Environment Agency

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Post-incident reporting for reservoirs

Annual report 2015

We are the Environment Agency. We protect and improve the environment.

Acting to reduce the impacts of a changing climate on people and wildlife is at the heart of everything we do.

We reduce the risks to people, properties and businesses from flooding and coastal erosion.

We protect and improve the quality of water, making sure there is enough for people, businesses, agriculture and the environment. Our work helps to ensure people can enjoy the water environment through angling and navigation.

We look after land quality, promote sustainable land management and help protect and enhance wildlife habitats. And we work closely with businesses to help them comply with environmental regulations.

We can't do this alone. We work with government, local councils, businesses, civil society groups and communities to make our environment a better place for people and wildlife.

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Introduction

We collect and record information on incidents at raised reservoirs, both large and small. Large raised reservoirs in England are those covered by the Reservoirs Act 1975.

We use this information to:

- Investigate incidents (where appropriate)
- Inform the reservoir industry of any trends and key lessons identified
- Contribute to research into reservoir safety and incident frequency analysis.

All incident data is entered onto the national database, which can be used to inform reservoir safety research.

Arrangements for reporting in the UK

England

For incidents at large raised reservoirs (i.e. reservoirs with a volume of at least 25,000 cubic metres above ground level) located in England, incident reporting has been mandatory since July 2013 under the provisions of Section 21B of the Reservoirs Act 1975 and regulation 14 of Statutory Instrument 2013 No. 1677.

As soon as the incident is under control, the reservoir undertaker (i.e. the owner, operator or user) must provide a preliminary report of the incident to the Reservoir Safety team. The preliminary report must contain:

- the date and time of the incident
- the location of the reservoir
- immediately observable facts.

Within one year from the day after the incident the reservoir undertaker must send us a final post-incident report, preferably using the form available online. The final report of the incident must contain:

- information about the facts relating to it
- analysis of its circumstances
- particulars to support the conclusions that can be drawn from it
- particulars to support the lessons learned from it.

We will review the final report and seek further clarification if necessary. Key learning points will continue to be reported in these annual review reports.

We classify incidents according to the following levels of severity:

Level 1: Failure (uncontrolled sudden large release of retained water)

Level 2: Serious incident involving any of the following:

- Emergency drawdown
- Emergency works
- Serious operational failure in an emergency

Level 3: Any incident involving:

- A precautionary drawdown
- Unplanned physical works
- Human error leading to a major (adverse) change in operating procedures.

We consider that an incident in any of the above incident categories is covered by the regulations.

Post-incident reporting for small raised reservoirs (i.e. reservoirs not covered by the legislation) in England remains voluntary.

It is important to note that the above incident reporting process is separate and subsequent to the immediate incident response which should be reported to the emergency services as necessary. For incidents in England the Environment Agency's incident hotline number is 0800 80 70 60.

Wales, Scotland and Northern Ireland

Natural Resources Wales (NRW) is the enforcement authority for the Reservoirs Act 1975 in Wales. Amendments to the Reservoirs Act 1975 came into force on 1 April 2016 making post-incident reporting a legal requirement in Wales. Incidents in Wales should be reported to NRW and guidance on this is available on request from reservoirs@naturalresourceswales.gov.uk. Incident reports are shared annually with the other UK regulatory authorities.

In Scotland reservoir safety is now regulated by the Reservoirs (Scotland) Act 2011, which as superseded the Reservoirs Act 1975. This legislation made the Scottish Environment Protection Agency (SEPA) the enforcement authority from the 1 April 2016 in Scotland. It may also make post-incident reporting a legal requirement but until then incidents in Scotland can continue to be reported on a voluntary basis to SEPA by emailing reservoirs@sepa.org.uk.

In Northern Ireland reservoir safety is regulated by the Reservoirs Act (Northern Ireland) 2015. This primary legislation will require reservoir managers to report incidents in the future. Until the relevant sections of the Act come into operation, reservoir managers may voluntarily report incidents to the Rivers Agency by emailing rivers.registry@dardni.gov.uk.

Analysis of reported incidents

Severity and number of reported incidents in 2015

We had six incidents reported to us during 2015 for incidents occurring in both 2014 and 2015.

You can see the number and severity of incidents that have been reported to us between 2004 and 2015 in the tables below. We have only included incidents where we have enough information to be able to assign an incident level. We intend to publish these statistics at intervals of five years, starting with this report.

Table 1: Number of incidents reported between 2004 and 2015

	2015	2004-2014
Total number of incidents	2	97
Incidents at large raised reservoirs	2	66
Incidents at small raised reservoirs	0	31

Table 2: Number of incidents by severity level 2004-2015

Year	Incident Level 1	Incident Level 2	Incident Level 3	Total
2015	1	0	1	2
2004-2014	5	32	60	97

Figure 1: Incident Severity Level 2004-2015

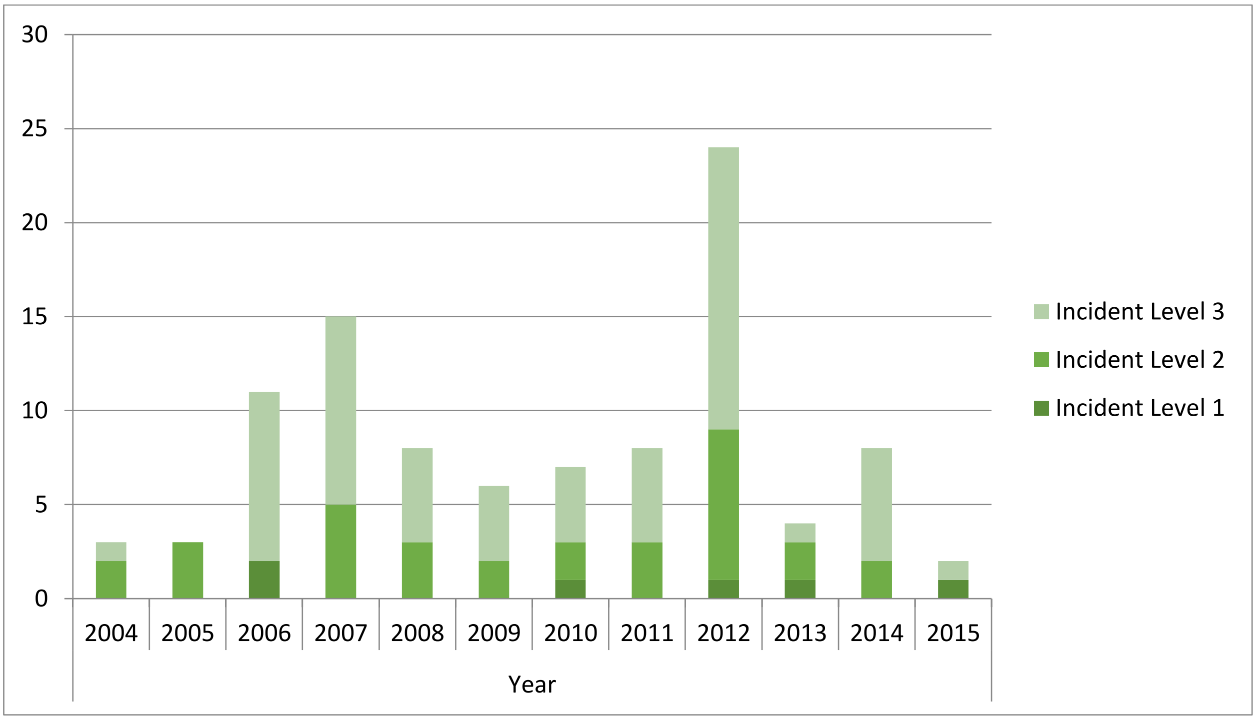
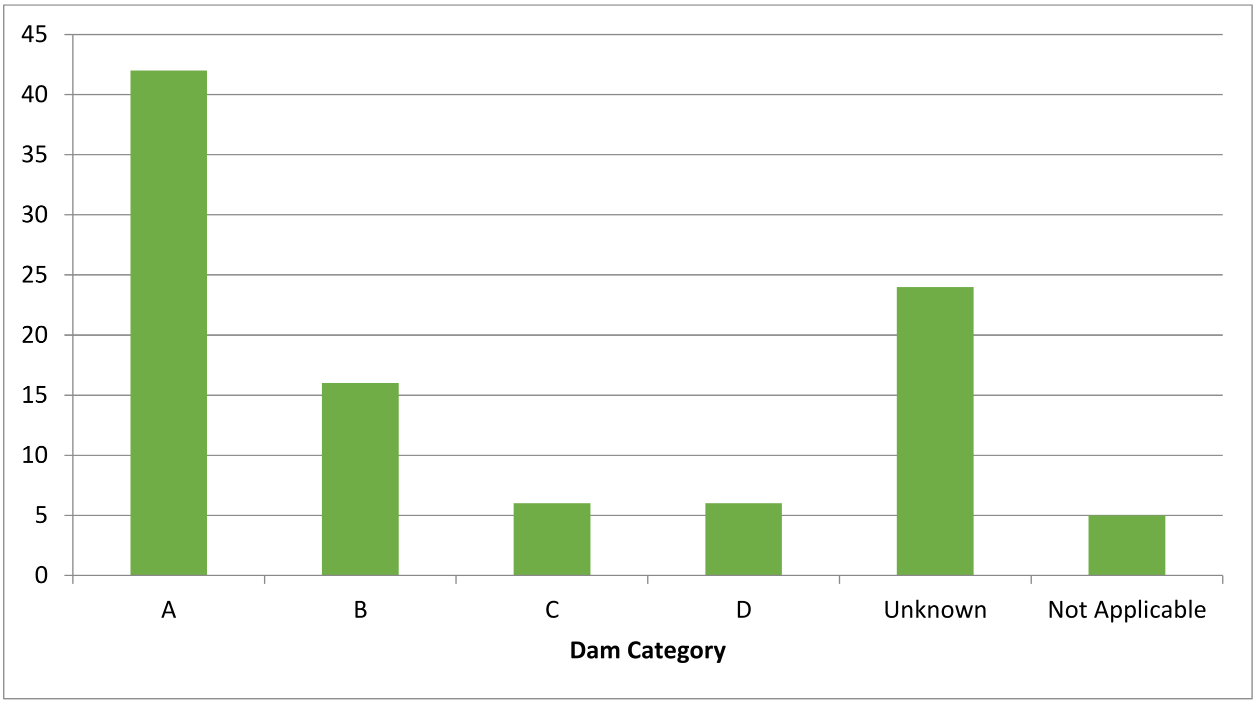


Figure 2: Incidents by dam category* 2004-2015



*Dam category definitions can be found in Appendix A.

Threats and mechanisms of deterioration

We analyse each of the incidents reported to us to determine the threat to the dam. We also analyse the likely method by which the dam has deteriorated (mechanism of deterioration) resulting from each of the threats.

Threats to dams can be broadly divided into internal and external threats.

Internal threats are:

- Instability associated with internal erosion of an embankment dam
- Slope instability associated with slip of an embankment dam
- Instability associated with appurtenant works
- Instability of the dam foundation
- Material deterioration (for example, corrosion)
- Vegetation (for example, tree roots).

External threats are:

- Inflow – flood
- Inflow – direct rainfall
- Inflow – failure of an upstream reservoir
- Seismic event
- Snow/ice
- Aircraft strike
- Vandalism
- Wind (wave generation or tree damage)
- Human error, animals and mining.

A summary of the threats and mechanisms of deterioration for each of the incidents reported can be seen in tables 3 to 5 below. For some locations more than one threat was identified.

Table 3: Summary of internal threats 2004-2015

Internal threat	
Embankment stability	32
Appurtenant works stability	7
Abutment stability	1
Foundation stability	2
Material deterioration	3
Vegetation	3
Other	3
Not applicable	48

Table 4: Summary of external threats 2004-2015

External threat	
Inflow - flood	32
Inflow – direct rainfall	2
Snow, ice	1
Mining	1
Wind – trees	1
Wind – waves	4
Animals	2
Vandalism	1
Human error	4
Other	3
Not applicable	48

Table 5: Mechanisms of deterioration 2004-2015

Mechanism of deterioration	
Damage to safety critical structures	5
Deterioration of upstream protection	3
Erosion by overtopping	29
Erosion from localised run-off	1
Fill deterioration	3
Foundation deterioration	2
Gates deterioration	2
Hydraulic fracture relating to internal erosion	1
Increased hydraulic loading	2
Internal erosion – adjacent to appurtenant works	9
Internal erosion – other	20
Pipework/culvert deterioration	5
Pore water pressure increase mass movement	2
Settlement/deformation	2
Structures deterioration	2
Valve deterioration	1
Wind damage – trees	1
Other	4
Not known	5

Types of lessons identified

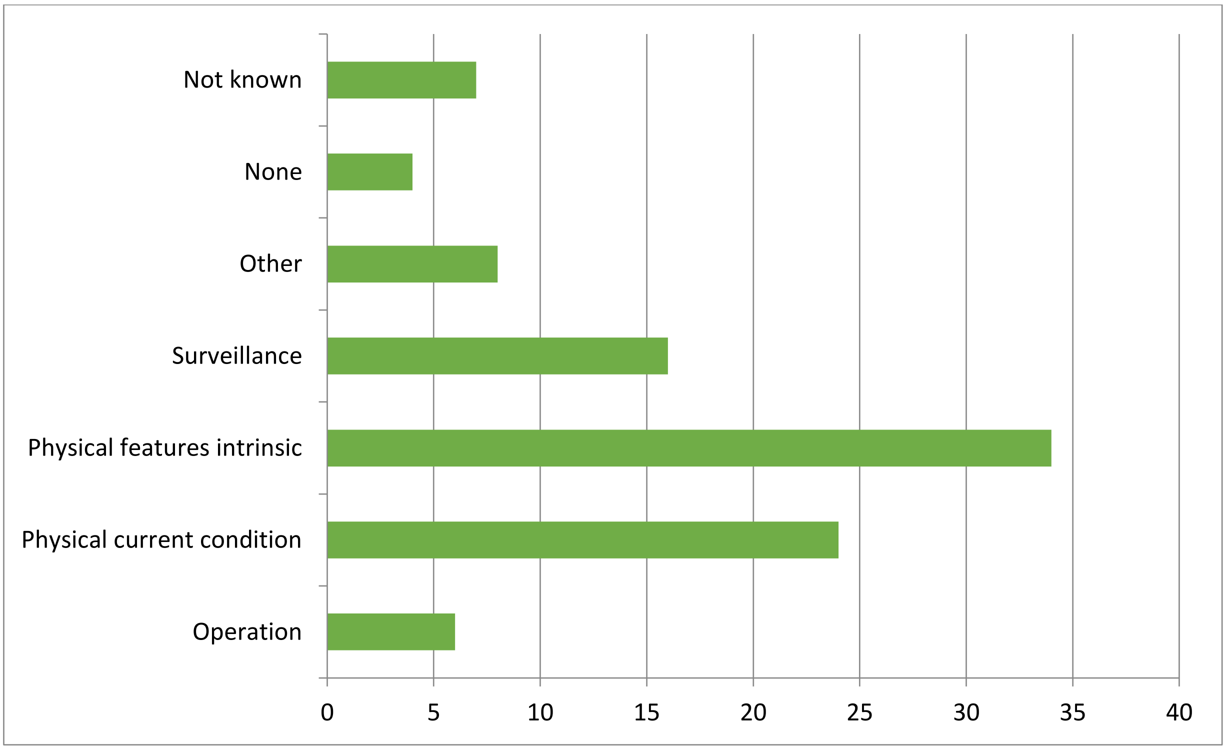
We ask undertakers and engineers reporting incidents to identify any lessons they think can be learnt from the events that have taken place. We can carry out further investigations and undertake research into these.

When we record incidents on our database we can classify the types of lessons that can be learnt from each incident. Table 6 and Figure 3 show the categories of lessons identified.

Table 6: Types of lessons identified

Type	Examples	Possible implications
Surveillance	Inadequate surveillance or processing of instrument observations	Reservoirs require more, or better, monitoring and surveillance
Operation	Malfunction or misuse of reservoir control facilities	Reservoirs require more or better trained staff or security against misuse
Physical (current condition)	Inadequate performance due to deterioration of a design element by erosion, wear, weather, corrosion, vandalism, poor management, etc.	Reservoir components require better or more frequent maintenance
Physical features (intrinsic)	Inadequate performance due to the original design and/or construction of a structure, or through changes in loading (structural or hydraulic)	Reservoir components should be designed and built to meet current physical conditions
Emergency planning	Incidents relating to the application of emergency planning provisions (alarms, evacuations, etc.)	There is a need for more effective use of emergency planning provisions at reservoirs

Figure 3: Lessons identified 2004-2015



Details of reported incidents

In 2015 we received information on six incidents. There were no reservoir incident investigations carried out in 2015.

2014 incidents

Incident 417	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	25
Incident type	Internal erosion
Incident severity	3

Description

The dam embankment was constructed with a central clay core but had experienced some leakage problems after it was first filled. As a result, the design was modified to provide a clay blanket on the upstream face, with stone pitching to protect it from wave action.

At the time of the incident the reservoir was 1.6m below top water level. During a routine surveillance inspection it was noticed that an area of stone pitching was missing. Investigations found that a void had formed underneath the pitching, approximately 300 mm deep by 700 mm wide. An inspecting engineer was called to the site and the reservoir was drawn down as a precaution to lower the reservoir level by a further metre to prevent water from entering the damaged area. Piezometers that had previously been installed within the upstream shoulder were used to check that the drawdown did not lead to large differential pressures behind the clay blanket. Ground investigations and dye tracing were completed.

The damaged area was repaired by removing the damaged material, filling the void and capping the area with concrete to allow the reservoir to operate normally. The clay blanket was found to be 700 mm thick and of good quality clay. However, it appears that wave action had caused deterioration of the stone pitching and erosion of the clay blanket to occur. It appears unlikely that the extent of the damage led to any increase in seepage flows.

Lessons learned

Where a dam relies on an upstream clay blanket to remain watertight, it can be difficult to verify the condition of the blanket where it has been necessary to overlay it with a wave protection system such as stone pitching. The monitoring and surveillance arrangements should be developed to closely monitor the performance of such face protection systems, recognising that voids can develop beneath stone pitching without noticeable damage to the pitching. This task can be very challenging at large embankments.

Incident 411	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	5
Incident type	Leak by pipe or culvert
Incident severity	2

Description

The outlet pipe through a 5m-high earth embankment dam required upgrading. Contractors were employed to line the existing timber culvert, fit a downstream valve and to remove the original intake structure and upstream control. Throughout the works, the water level in the reservoir was close to top water level.

Removal of the intake structure resulted in leakage occurring along the outside of the new pipe through the dam. The works also resulted in local steepening of the downstream face and a tension crack appeared on the dam crest. There were concerns both for the stability of the embankment and the risk of failure through internal erosion.

The supervising engineer was contacted and an inspecting engineer was called to the reservoir. Pumps were brought to the site to draw down the water level by 1.2 m over a period of three days. The reservoir was then emptied using the existing outlet.

Investigations found that part of the original timber culvert roof was missing and fine material had been washed out from the overlying earthfill. The reservoir owner decided to abandon the outlet rather than attempting to improve its condition.

Lessons learned

Improvement works that affect the safety of a statutory reservoir should be carried out under the supervision of a suitably qualified engineer. Any works on existing dam structures should carefully consider the conditions that might be encountered to ensure contingency plans are in place if the conditions found differ from those anticipated.

Reservoir improvement works of this nature should normally be carried out with a lowered reservoir level if possible.

Photo shows seepage along the line of the culvert.

Incident 414	
Dam type	Earth embankment
Reservoir legal status	Statutory non-impounding reservoir
Dam height (m)	6
Incident type	Leakage - concrete/masonry
Incident severity	3

Description

During a routine surveillance inspection of a non-impounding reservoir, increased leakage was noted through the joints in the masonry spillway weir in two areas. Silty sand was observed being washed through the joints. The reservoir water level was reduced by 200 mm, which was sufficient to stop the leakage. Grouting works are planned to fill voids within the dam upstream of the weir.

Lessons learned

This incident illustrates the value of routine surveillance at reservoirs. In this case, the reservoir spillway was on a non-impounding reservoir which rarely overflowed and it was easy to notice the deterioration of the weir structure. In the case of impounding reservoirs that regularly have flows over the spillway, it is useful to inspect the downstream face of masonry weirs when the water is just below the sill level. Any leakage and loss of fine material over an extended period of time could potentially reduce the stability of the weir (see also incident 413 below).

Photos, courtesy of the Canal and River Trust, shows seepage with deposition of fine material.

Incident 415	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	4
Incident type	Other
Incident severity	3
Description An automated sluice gate was partially opened to reduce the reservoir water level at a site where construction works were being undertaken. The gate failed to close on request during the closing sequence. The reservoir substantially emptied through the gate over a period of two hours before the owner was able to close the gate manually. There was no downstream flooding as a result but there was some loss of fish and some silt was washed out from the reservoir. Investigations found that the failure to close the gate was the result of an electrical fault. Works on the electrical system had recently been carried out but had not been tested. There was also a delay in implementing the manual closure as staff on site had been provided with an incorrect procedure. There was no secondary gate or other means provided to stop the flow through the gate. Lessons learned This incident illustrates the importance of testing systems and procedures used for operating equipment. Where works are carried out on electrical or mechanical equipment it is essential that proper testing is carried out promptly. Gated waterway designs should consider the implications of gate failure and provide a secondary means of sealing waterways. Backup systems and procedures should be periodically reviewed and tested to ensure that they are effective when needed. Photos show gate and empty reservoir	 

2015 incidents

Incident 413	
Dam type	Lock gates (raised loch)
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	Unknown
Incident type	Breached
Incident severity	1

Description

A breach occurred at a weir structure which retains a large raised loch at the outfall to a canal. The breach occurred following a period of unusually high levels in the loch resulting in high flow rates over the overflow weir. The catchment area had been subject to an extreme storm event.

The breach was noticed by a local resident and there was a rapid response from the reservoir owner to investigate the problem and alert the supervising engineer. Hydroelectric flows into the loch were reduced.

The weir was constructed of stone masonry with a core of erodible fill material. The stone masonry facing had been damaged by the unusually high flows leading to erosion of a section of the weir and adjacent canal embankment which resulted in a breach. The water level in the loch dropped by approximately 1m as a result.

The breach area was isolated from the downstream canal using steel sheet piles to temporarily repair the breach and the weir was permanently rebuilt using reinforced concrete. The breach did not cause any significant damage downstream.

Lessons learned

The 165-year old historic masonry-faced weir structure was unable to withstand the hydraulic forces associated with the extreme flood event. Once the facing had been damaged, the breach developed quickly as the fill within the centre of the weir was constructed of erodible material.

The incident demonstrates the importance of understanding the nature of historic structures for which design details might not be available. Where weirs are in almost constant operation it can be difficult to assess their structural condition. Arrangements should be made to allow for periodic structural inspections wherever possible.

Incident 412	
Dam type	Earth embankment
Reservoir legal status	Statutory non-impounding reservoir
Dam height (m)	8
Incident type	Leakage - embankment
Incident severity	3

Description

A wet area was discovered at the downstream toe of an earth embankment and an inspecting engineer was called to the site. The grass on the embankment had recently been cut and the machine had got stuck in the wet ground but this had not been reported by the owner.

The same area had previously been identified as wet and a toe drainage system was installed four years earlier. It appears that the drain had not been set deep enough to capture the seepage flows.

Ground investigations were carried out and some piezometers were proposed to monitor the condition of the embankment in this area. The cause of the seepage flows has not been determined. The owner has re-laid the drain at a deeper elevation to better capture the seepage flows.

Lessons learned

It is not uncommon for seepage to be present at the downstream toe of old earth embankment dams. It is important to provide effective means of monitoring changes in the seepage flow rate and turbidity which could indicate internal erosion of the embankment. Filter drains, set low enough to capture the seepage and convey the flow to a measurement point, are usually appropriate.

Monitoring pore water pressures within the dam embankment, together with reservoir water level monitoring, can also provide useful indications of long-term changes in the dam condition and performance.

It is important for reservoir owners to train staff on the types of changes in dam condition that should be reported immediately, including any possible signs of increased seepage rates.

Appendix A: Dam categories

Dam categories are defined in Floods and Reservoir Safety, 4th edition (Institution of Civil Engineers, 2015) as shown in the table below.

Dam Category	
A	Where a breach could endanger lives in a community*
B	Where a breach could endanger lives not in a community or result in extensive damage
C	Where a breach would pose negligible risk to life and cause limited damage
D	Special cases where no loss of life can be foreseen as a result of a breach and very limited additional flood damage would be caused

* A community in this context is considered to be 10 or more persons affected