

Flood risk management: modelling blockage and breach scenarios

Guidance note

Reference number: GN 043

Document Owner: Head of Business, Flood

What is this document about?

Flood defences are an important part of managing risk to people and property. Defences can reduce the frequency of flooding; however, they can be overtopped and potentially fail. The onset and consequences of flooding can be particularly sudden and severe in the event of defences being overtopped or breached.

The performance of structures and defences can significantly affect the speed of inundation of a site, the flow routes, flood extents, depths and velocities, and is something that must be considered as part of a flood consequences assessment.

Flood water is also likely to carry a significant amount of debris which has the potential to cause blockage at structures, potentially increasing the extent and severity of flood risk.

This guidance sets out how Natural Resources Wales (NRW) assesses these two variables: blockage at structures and breaches in defences, through hydraulic modelling

Who is this document for?

This guidance is aimed at anyone required to undertake or assess a flood consequences assessment to support a plan/proposal where an assessment of flood risk is required, for example, a development plan, a planning application or flood risk activity permit

Contact for queries and feedback

Flood Risk Analysis Team. FRA.Wales@cyfoethnaturiolcymru.gov.uk

Version History

Document version	Date published	Summary of changes
1.0	12-2014	Document published
2.0	02-2015	Updates made and signed off
3.0	09-2020	Document amended to external guidance note
4.0	02-2026	Document amended to take account of changes to planning policy TAN15: Development, flooding and coastal erosion

Review Date: February 2028

To report issues or problems with this guidance contact:
guidance.development@cyfoethnaturiolcymru.gov.uk

Contents

1. Introduction.....	3
2. Our approach.....	3
3. Blockage.....	3
4. Overtopping, breach and /or failure of defences.....	6
TAN15 defended zones.....	7
Assessing overtopping / breach	8

1. Introduction

TAN15 (paragraph 6.8) notes that “Where appropriate, the Flood Consequences Assessment should demonstrate that in the event of overtopping, breach or blockage the consequences of flooding can be managed to an acceptable level”.

It also states (paragraph 10.26) “Where an assessment is required for the breach of a defence or blockage of a structure, this should be considered as the ‘**design event**’”.

2. Our approach

The level of assessment required will be dependent on the nature and scale of proposed development. This guidance sets out our approach where the blockage of a structure, and/or a breach assessment is required.

Uncertainties in modelling of breach or blockage should be carefully considered and the chosen approach fully documented. This is reflected in TAN15 (paragraph 11.2) which sets out the importance of taking uncertainties into account.

An industry standard framework for undertaking an assessment can be found in [Accounting for residual uncertainty: updating the freeboard guide. Report SC120014](#) (2018) with supplementary guidance (2024) provided by the Environment Agency on request.

3. Blockage

During a flood event, flood water can carry a significant amount of debris. This has the potential to cause a blockage at structures. Within a flood consequences assessment (FCA), consideration may need to be given to the likelihood of flooding caused by the blockage of a structure, and the potential consequences of such a blockage. For example, a culvert with only 40% capacity due to a blockage. Hydraulic modelling of flood risk should include sensitivity testing to understand the full range of consequences of a blockage.

Whilst it is relatively straightforward to assess the impact of obstruction on upstream water levels, it is more difficult to decide on a credible degree of blockage. The likelihood of material accumulating depends on various risk factors including the type and size of structure and nature of the debris. In order to carry out a hydraulic analysis of blockage, it is necessary to make assumptions about the degree of blockage.

The appropriate proportion of blockage is usually a matter for pragmatic judgement and often relies on local knowledge. There is no definitive guidance, although some guidance for culverts is available, as shown in Table 1.

Figure 1: Example of a typical blockage scenario (Monmouth Bridge)



Table 1: Current culvert blockage guidance

Guidance document	Blockage proportion
CIRIA Culvert design and operation guide, 2010 (Table 6.4)	Blockage /blinding <ul style="list-style-type: none"> • 30% to 67% depending on catchment • 100% Sedimentation of culvert barrel <ul style="list-style-type: none"> • 5%, 15%-25%, 80-100%
Blockage Management Guide Report -SC11005/R2, 2019 (Section 8)	Blockage /blinding <ul style="list-style-type: none"> • 33%, 67%, 100% Sedimentation of culvert barrel <ul style="list-style-type: none"> • 5%, 15%-25%, 80-100%
Culvert, screens and outfall manual (May 2022) complemented by the Blockage management guide (Nov 2019)	Blockage /blinding <ul style="list-style-type: none"> • 33%, 67%, 100% Sedimentation of culvert barrel <ul style="list-style-type: none"> • 5%, 15%-25%, 80-100%

To ensure consistency, the standard figures shown in Table 2 should be used for modelling blockage at bridges and culverts where no better information is available. These figures are based on the guidance shown in Table 1 and current working practices.

Lower figures are applied at bridges as they are normally less prone to blockage. However, local knowledge and engineering judgement or scientific evidence may be used to apply varying proportions if considered appropriate at a particular location. Full justification for using an alternative value will need to be set out in the FCA.

Table 2: Standard blockage proportions

Blockage Scenario	Culvert blockage proportion	Bridge blockage proportion
Low	30%	5%
Medium	67%	25%
High	100% ¹	80%

To understand the potential impacts as a result of blockage to a culvert, bridge or other in-channel structure, a range of flows and blockage proportions must be assessed.

The assessment must also consider how climate change will affect flood risk where a blockage is considered appropriate. TAN15 (paragraph 11.7) states that a:

“blockage scenario should be assessed against return periods up to and including the 1 in 1000 year (0.1% AEP) flood event, including an allowance for climate change”.

To meet TAN15 requirements we expect the following events to be included in a FCA to assess against the flood free thresholds and the tolerable conditions set out in Figures 5 and 6 of TAN15, along with the requirement for “no increase in flooding elsewhere”:

- 1% AEP² (1 in 100 year) plus central estimate of climate change.
- 0.1% AEP (1 in 1000 year) plus central estimate of climate change.

Where a risk of blockage is included within the FCA, it may be beneficial to assess the 1% AEP (1 in 100 year) risk against the upper end estimate of climate change. This will help provide a better understanding of how higher scenarios of climate change may impact a proposed development and can be used to inform resistance and resilience measures. Factors such as vulnerability of development may need to be considered when establishing upper end requirements.

If the events set out in paragraph 3.8 are not included in the FCA, full justification/reasoning will need to be provided. For example, an assessment against the 1000 year plus climate change (including blockage) event may not be necessary if the FCA has already demonstrated the site cannot meet the TAN15 flood free thresholds in Figure 5 (of TAN15), or the tolerable conditions in Figure 6 during lower magnitude events. It is also acknowledged that in some instances, the modelling may be so complex that it becomes unstable, and the corresponding outputs may not be reliable.

Note: we recommend a range of scenarios are modelled in addition to the 1% AEP CC and 0.1% CC AEP events (e.g. 50%, 10%, 3.3%, 1.33% AEP) to ensure:

¹ Note that a 95% blockage is usually adopted over a 100% in the hydraulic model to maintain a minimum opening and ensure the model remains stable. You must ensure the software maximum is used.

² AEP is the Annual Event Probability

- a full understanding of flood risk due to blockage
- there is no change in risk against smaller return events both to and from development
- there is no increase in flood risk elsewhere from lower magnitude flood events as a result of the proposed development.

Further guidance is set out at [Natural Resources Wales / Developing hydraulic models for flood risk](#) and [Natural Resources Wales / Model output requirements](#).

For simplicity in hydraulic modelling terms, if a blockage is included in a FCA it must be in place for the full duration of the flood events indicated in paragraph 3.8. Its effect on flood risk over the whole event should be sufficiently detailed within the FCA.

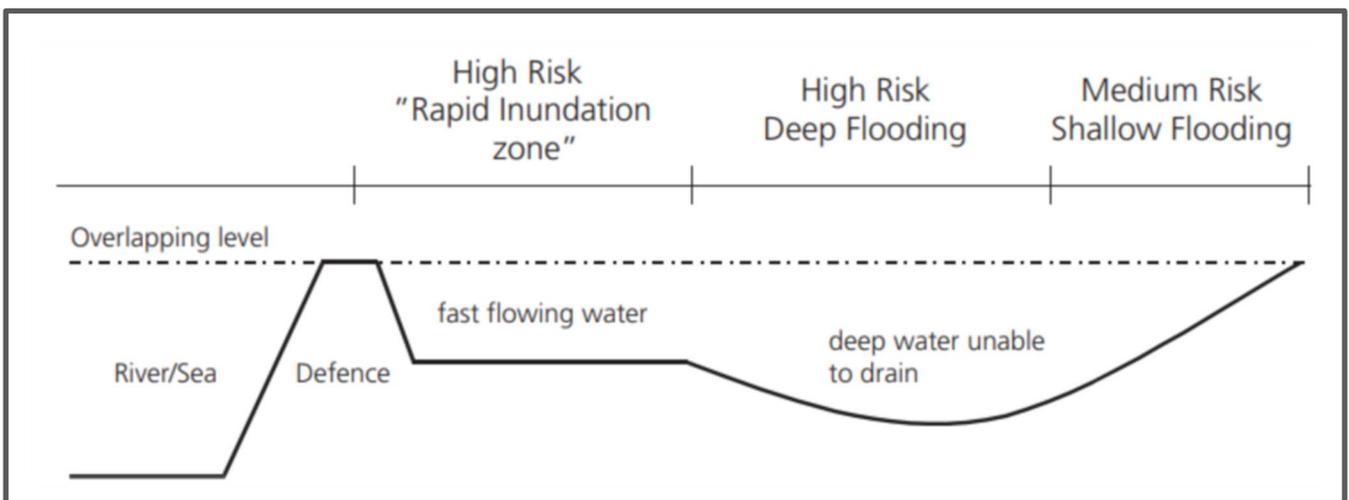
4. Overtopping, breach and /or failure of defences

Land protected by flood defences can be extremely vulnerable in the event of overtopping or breach due to significant volumes of water being held back by the defence, and the potential for rapid inundation in such circumstances, with little or no warning. The likelihood and risk of overtopping and a breach occurring on defences that provide any degree of protection to a proposed development site must always be assessed.

The likelihood of overtopping and breach can be significantly influenced by factors such as defence type, construction, location, current condition, ownership, maintenance, peak water levels or overtopping rates.

The presumption is that once a defence is overtopped, the greater the risk of failure, especially for earth embankments (soft engineered defences).

Figure 2: Risk behind a river or sea defence



Note: This figure is a simplification which does not account for any possible overland flood routing or other local factor this will require accurate modelling to consider these factors have to the flood risk behind a defence.

The level of risk depends on several factors, including the timing, duration and peak flood level, the depth/velocity (flood hazard), the volume of floodwater entering the area, local overland flow paths and the site's distance from the defence. It is also influenced by how quickly floodwater will drain or be removed following an event. In general, the sites most at risk of rapid inundation are those located immediately behind flood defences.

If the failure of a defence is considered so unlikely it does not need to be assessed, then this must be supported by appropriate justification and evidence set out in an FCA.

Where an assessment of failure is required, the location and nature of any breach should be agreed with NRW and should generally be located as follows in terms of priority:

- at any known areas of weakness (e.g. low-spots, the interface between soft and hard defences, outfall structures etc).
- the location where the defence is closest to the development site.

Ultimately any decision on the breach location will need to be guided by local knowledge including known asset condition and performance during previous flood events.

Figure 3: example of a breach scenario (Tan Lan Embankment)



TAN15 defended zones

The [Flood Map for Planning](#) identifies areas that benefit from Risk Management Authorities (RMA's) operated, managed and maintained defences. While these defences are considered to meet the minimum level of protection set out in TAN15, the Standard of Protection (SoP) afforded by them is our best estimate based on the most recent

assessment data. This may be several years old and it should be recognised the SoP is likely to have reduced from when the defence was constructed, for example, as a result of changes in hydrology, or due to the impacts of climate change. Hydraulic modelling is therefore likely to be needed to determine the current SoP.

TAN15 Defended Zones should not be considered automatically suitable for any type of development. The flood risks and consequences, including an overtopping and/or breach assessment must be assessed within a FCA to determine whether a development can comply with TAN15 acceptability criteria, be managed safely over its lifetime and ensure no increase in flood risk elsewhere.

A breach of defences must always be assessed if the site is within a TAN15 defended zone, unless sufficient justification can be provided within the FCA to say why this is not necessary.

Assessing overtopping / breach

Development proposals that benefit from flood defences will require an assessment of overtopping and/or breach. Full details of the scope of the assessment should be agreed with NRW prior to FCA submission.

An allowance for climate change over the lifetime of development must be included.

Breach widths will vary depending on the nature of the defence. Table 3 summarises suggested breach width depending on location and defence type. This can be used as a starting point unless more appropriate site-specific information is available to justify the use of an alternative value.

Table 3: Breach widths by defence type and location

Location	Defence type	Breach width (m)
Open coast	Earth bank	200
Open coas	Dunes	100
Open coas	Hard	50
Open coas	Sluice	Sluice width
Estuary / tidal river	Earth bank	50
Estuary / tidal rive	Hard	20
Fluvial river	Earth bank	40

Location	Defence type	Breach width (m)
Fluvial river	Hard	20

The duration to be modelled is 3 tide cycles or an appropriate fluvial duration (this is based on an estimation of the time lapse between the initial breach and subsequent repair (even if this is a temporary solution)).

The breach could be present for the whole event (i.e. is deemed to have occurred prior to the event peak). Alternatively, breach initiation can be timed to coincide with peak water levels or at the point of overtopping (whichever occurs first). This approach takes into account rapid inundation of areas behind defences. A sudden breach is often an issue for model stability and so defence height may need to be gradually reduced to the base level. The failure mode of a defence will be a function of the defence type.

Paragraph 11.7 of TAN15 notes that a breach assessment should be undertaken ‘...against return periods up to and including the 0.1% AEP (1 in 1000 year) flood event, including an allowance for climate change’.

To meet TAN15 requirements, the FCA should consider a range of scenarios where a breach could occur. To assess against the TAN15 flood free thresholds and tolerable conditions (TAN15 Figures 5 and 6), and the requirement for ‘*no increase in flooding elsewhere*’, we expect the FCA to consider the scenarios shown in Table 4 below.

Table 4: assessing breach

Type of development	Rivers AEP	Sea AEP
Emergency Services	<ul style="list-style-type: none"> 0.1% plus central estimate of climate change 	<ul style="list-style-type: none"> 0.1% plus upper central estimate of climate change
All other development	<ul style="list-style-type: none"> 1% plus central estimate of climate change 0.1% plus central estimate of climate change 	<ul style="list-style-type: none"> 0.5% plus upper central estimate of climate change 0.1% plus upper central estimate of climate change

If a full range of events are not included in the FCA, full justification and reasoning will need to be provided.

We recognise that it may not be necessary to undertake an assessment against the more extreme event, for example if it has been shown the defence has already failed in the 1% CC event. We also acknowledge that modelling may not be achievable as hydraulic models can become unstable and may not provide reliable outputs for such an extreme event. However, a reasonable effort must be made to stabilise such models before discounting it and evidence of such must be set out in an FCA.