

For the remainder of the forecast period there is an ongoing risk of thundery downpours, however, confidence in the detail is not sufficiently high to extend the risk level.

River Flood Risk
Depending on where the heaviest showers fall, some small watercourses, particularly in urban areas, may experience a

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Page 1 of 2



Met Office NSWWS



Aims & Objectives

Review the current state of the art in surface water flood forecasting for urban communities and to develop a potential methodology for surface water flood forecasting in Scotland

Pilot application

You are in: Scotland

Wednesday, 31 July, 2002, 16:03 GMT 17:03 UK

Commuter line back on track[News Front Page](#)
[World](#)
[UK](#)
[England](#)
[N Ireland](#)
Scotland
[Wales](#)
[Politics](#)
[Business](#)
[Entertainment](#)
[Science/Nature](#)
[Technology](#)
[Health](#)
[Education](#)[Talking Point](#)[Country Profiles](#)
[In Depth](#)[Programmes](#)**BBC SPORT**
[WEATHER](#)**BBC NEWS**

You are in: Scotland

Wednesday, 31 July, 2002, 04:29 GMT 05:29 UK

Homes evacuated after flooding[News Front Page](#)
[World](#)
[UK](#)
[England](#)
[N Ireland](#)
Scotland
[Wales](#)
[Politics](#)
[Business](#)
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[Science/Nature](#)
[Technology](#)
[Health](#)
[Education](#)[Talking Point](#)

The scene on a road at Livingston.

to severe flood



July 2002



July 2002



July 2013



Summer flooding in Glasgow

July 2002, June 2007,
August 2011,
July 2012, July 2013

The Commonwealth Games Pilot

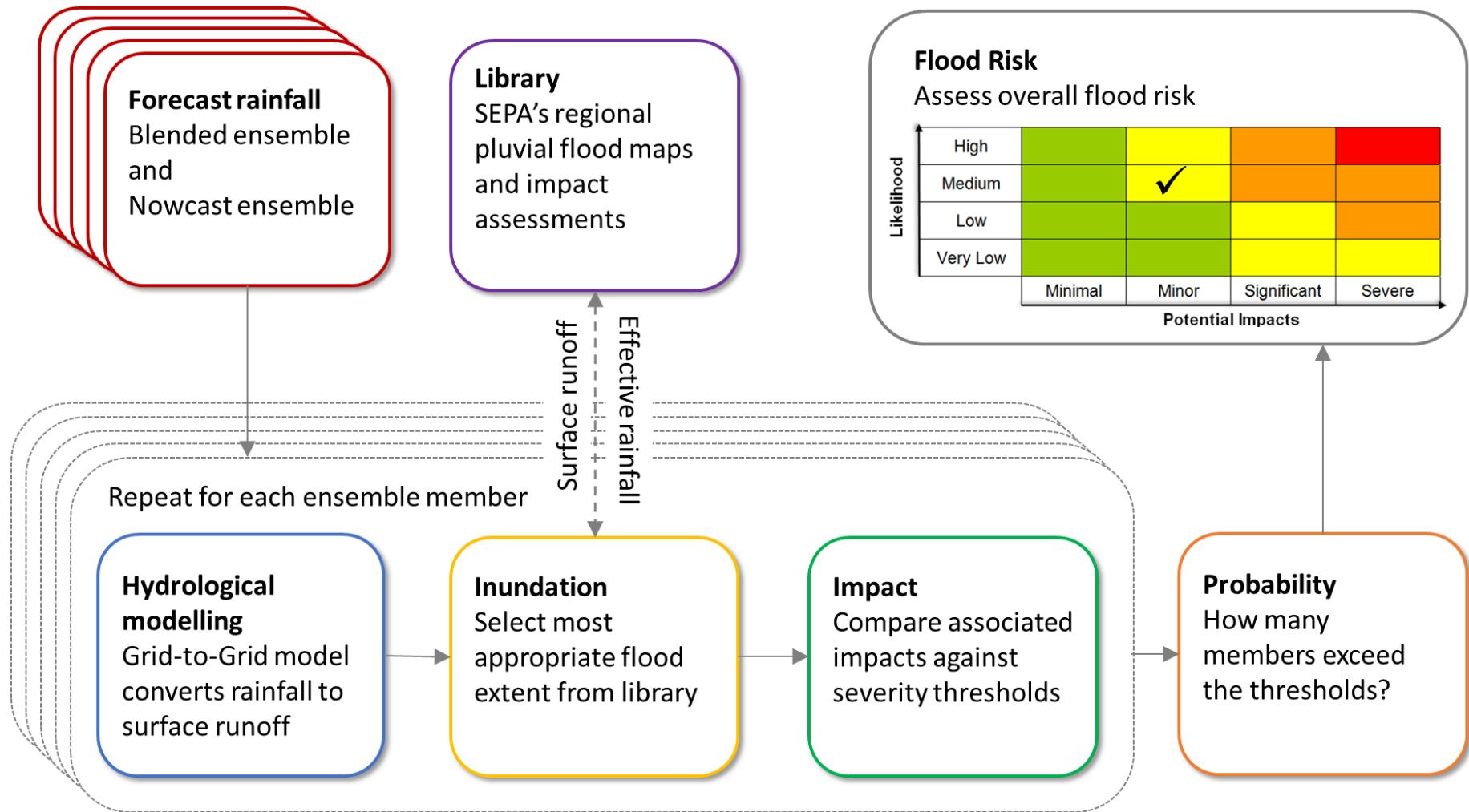


- High profile event to demonstrate science
- Opportunity to share resources / knowledge
- Strategic Flood Risk Assessment for Games identified flooding as a risk
- Well established network of responders



Technical set up

Methodology



FEWS Glasgow

FEWS Glasgow

Select a current forecast
26-08-2014 09:23

Show Reports

Glasgow Reports

- Impact (MOGREPSUK)
 - Rainfall (Minor)
 - Surface Runoff (Minor)
 - Surface Runoff (Significant)
 - People and Property (Minor)
 - People and Property (Significant)
 - People and Property (Severe)
 - Roads
 - Railways
 - Overall Risk
 - Surface Runoff (TimeSeries)
- Impact (NOWCAST)
- System Status Report

Blended Ensemble

Region: Glasgow

Time of Report: 18/07/2014 21:3:

People & Property (Overall) - Forecast 22:00

Overall Surface Water to People and Property forecast period

Probability of exceeding the minor impacts threshold during the forecast period

| |
|----------|
| Very Low |
| Low |
| Medium |
| High |

Forecast name : Blended Ensemble
Forecast time (T0): 18/07/2014 19:00 GMT

Rainfall (minor) - Forecast T3 - T27 2

Probability of exceeding rainfall within 3 hours forecast period

| |
|------------|
| 5% - 19% |
| 20% - 39% |
| 40% - 59% |
| 60% - 79% |
| 80% - 100% |

Forecast name : Blended Ensemble
Forecast time (T0): 18/07/2014 19:00 GMT

Surface Runoff (Minor) - Forecast T3 - T27 2

Probability of exceeding the minor impacts threshold during the forecast period

| |
|------------|
| 5% - 19% |
| 20% - 39% |
| 40% - 59% |
| 60% - 79% |
| 80% - 100% |

Forecast name : Blended Ensemble
Forecast time (T0): 18/07/2014 19:00 GMT

People and Property (Minor) - Forecast 22:00

Probability of exceeding the minor impacts threshold during the forecast period

Blended Ensemble

You are here: Home > Overview Blended Ensemble

Glasgow Reports

- Impact (MOGREPSUK)
 - Rainfall (Minor)
 - Surface Runoff (Minor)
 - Surface Runoff (Significant)
 - People and Property (Minor)
 - People and Property (Significant)
 - People and Property (Severe)
 - Roads
 - Railways
 - Overall Risk
 - Surface Runoff (TimeSeries)
- Impact (NOWCAST)
- System Status Report

You are here: Home > Overview > People and Property (Minor)

Region: Glasgow

Time of Report: 18/07/2014 21:33 GMT

SEPA
Scottish Environment Protection Agency

print report

People and Property (Minor)

Whole Forecast T3 - T27 22:15 : 22:00

Probability of exceeding the minor impacts threshold during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>20 members) |

Forecast name : Blended Ensemble
Forecast time (T0): 18/07/2014 19:00 GMT

Legend

T3 - T9 22:15 : 04:00

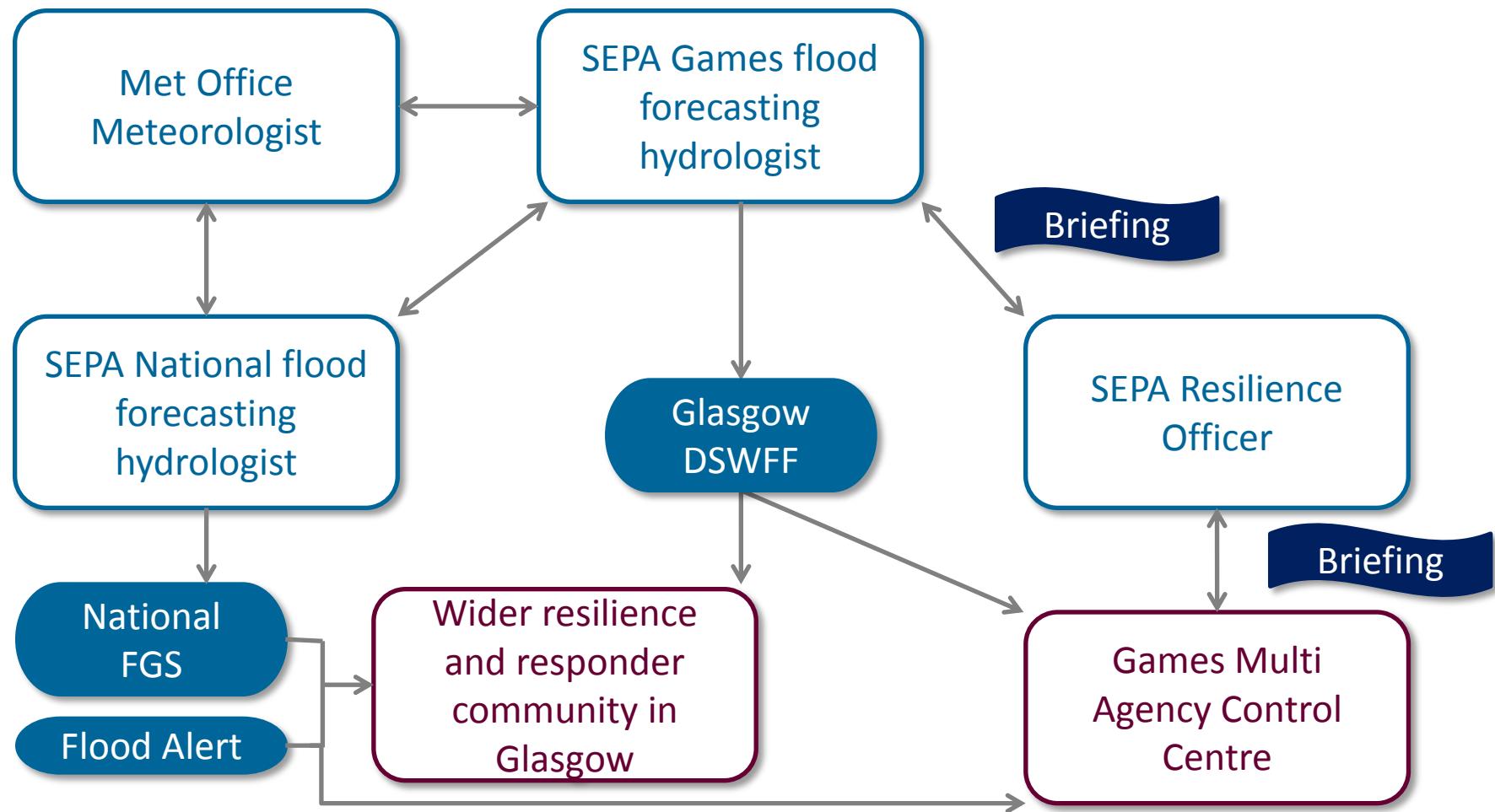
T9 - T15 04:15 : 10:00

T15 - T21 10:15 : 16:00

T21 - T27 16:15 : 22:00

Operations

SFFS Games Operations





Scottish Flood Forecasting Service

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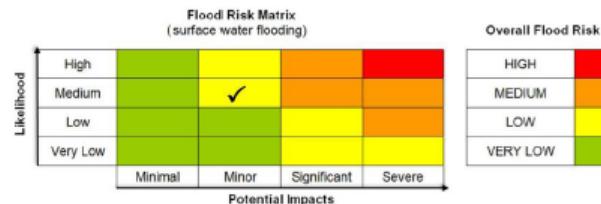
Glasgow Surface Water Flood Forecast Issued at 17:00hrs Sunday 03 August 2014

Our assessment of surface water flood risk in Central Glasgow for the next 24 hours is below. This statement is valid at the time of issue.

Headline surface water flood risk

The overall surface water flood risk for Glasgow for Sunday evening is LOW. The flood risk on Monday is VERY LOW.

Minor disruption is possible including flooding and disruption to infrastructure and transport links. The risk is highest in the north and centre of Glasgow.



Weather Situation

Further rain this afternoon, evening and overnight, occasionally heavy but becoming patchier and unlikely to be as heavy as this afternoon. Rain gradually clearing north during Monday morning.

General overview of surface water flood risk in Glasgow

The surface water flood risk for Glasgow for Sunday evening is LOW and on Monday is VERY LOW.

Following heavy rain witnessed on Sunday afternoon and further lighter rain forecast throughout the evening, there is an increase in the flood risk to the north and centre of Glasgow, primarily to main transport routes in these areas.

Typical impacts will include standing water and spray on the road network. Transport links to and from event venues, especially the city centre, may be impacted. Rail links and infrastructure may also be at risk. Residual impacts may continue into Monday however these are expected to be very isolated and minor, if at all.

Potential flooding impacts may include:

Transport

- City centre roads
- M8 J14-18

Surface water flood risk heightened from: 15:00hrs 3rd August 2014

Expected time of highest risk: 17:00hrs 3rd August 2014

Expected end of heightened risk: 18:00hrs 3rd August 2014

General overview of other sources of flood risk in West Central Scotland (See the Scottish Flood Forecasting Service Flood Guidance Statement issued daily at 10:30hrs for details)

River Flood Risk: Very Low

Coastal Flood Risk: Very Low

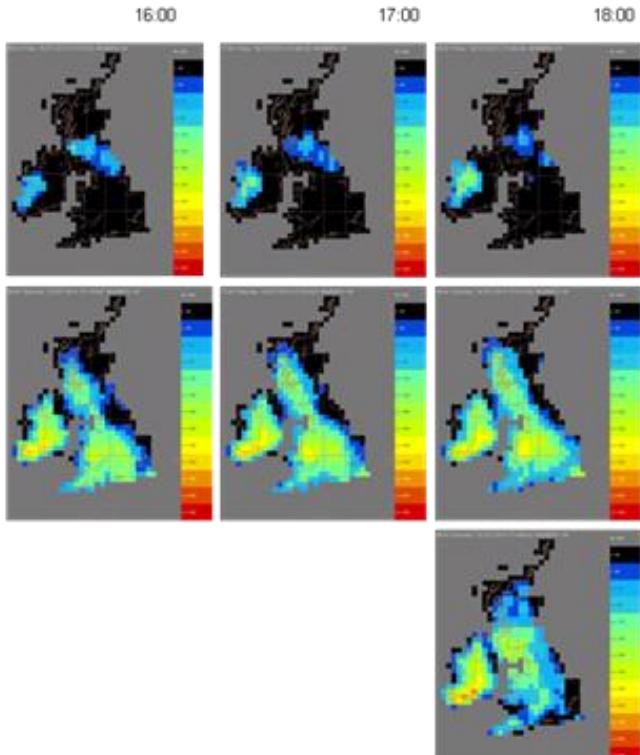
No further Glasgow Surface Water Flood Forecast daily assessments are scheduled, unless the situation changes significantly.

Initial Event Review

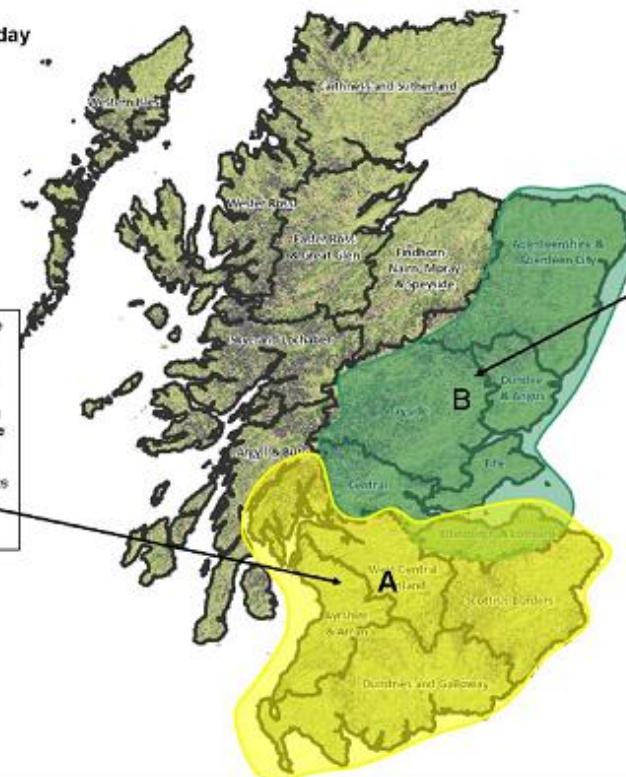


Launch weekend 19th – 20th July

Forecast data time
09:00 GMT
18/07/2014

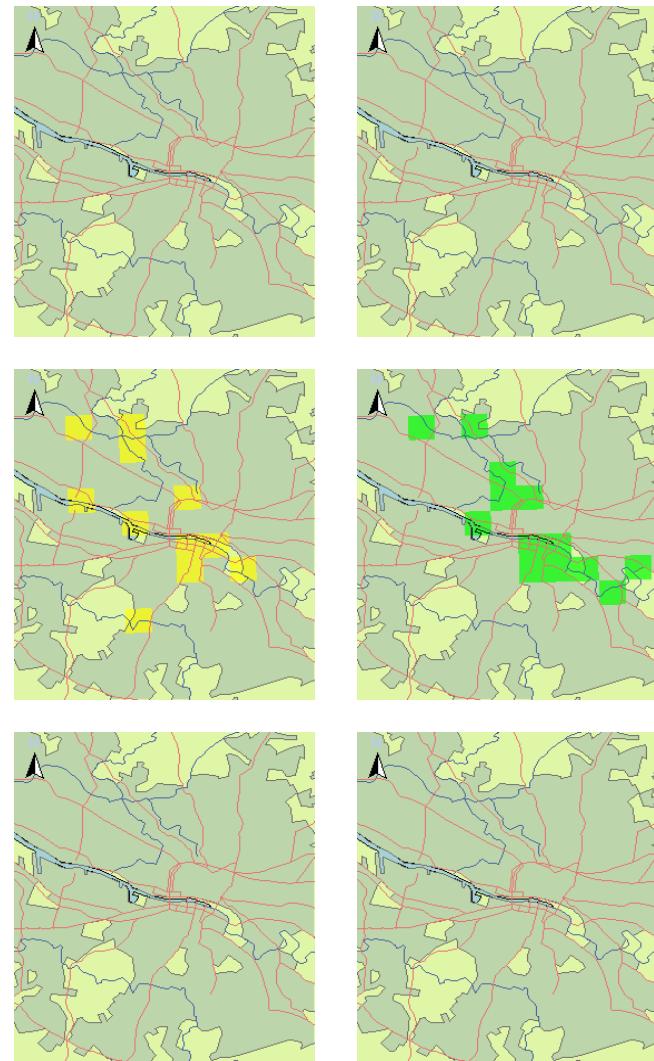


Saturday 19th and Sunday 20th July 2014



HRA Probability of greater than 20mm in 3 hours

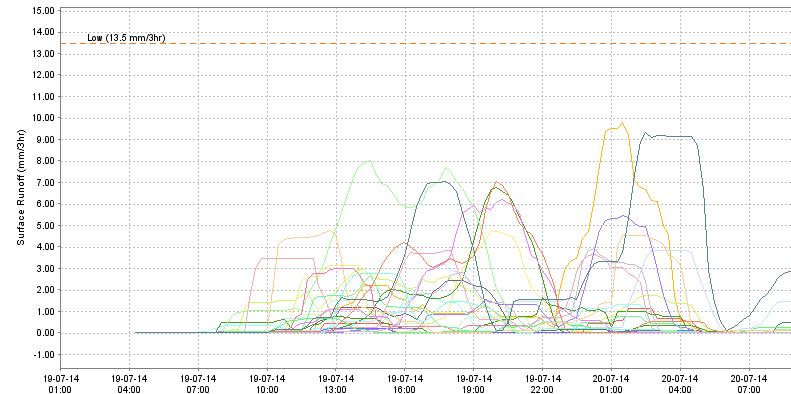
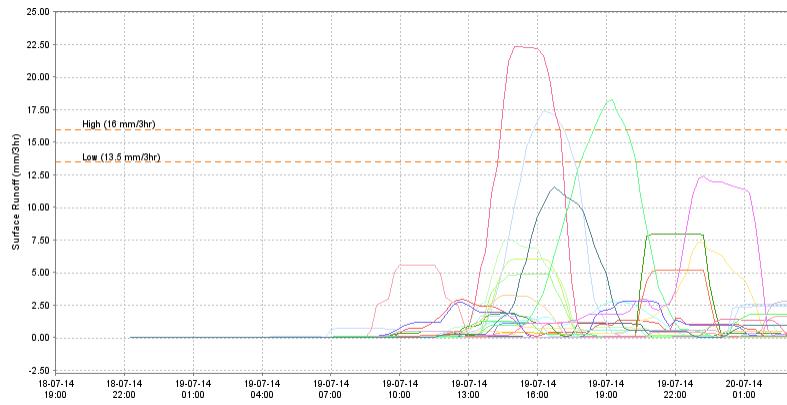
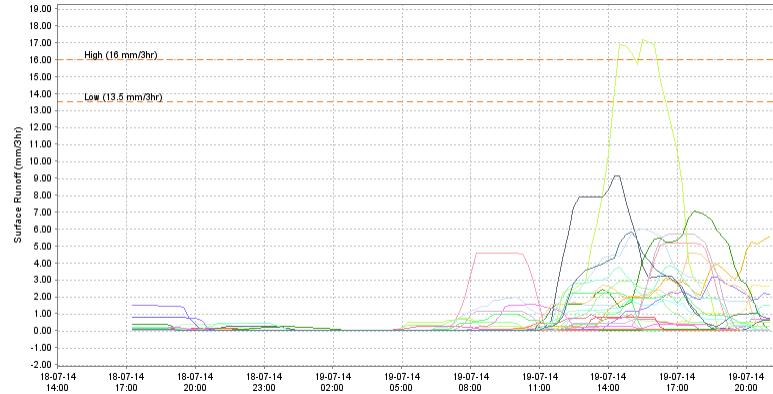
Transport



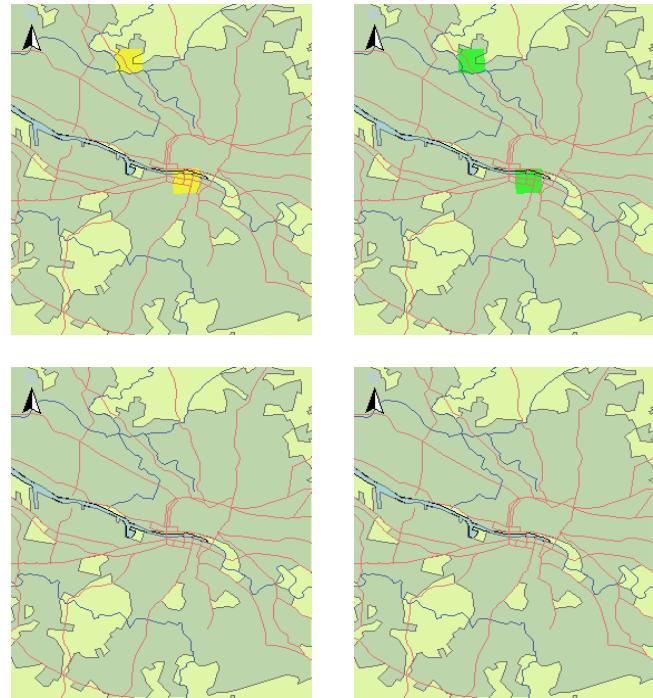
18/07/2014
16:30 GMT

18/07/2014
21:30 GMT

19/07/2014
03:30 GMT

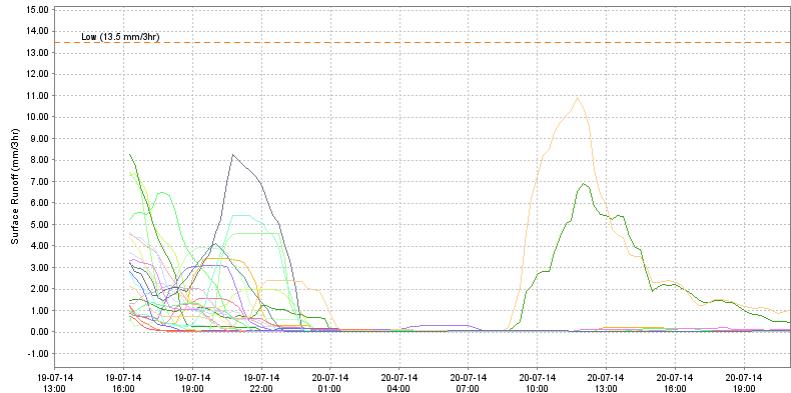
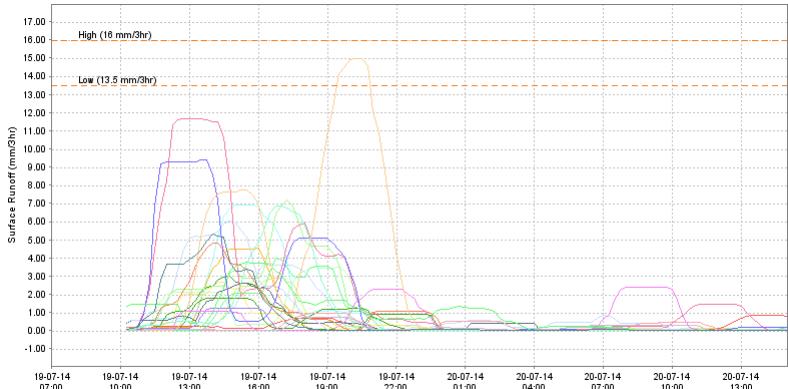


Transport



19/07/2014
09:32 GMT

19/07/2014
15:27 GMT



Flood Risk Matrix
(surface water flooding)

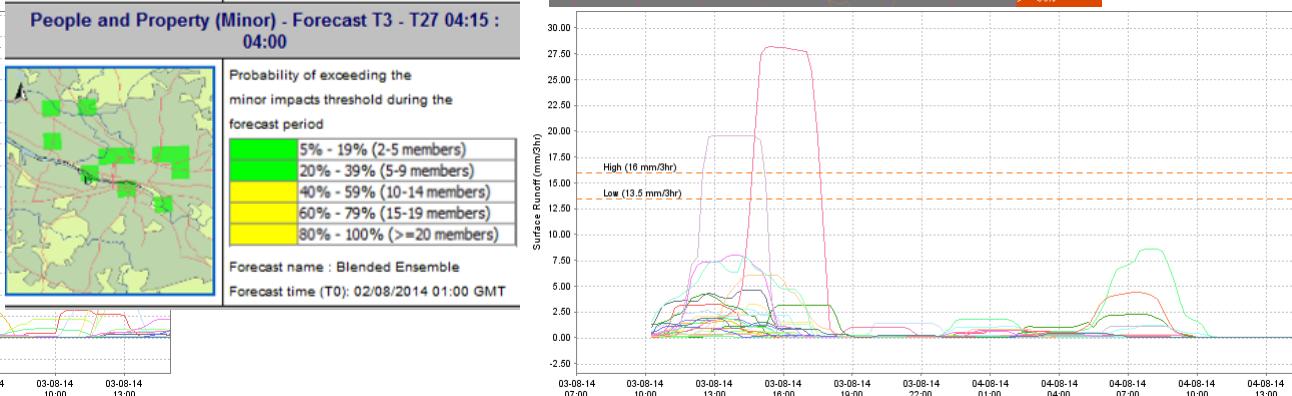
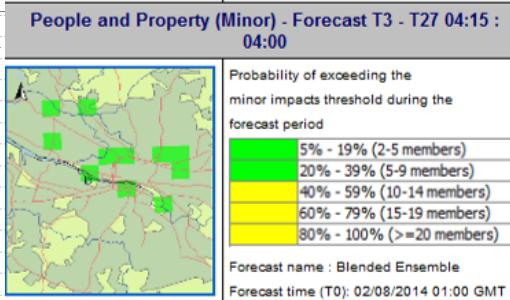
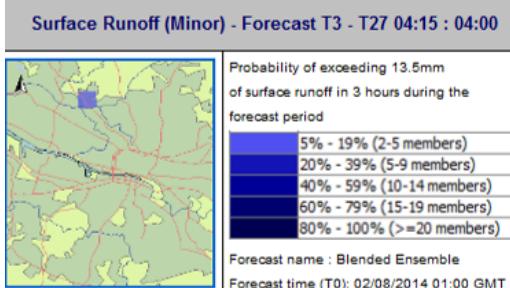
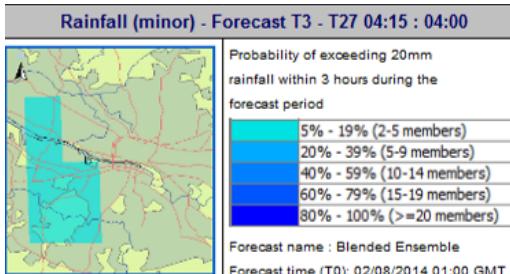
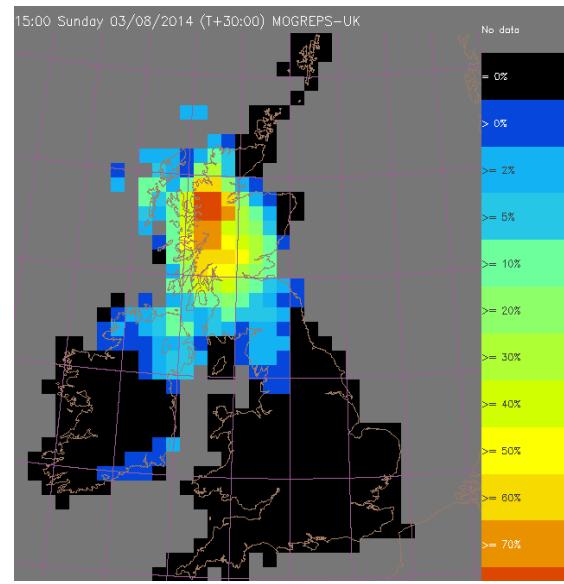
| Likelihood | Potential Impacts | | | |
|------------|-------------------|-------|-------------|--------|
| | Minimal | Minor | Significant | Severe |
| High | | | | |
| Medium | | | | |
| Low | | | | |
| Very Low | | ✓ | | |

Overall Flood Risk

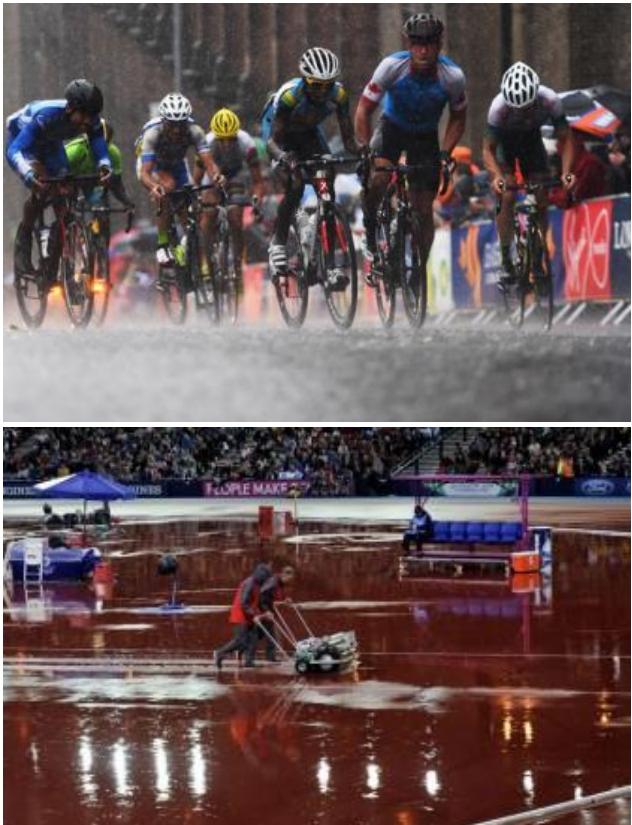
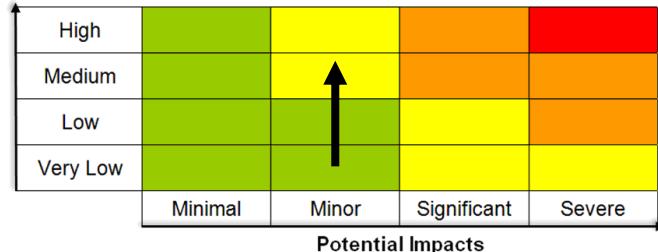
| | |
|----------|--|
| HIGH | |
| MEDIUM | |
| LOW | |
| VERY LOW | |

Final weekend 2nd – 3rd August

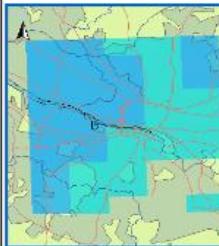
Probability of > 20mm in 3 hours



Flood Risk Matrix
(surface water flooding)



Rainfall (minor) - Forecast T3 - T27 16:15 : 16:00



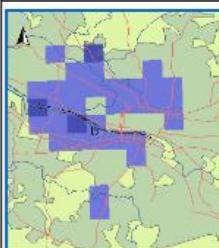
Probability of exceeding 20mm rainfall within 3 hours during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

Surface Runoff (Minor) - Forecast T3 - T27 16:15 : 16:00



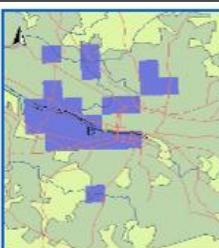
Probability of exceeding 13.5mm of surface runoff in 3 hours during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

Surface Runoff (Significant) - Forecast T3 - T27 16:15 :
16:00



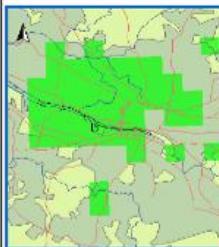
Probability of exceeding 16mm of surface runoff in 3 hours during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

People and Property (Minor) - Forecast T3 - T27 16:15 :
16:00



Probability of exceeding the minor impacts threshold during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

People and Property (Significant) - Forecast T3 - T27
16:15 : 16:00



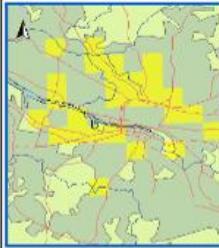
Probability of exceeding the significant impacts threshold during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

Roads - Forecast T3 - T27 16:15 : 16:00



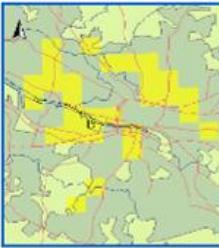
Probability of flooding of > 5m of roads during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

Railways - Forecast T3 - T27 16:15 : 16:00



Probability of flooding of > 5m of railways during the forecast period

| |
|---------------------------|
| 5% - 19% (2-5 members) |
| 20% - 39% (5-9 members) |
| 40% - 59% (10-14 members) |
| 60% - 79% (15-19 members) |
| 80% - 100% (>=20 members) |

Forecast name : Blended Ensemble

Forecast time (T0): 03/08/2014 13:00 GMT

Conclusion

Success and future development

- Actively addressed the challenge of surface water flooding
- Linking science and operational needs
- Real time inclusion of impacts
- Importance of communication

Responders were 'hanging on every word (of the forecast) when the weather turned and the forecasts were pretty accurate'.

→ How could we extend this to other areas in the future?

More information:

SFFS Blog: www.floodforecastingservice.net

CEH Blog: www.cehsciencenews.blogspot.co.uk

SEPA View: www.sepaview.com

Stage 1 project report: <http://www.crew.ac.uk/publications/>

Email me linda.speight@sepa.org.uk

Additional slides

Steering Group



Scottish Water
Always serving Scotland



- Provide input, advice and data
- Advise on existing models and mapping
- Inform on what alerting mechanisms would be beneficial
- Provide link between project and responder community

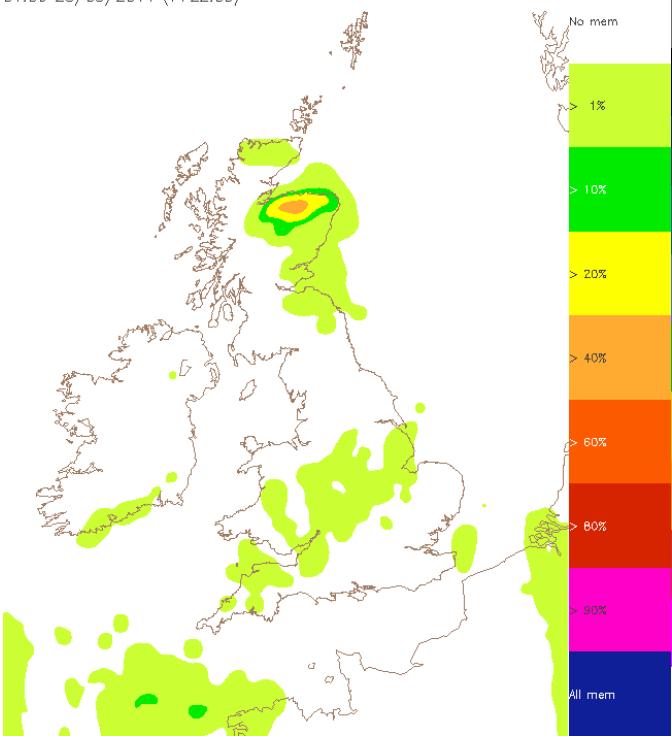


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Meteorology

01:00 23/05/2014 (T+22:00)

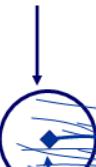


Example of Met Office MOGREPS-UK forecast

Met Office blended ensemble

- 4 times a day
- 27 (24) hour lead time

Initial Condition
Uncertainty



Analysis

Deterministic Forecast

Climatology

time

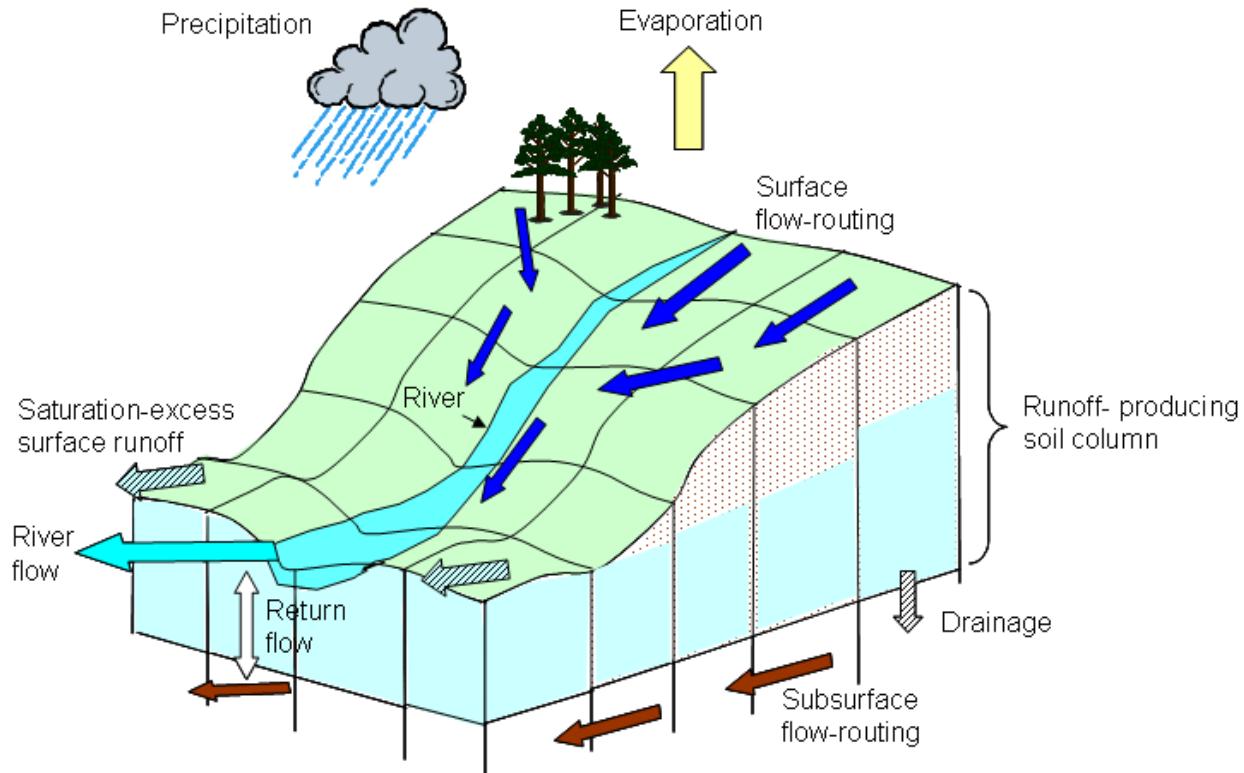
Forecast
uncertainty



Met Office Nowcast ensemble

- 4 times a day
- 7 (6) hour lead time

Hydrology – CEH Grid to Grid model



- Uses spatial datasets on **terrain, soil/geology, land-cover**
- Responds to **spatial variation of rainfall input**
- Already **used countrywide by FFC and SFFS**

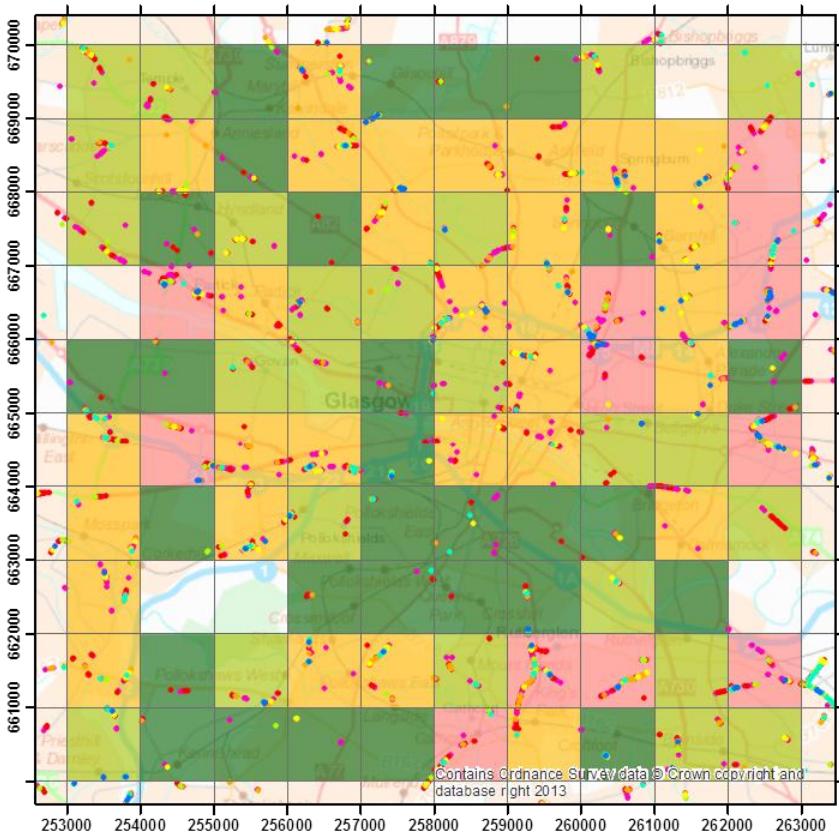
SEPA regional pluvial flood maps



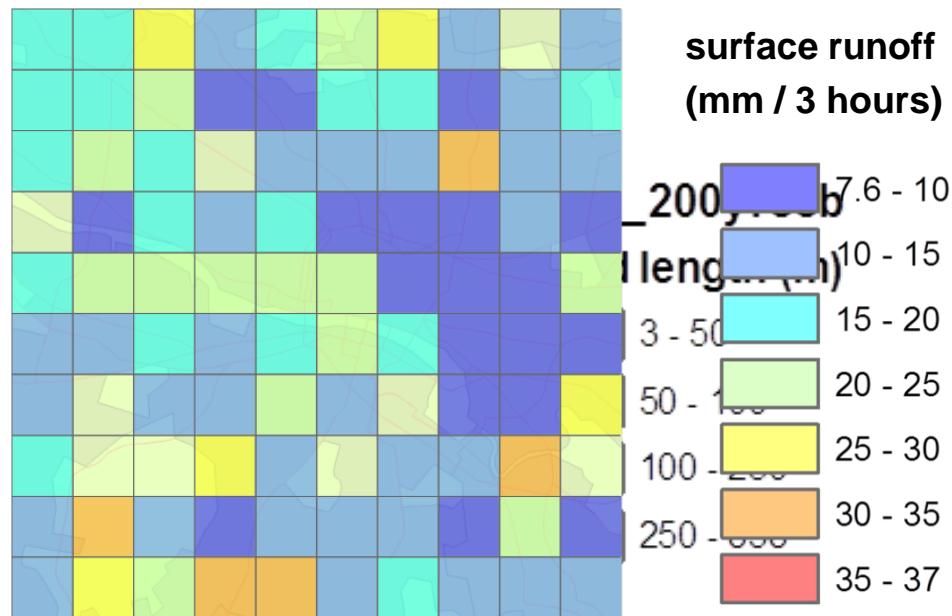
JFlow+
2m LiDAR Grid
'Stubby buildings' 0.3m

| Return Period | Loss | Blanket Storm Duration (hours) |
|---------------|----------|--------------------------------|
| 10 | 1 in 5yr | 1&3 |
| 30 | 1 in 5yr | 1&3 |
| 30CC | 1 in 5yr | 1&3 |
| 50 | 1 in 5yr | 1&3 |
| 100 | 1 in 5yr | 1&3 |
| 200 | 1 in 5yr | 1&3 |
| 200CC | 1 in 5yr | 1&3 |

Flood Extent and Impacts



5m of road flooded in any cell
 =
 significant impact

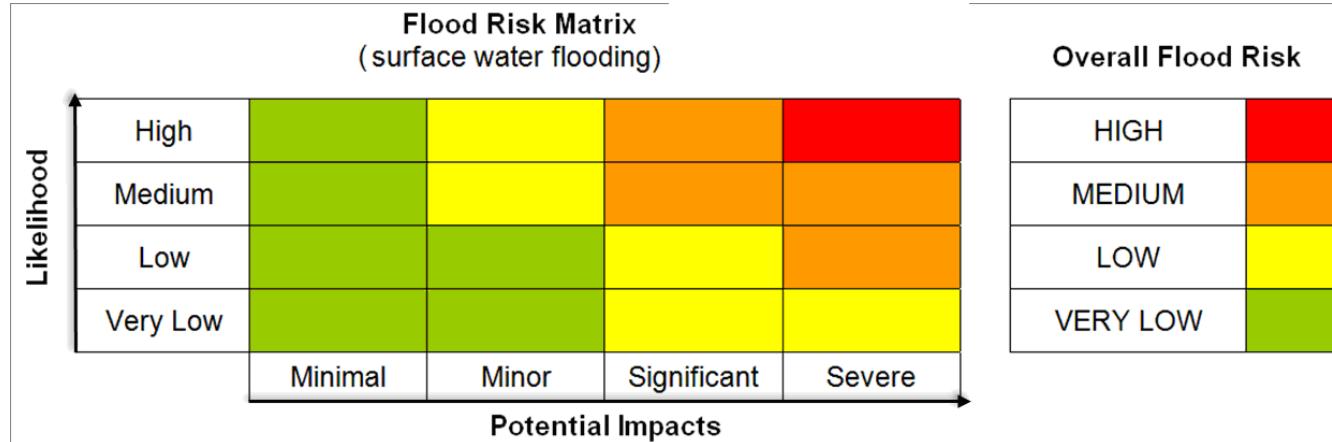


Population
 Community Services
 Utilities
 Commercial Properties

Roads
 Railways

Likelihood

| | Probability | Number of members |
|------------|-------------|-------------------|
| Negligible | 0-5% | 0-1 |
| Very Low | 5-20% | 2-5 |
| Low | 20 – 40% | 5-9 |
| Medium | 40 – 60% | 10-14 |
| High | >60% | >15 |



Full References

SFFS Blog: <http://floodforecastingservice.net/2014/07/14/operational-surface-water-flood-forecasting-model-for-glasgow-now-live/>

CEH blog: <http://cehsciencenews.blogspot.co.uk/2014/07/surface-water-flood-risk-forecasting-glasgow-commonwealth-games.html>

SEPA view: <http://www.sepaview.com/2014/07/new-surface-water-flood-forecasting-tool-benefits-glasgow-and-the-commonwealth-games/>

Stage 1 project report: <http://www.crew.ac.uk/publications/surface-water-flood-forecasting-urban-communities-review>

SEPA Flood forecasting and warning strategy:
<http://www.sepa.org.uk/flooding/idoc.ashx?docid=694c7071-519d-4967-835d-9bd087c18d64&version=-1>