Groundwater flooding summary: Methodology and mapping

Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

1. Introduction

The Flood Risk Management (Scotland) Act 2009 (FRM Act) introduced a co-ordinated and partnership approach to how we sustainably tackle flood risk in Scotland. To fulfil this we are considering all sources of flooding and whole river catchments when making flood risk management decisions.

A key milestone of the FRM Act is the production of flood hazard and flood risk maps for Scotland. These maps provide the most comprehensive national source of data on flood hazard and risk and include information on different likelihoods of flooding.

Due to the nature of groundwater flooding in Scotland there is currently limited information on flood events for this source of flooding and therefore a map showing the different likelihoods of groundwater flooding cannot be produced.

The approach that has been taken to create a groundwater flood map shows a proxy for low likelihood flooding. The groundwater flood map does not show flood hazard or extents. It is an indicative map which highlights catchments within which there are areas where groundwater may contribute to flooding by prolonging a flood event or exacerbating its impacts.

This summary provides information on how we developed our groundwater flood map and how to interpret this data. Its primary purpose is to support Scottish Government, local authorities, Scottish Water and other responsible authorities in their understanding of how the maps were developed and support internal/external briefings and enquiries. This in turn will help to increase public awareness and understanding of flood risk. Previous knowledge of the flood maps and their development is assumed.

2. Development and review

The mapping of flooding is a dynamic process and the flood maps will be subject to review and change as we develop our input data, methodologies and techniques. SEPA will continue to work with responsible authorities and partner organisations to improve our confidence in representing groundwater flooding across Scotland.

Specific work which will help to develop the groundwater flood map includes:

- Improved input data. For example, the collation of additional historic groundwater flooding data;
- Investigate how to effectively apply hydrological and hydraulic modelling methods;
- Incorporation of outputs from detailed local studies where appropriate;
- Undertaking more specific work to develop further flood hazard information;
- Seeking to install new or utilise existing groundwater level monitoring to help interpret flooding events with an aim to establish a probability of occurrence;
- Developing material to help educate stakeholders and the public on the mechanisms of groundwater flooding to enable better reporting of flooding events.

3. Methodology and data

3.1 Approach

A nationally-applied methodology has been used to produce the groundwater flood map for Scotland. The map provides a proxy for a low likelihood flood map. Local flood event information has been taken into consideration where it is available and useable.

The groundwater flood map shows areas where groundwater has the potential to be a contributory factor to flooding or where there has been evidence of groundwater flooding. It is not a flood hazard or extent map.

3.2 Data

The data used to produce the river flood map is listed in Table 1 (Appendix), alongside a description of the data, how it was used and the quality review process.

3.3 Methodology

With any mapping approach, assumptions have been made and the approach will be subject to development as data, methodology and techniques improve. It is the first step in improving our knowledge and understanding of groundwater flooding and as such, should be considered only at the catchment level.

This is a high-level generalised assessment identifying locations where there is sufficient confidence in the prediction that groundwater could contribute to flooding and where there are historic records of flooding.

3.3.1 Aquifer productivity

Aquifer productivity has been used as a coarse indicator of potential susceptibility for groundwater flooding. The highest productivity aquifers are assumed to have high storage potential and have the ability for groundwater to rise and fall in response to a prolonged exceptional rainfall event.

Although this is a generalisation it highlights areas where groundwater could potentially contribute to the extent and duration of other sources of flooding such as river or surface water flooding. This approach may include some aquifers of limited thickness and deep groundwater aquifers e.g. superficial gravel aquifers or Dumfries Sandstone Basin. In these locations, groundwater may rise in response to rainfall but not result in the emergence of water at the ground surface. However, in large river catchments the delay of water moving down the river system may mean that groundwater levels could rise again as the river flood peak passes and water flows from the river into valley gravel deposits

3.3.2 Groundwater flooding associated with rivers

Due to the lack of topographic data, areas in the groundwater vulnerability classification map[1], where the water table is less than 3m below ground level, were viewed alongside the Indicative River and Coastal Flood Map (Scotland). Information on high-productivity aquifers was used to create a proxy indicator of areas that could potentially contribute to groundwater flooding associated with rivers (alluvial flooding).

In line with the generalised national methodology and the inherent uncertainties in the methodology, the proportion of a catchment identified using the above method was used to classify the catchment from low to high confidence that groundwater could have a significant contribution to flooding issues within part of that catchment.

3.3.3 Historic records of flooding

Where appropriate, information on historical records of flooding associated with groundwater have been considered and these areas manually added to those identified through the national methodology.

4. Validation and quality review

Given the more simplistic approach to groundwater flood mapping compared to that taken for other sources of flooding the validation and review process was less comprehensive as there is limited information on local groundwater events and previous outputs at a national scale to compare to and build on.

- **Peer contribution -** Previous reports and publications were used as a knowledge base from which the approach was developed. With future development of the approach it is anticipated that peer contribution will be captured.

[1] Groundwater vulnerability classification map shows the likelihood for contaminants to reach the water table from ground level and therefore includes information on the level of the water table below ground level. See Table 1, (Appendix).

- **Internal review -** SEPA undertook an internal review of the approach and its method of presentation on the flood maps viewer. Operational staff responsible for providing flood risk advice to Planning Authorities also reviewed draft outputs to ensure consistency with expectations.

- **Local authority review** - The approach was presented to flood risk management Local Advisory Groups.

5. Interpretation

The groundwater flood map has been developed using a nationally-applied methodology. It is a tool to help raise public awareness and understanding of flood risk, support flood risk management and land use planning decisions.

The map focuses on providing an indication of the potential for groundwater to contribute to flooding at the catchment scale and is not appropriate for property level assessment. This is due to the application of a nationally consistent methodology to provide Scotland-wide mapping. With this approach there are assumptions and inherent uncertainty so we have set the visual zoom on the map, hosted on the website, to inhibit the use of information at a local scale. Similarly, we would advise that when data is hosted on your internal servers that going beyond the recommended level of zoom will lead to increased uncertainty in the application of the map.

The map is not licensed for commercial use and all users must agree to terms and conditions before viewing the map.

5.1 Confidence

This is the first national scale map to provide an indication of the areas where groundwater could contribute to flooding from other sources. Given the limited information and datasets available at this national scale, a simplistic approach has been adopted. With this approach there are assumptions and inherent uncertainty.

This uncertainty has been managed by providing a proxy for low likelihood flooding rather than a representation of likelihoods of flooding specific to this source of flooding. Identifying catchments where groundwater could contribute to flooding from other sources provides an indication of the areas where further development of data and information is required and will support the flood risk management planning process.

5.2 Limitations

The groundwater flood map has been produced at the national scale using national datasets and a standard methodology. This map helps us to understand groundwater flooding and will provide a tool to help decision making about what actions would be most effective to manage flood risk.

5.2.1 Method limitations

Other more specific mechanisms which may result in groundwater flooding e.g. karstic limestone areas, resurgence of minewater, coastal, placement of obstructions in groundwater flow paths such as sheet piling or flood defences have not been considered in the methodology unless a historic event has been recorded. The methodology may also over-represent some contribution of groundwater where geological mapping exists under significant bodies of water such as Loch Ness, Loch Lomond and the Forth Estuary (some manual interpretation may be required in these areas).

As no monitoring data is appropriate to indicate groundwater flooding events, a return period cannot be attributed to this dataset. This means that the information presented can only be considered as an indication of catchments where groundwater hazard may contribute to flooding. This, therefore, differs from flood maps for other sources (river, coastal and surface water) that show flood hazard.

This dataset does not include a consideration of how climate change may change the nature of groundwater flooding in the future.

5.2.2 Resolution and Caveats

The main difference between the groundwater flood map and the river, coastal and surface water flood maps is that it does not show a groundwater flood extent, but instead highlights those river catchments where groundwater could contribute to flooding from other sources. This does not mean that the entire catchment would be expected to flood during a groundwater flood event, but rather that areas of this catchment could.

This approach is appropriate at the strategic level and serves to raise awareness of groundwater flooding in Scotland and indicate those areas where groundwater needs to be considered in any flood risk management planning process or to prioritise strategic investigations. It should be noted that groundwater flooding can still occur outside the areas shown.

Appendix

Table 1: Data used as an input to the groundwater flood map

Data	Description	How the data was used
Aquifer Productivity Classification	Based on the British Geological Survey superficial and solid geology mapping. Both superficial and bedrock deposits were classified (Scotland only) into aquifers to help characterise groundwater for the Water Framework Directive. This classification produced very low to very high productivity attributes which can also be interpreted as a horizontal groundwater flow pathway	• To provide base data on the location of geological units which have characteristics of high storage potential and have the ability for groundwater to rise and fall during a rainfall event (high and moderately productive aquifers)
Groundwater Vulnerability Classification Map	This classification map assists SEPA in determining the risk of groundwater contamination within groundwater bodies in Scotland. This inherently includes an estimate of depth to water table.	• To identify coarse areas where groundwater may occur at a shallow depth (0-3m) below ground surface.
Indicative River and Coastal Flood Map (Scotland)	Until the publication of flood hazard map, this is the national source of flood risk information. The Flood Map shows the possible extent of flooding from these sources and is an important strategic tool for managing flood risk, primarily focusing on the 200 year flood event (an event with a 0.5% chance of occurring any year) in line with Scottish Planning Policy (SPP).	• Proxy indicator of areas where groundwater is likely to be in continuity with the river system along with high productive aquifers.
Historical information	Historical records of flooding from SEPA and local authorities.	• Review of all records which mention groundwater, expert judgement applied to consider if groundwater is a likely source of flooding or contribution to the flooding account. • Accounts of groundwater flooding were considered but discounted if the description of the source or location of the flooding was ambiguous. • Review was undertaken of current issues raised within SEPA's work on development planning applications, areas were included if groundwater was considered to contribute to other sources of flooding.

Inter-confluence catchments.	Catchments generated from each confluence on the baseline river network, i.e. where two or more rivers, each with a catchment area greater than 10 km2, meet	• The areas predicted to contribute to groundwater flooding were considered in terms of amount occurring within a catchment. • The catchments were then classified according to confidence that groundwater contribution to flooding was significant.