Reservoir Inundation Mapping summary: Methodology

1. Introduction

The Reservoirs (Scotland) Act 2011 (the 2011 Act) supersedes the Reservoirs Act 1975 (the 1975 Act) in Scotland and introduces a risk-based approach to reservoir safety.

As part of the implementation work for the new legislation, the Scottish Environment Protection Agency (SEPA) has produced reservoir inundation maps (RIMs) for the majority of those reservoirs currently regulated under the 1975 Act. These maps are required to enable SEPA to assign a risk designation to each registered reservoir and so that a copy of the outline inundation map can be placed on the controlled reservoirs register.

These maps provide the most comprehensive national source of data on reservoir inundation mapping.

This summary provides information on how we developed our reservoir inundation maps and to how to interpret this data. The primary purpose of this summary is to support reservoir managers and panel engineers in their understanding of how the maps were developed.

2. Development and review

SEPA has worked collaboratively with key stakeholders from the reservoir industry to develop a nationally consistent reservoir inundation mapping methodology. It utilises available and reliable national datasets, such as ground level information, in a consistent modelling approach.

2.1 Improvements

The production of the reservoir inundation maps has improved our understanding of reservoir flooding. In particular improvements relate to:

- Mapping of the areas likely to be flooded by an uncontrolled release of water from a reservoir
- Improved ground model quality

2.2 Future review and development

The mapping of flooding is a dynamic process and the reservoir inundation maps will be subject to review and change as we develop and/or improve our input data, methodologies and techniques.

The maps, which will be made publically available from the 1st October 2015, reflect the knowledge and data we have available at that time and were able to incorporate into our national methodologies.

3. Methodology and data

3.1 Approach

A nationally-applied methodology has been used to produce reservoir inundation maps for reservoirs regulated under the 1975 Act. The maps provide indicative flood hazard information and identify potential areas that could be affected by an uncontrolled release of water from reservoirs.

At least one RIM has been derived for every dam associated with a reservoir that impounds a storage volume of 25,000m^3 or more, even if situated on the same reservoir. Multiple breach scenarios have been modelled for single dams, where required, such as for dams with multiple sections or orientations.

There is an inherent uncertainty in flood modelling as a result of assumptions and simplifications that are required to enable complex processes to be reflected through hydraulic modelling software. Please refer to section 5 for guidance on interpretation.

3.2 Methodology

The development of the reservoir inundation maps is based on a two dimensional (2D) flood modelling method. This method of flood modelling has the capability to estimate flood depths, velocities, extents and, in turn, an estimate of flood hazard.

3.2.1 Model domains

A model domain was created for each dam breach to define the area that each model would cover, with the model extending downstream far enough that floodwaters are contained back within channel or where there is judged to be limited downstream floodplain flooding. Alternatively the model may extend as far as a physical boundary such as a loch or tidal limit.

The model resolution applied to each domain was assigned based on consideration of:

- the ground model (Digital Terrain Model or DTM) available,
- the required model domain extent versus computational time,
- the model cell size that would account for features with the potential to alter flow paths.

3.2.2 Flow

Model inflows representing the dam breach hydrographs were applied to the model downstream of the toe of the dam.

A Wet Day scenario (an over-topping failure) was applied in all cases except for service and cascade reservoirs where a Dry Day scenario (an internal failure) was used.

The breach hydrographs were calculated using different approaches on the basis of dam type and construction.

3.2.3 Structures and defences

Bridges, culverts and other hydraulic structures were removed from the DTM used in the modelling. These structures were modelled as open channels by manually adjusting the underlying DTM to allow flow to pass through the structure location where required.

Small culverts (diameter <2m) are assumed to block easily in a RIM event and so openings for these have not been included in the modelling.

In general for features such as road embankments levels from the DTM were used. In some instances, manual intervention was used to enforce key levels such as dam crest levels.

4. Validation and quality review

A validation and review process was undertaken for the reservoir inundation mapping data:

- **Peer contribution -** SEPA has worked collaboratively with key stakeholders from the reservoir industry and Scottish Government to develop a nationally consistent reservoir inundation mapping methodology. It utilises available and reliable national datasets, such as ground level information, in a consistent modelling approach. The Reservoir Inundation Mapping and Risk Designation Technical Review Group provided peer contribution to the approach for reservoir inundation modelling. This group included representatives from SEPA, Scottish Government, reservoir managers and a number of panel engineers.

- **Internal review-** a high level internal review of the results at the reservoir breach scale including:
    - Sense checking depth, hazard and velocity ranges given topography
    - Checks for structures falsely preventing flow from passing through.
    - Checks that the model extended sufficiently downstream.

5. Interpretation

The reservoir inundation maps have been developed using a nationally-applied methodology. The primary purpose of the inundation maps is to assist SEPA in assigning a risk designation to all registered reservoirs, as required by the 2011 Act. The maps are indicative only and of a strategic nature. The RIMs are not suitable for property level assessment.

The zoom on the map, published on the SEPA website, is set to support the intended use of the maps at a community level.

5.1 Assumptions

Reservoir inundation mapping is a complex process. Due to assumptions that are necessary to allow us to reflect the complex processes that take place following an uncontrolled release of water, there are uncertainties associated with developing any modelling methodology. This equally applies to modelling dam breach flooding processes which have been assessed consistently on a national scale. Examples of these assumptions include:

- The use of a simplified breach scenario (e.g. failure of an entire dam).
- The use of national scale topography datasets.
- The application of standard overtopping rates based on reservoir type.
- The use of national scale datasets to sense-check dam structure parameters such as dam heights.

The modelling methodology has been subject to a number of sensitivity analyses of key parameters to better understand the impact of these assumptions on the outputs. Results indicate the outputs are not significantly affected and are appropriate for the scale and purpose of the RIMs which are to enable risk designation.
The risk designation is driven by the number and density of downstream receptors and therefore limited changes in the inundation outlines will have a minimal implication on the risk designation in the majority of cases.

5.2 Limitations

The reservoir inundation maps have been produced at the national scale using national datasets and a consistent methodology. This map is a strategic product and should not be used at the individual property level.

Due to the strategic nature of the output and the methodology used there are limitations associated with the reservoir inundation maps, which mean it can be difficult to represent:

- Urban areas where there is a complex surface drainage system such as heavily culverted areas
- Very steep and upland catchments
- Areas with lower resolution DTM. LiDAR (Light Detection and Ranging) datasets have a higher resolution than IFSAR (Interferometric Synthetic Aperture Radar) datasets, therefore where available LiDAR is used in preference to the lower resolution IFSAR data.
- Small or narrow river channels where even high resolution models cannot accurately identify the channel
- Hydraulic structures and flood defence assets

Every effort has been made to create reservoir inundation maps which reflect the knowledge and information available to us and which are fit for purpose.

5.3 Caveats

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

6. Further information

More detailed information on the methodology is available by request through contacting reservoirs@sepa.org.uk

For further information about the 2011 Act and its implementation visit SEPA's website or contact reservoirs@sepa.org.uk