Post-incident reporting for reservoirs

Annual report 2017

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 in England. Large raised reservoirs are those covered by the Reservoirs Act 1975, and most are capable of holding more than 25,000 cubic metres of water above natural ground level.

We use the information that we are sent to:

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

The regulatory authorities for Wales, Scotland and Northern Ireland will publish their own incident reports.

Arrangements for reporting

Incident reporting is separate and subsequent to the immediate incident response which should be reported to the emergency services as necessary. The Environment Agency's incident hotline number is 0800 80 70 60.

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 demonstrate the conclusions that can be drawn from it
- particulars to demonstrate 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.

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

Reported incidents - England

Severity and number of reported incidents in 2017

In 2017 we received information on four incidents that occurred in 2016 and five incidents that occurred in 2017.

One of these incidents was the subject of an industry bulletin and an investigation. The bulletin is available in Appendix A and the full investigation report is available separately from the Environment Agency on request. The report will be of interest to owners of service reservoirs.

The incident statistics for all incidents reported since 2004 are presented every five years starting with the 2015 annual report.

2016 incidents

Incident 429	
Dam type	Earth embankment
Reservoir legal status	Statutory non-impounding reservoir
Dam height (m)	8
Incident type	Embankment leakage
Incident severity	3

Description

Leakage was noticed on the downstream face of a newly-constructed reservoir just below the elevation of the full supply level. The reservoir level was lowered and the seepage ceased and increased again as the reservoir level was raised. Piezometers had been installed within the dam but had not detected any pore-water pressure increase. The reservoir was held well below the full supply level until repairs could be completed. The cause of the seepage is unconfirmed but is likely to be associated with the materials used for construction or the degree of compaction or both. The design used re-compacted Mercia Mudstone to form a lining to the internal face of the non-impounding reservoir. Surveillance of the area was increased from monthly to daily visits for the duration of the seepage incident.

Lessons learned

The incident highlights the need for increased surveillance and for maintaining the length of grass on newly-constructed reservoir embankments to detect seepage as and when it may occur. Piezometers will not usually provide a failsafe means of monitoring for seepage so should be supplemented with other forms of monitoring where appropriate and frequent surveillance visits to check the performance of the embankment. The cause of the incident appears to have been poor construction.

Incident 430	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	Unknown
Incident type	Internal erosion
Incident severity	3

Description

Leakage was noted past the right side of an overflow spillway at an old embankment dam. Water was observed to be passing close to the line of the right spillway wall and exiting on the spillway chute downstream of the overflow. An earth bund was placed in front of the point of leakage to allow investigations to be carried out. Excavations revealed large voids beneath the footings of the spillway side wall. Voids were also found beneath the floor of the spillway chute. Cracks had formed in the brickwork forming the side walls. The management of the incident was made challenging as no bottom outlet pipe was available to draw the reservoir water level down.

Lessons learned

Voiding below the spillway structure occurred as a result of an ineffective cutoff and an absence of filters to prevent the migration of soil particles. The incident demonstrates that internal erosion can occur at structures which have performed satisfactorily for a very long time. This underlines the need for vigilance and frequent surveillance at dam structures. The incident also shows the value of low level outlet facilities in managing such incidents.

Incident 431	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	4
Incident type	Embankment instability
Incident severity	3

Description

A shallow slip occurred on the downstream face of an embankment dam following prolonged heavy rainfall. A translational slide affected the surface topsoil and the uppermost part of the underlying clay fill. There was no indication of seepage from the affected area. The failure occurred in an area designated as an auxiliary spillway. The area was covered with plastic sheeting to prevent rainfall ingress until remedial works could be arranged and the area was monitored for continuing movement. The damaged material was subsequently excavated and re-constructed using a more granular material and incorporating a drain.

Lessons learned

The slip occurred in an area of the downstream face that had been recently slackened to provide an auxiliary spillway. It appears that the design or construction of the fill was insufficient to prevent shallow failure following heavy rainfall.

Incident 432	
Dam type	Embankment dam
Reservoir legal status	Statutory non-impounding reservoir
Dam height (m)	4
Incident type	Upstream face instability
Incident severity	3

Description

Relatively rapid lowering of the reservoir water level may have contributed to the deterioration in the condition of the upstream face protection at an old embankment dam. Rotational failure and deformation of the upstream face occurred at two locations. As a precaution, the reservoir water level was maintained at a low level and the affected areas covered with plastic sheeting until repair work could be arranged.

The mechanism of deterioration has not been confirmed. Wave action and deterioration of the facing over the long history of the dam is likely to have been a factor. The inspecting engineer who attended the site believes that the erosion of fill or dam formation material into rock fissures present at a shallow horizon below the embankment may be also have been a factor. One of the locations is close to a scour culvert and leakage into the culvert is also possible.

Lessons learned

The incident highlights the difficulties associated with managing old embankment dams which may have deteriorated by many mechanisms in a gradual manner. Operational factors such as rapid reservoir water level lowering can instigate instability of the upstream face, particularly if the face has been weakened. Water levels should normally be managed to restrict the rate of water level lowering except under emergency conditions. At this reservoir, the dam crest was relatively wide and the risk of breach was considered small. The impact could have been more significant had the crest been narrower.

2017 incidents

Incident 433	
Dam type	Embankment dam
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	7.7m
Incident type	Embankment leakage
Incident severity	3

Description

Leakage from the toe of the earth embankment dam was noticed. The reservoir water level was lowered by approximately 230mm which significantly reduced the leakage rate. The Supervising Engineer attended the site. A plan was prepared to manage the leakage until the embankment could be repaired. No roots were found during the repair work so the cause of the leakage could not be identified.

Lessons learned

Leakage through earth embankments can occur without any obvious cause of what instigated it. The owner decided to increase the surveillance frequency at the dam to improve the detection of seepage and reduce the risk of failure by internal erosion.

Incident 434	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	7
Incident type	Internal erosion
Incident severity	3

Description

The incident concerns erosion adjacent to a spillway weir and cascade at an old embankment dam. The first indication of deterioration was the detection of a void on the left bank of the reservoir and a further void under the concrete apron on the approach to the spillway weir. There was evidence that water was by-passing the cascade on the left side although dye testing was not able to confirm the route of the leakage. The weir was isolated using a temporary dam to complete an investigation of the apron. Remedial works were completed which included the infilling of voids with foamed concrete. The works were carried out under the supervision of an All Reservoirs Panel engineer.

Lessons learned

The void on the left bank, which was measured as 5m long in one direction, 1m deep with 600mm of standing water, was found in the vicinity of a tree which had been removed some years earlier. Although not proven, it is likely that the apparent leakage past the left abutment was associated with the voiding under the concrete apron and potentially with the left bank void. The felling of trees and associated decay of roots can lead to seepage and internal erosion at dams. This is likely to have been a contributory factor in this incident.

Incident 435	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	3
Incident type	Embankment sinkhole
Incident severity	3

Description

A sinkhole on the crest of an embankment dam was found above the position of a brick-lined culvert through the embankment, sealed by a gate at the upstream end. The water level was reduced and the sinkhole excavated to investigate the cause. The dam features a masonry wall on the upstream face, backed with a clay lining. Mortar loss from the wall and deterioration of the clay lining had allowed reservoir water to leak into the culvert forming a large void, approximately 2.5m in diameter. The clay lining was replaced with a mass concrete backing to the masonry wall and the void was repaired.

Lessons learned

The incident highlights the particular vulnerability of embankments which feature old brick culverts. The rate of flow through the masonry wall and into the culvert was limited by the size of the openings but the long-term seepage had created a void above the culvert which had the potential to cause collapse of the crest and failure of the dam by overtopping. The incident also shows how the apparent extent of voiding within embankments can be reduced by adjoining surface structures such as pre-cast concrete road kerbs which can span voids.

Incident 436	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	7
Incident type	Internal erosion
Incident severity	3

Description

A statutory inspection recommended an increase in spillway capacity and/or improvement in dam freeboard. Without appointing a qualified civil engineer, the owner reconstructed the overflow spillway to increase the spillway capacity. Leakage was observed adjacent to the structure. The reservoir water level was reduced to isolate the upstream end of the seepage path. The internal erosion was believed to have been caused by insufficient compaction of the fill against the overflow structure. The fill was removed and replaced with fresh clay fill.

Lessons learned

It appears that inadequate supervision was provided at works which could have affected the safety of the reservoir. Such works should be designed and constructed under the supervision of a qualified civil engineer as defined under the Reservoirs Act 1975. Particular care is required with the design of appurtenant works to prevent concentrated leakage and internal erosion adjacent to wall structures on refilling the reservoir.

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

Appendix B: Risk Designation

All large raised reservoirs in England need to be registered with the Environment Agency. The statutory threshold is currently 25,000m3. In England the Environment Agency is required to determine whether a large raised reservoir is high-risk or not. In Wales this duty is carried out by Natural Resources Wales.

Only large raised reservoirs that are designated as 'high-risk' are subject to the full requirements of the Reservoirs Act. Reservoirs that are designated 'not high-risk' do not have to comply with the inspection and supervision requirements of the Act. However, the incident reporting requirements of the Act continue to apply to both 'high-risk' and 'not high-risk' large raised reservoirs.

Section 2C of the Reservoirs Act requires the Environment Agency to determine whether a large raised reservoir is a high-risk reservoir if:

(a) the Environment Agency thinks that, in the event of an uncontrolled release of water from the reservoir, human life could be endangered, and

(b) the reservoir does not satisfy the conditions (if any) specified in regulations made by the Minister (NB: At present there are no such conditions specified).

The Environment Agency considers that life could be endangered if there is a reasonable expectation that in the event of an uncontrolled release of water from a reservoir, conditions downstream will be such that:

(a) persons within or in the immediate vicinity of residential, business or recreational areas, whether they be permanent or temporary establishments, could be endangered

(b) damage to infrastructure is sufficient to lead directly to human life being endangered.

Appendix C: Bulletin 06

Environment Agency

Over-pumping of service reservoirs

Bulletin No. 6 - December 2017

What happened?

A non-statutory, reinforced concrete service reservoir was over-filled by pumping causing the single cell to become pressurised. Water escaped through vents in the roof covers, spilled over the perimeter of the roof slab and caused damage to the surrounding earth embankments. The escaping water flowed from the reservoir site over a minor road towards a motorway but did not cause any flooding of residences or any significant damage beyond the reservoir. The maximum operational water level was subsequently lowered until an internal inspection could be arranged. The internal inspection revealed no structural damage to the reinforced concrete columns, floor slab, roof slab or side walls.

What caused it?

While the reservoir was being filled overnight, a power failure at the site caused a loss of accurate water level telemetry data being sent to the control room. Information which would have been used to stop the pumping into the reservoir was not received.

Normally, service reservoirs feature an overflow arrangement to prevent overfilling even if the water level control system fails. This reservoir features a high-level overflow pipe but the capacity of the pipe was insufficient to prevent the reservoir from overtopping.

Small overflow pipe within the reservoir

What are the issues?

The incident was caused by inadequacies in the water level control system and physical issues with the reservoir design.

Telemetry systems should feature some form of backup power supply or failsafe arrangement to ensure that accurate data is provided continuously or otherwise filling operations cease in the absence of reliable information from the site.

The overflow provisions at the site were inadequate to prevent the reservoir from being pressurised. Service reservoirs are not designed to be pressurised and damage to the structure can occur depending on the reinforced concrete design and the degree of pressurisation. The stability of service reservoir walls occasionally relies on the support provided by the perimeter embankments. If this

The reservoir over-spilled through air vents in the roof covers, causing the vents to distort outwards

support is reduced by erosion from water spilling through the roof slab, the safety of the structure could be compromised.

The water pressure caused the collapse of a retaining wall

Grass flattened by the escaping water

Water spilled over the edge of the roof slab, saturated the perimeter embankment and destabilised the earthfill.

Reservoir undertakers should:

- Review the reliability of the water level and alarm systems in the event of a power outage at service reservoir sites
- Review the overflow capacity of their stock of service reservoirs in relation to the peak inflow rate
- Understand the importance of perimeter embankments with respect to the stability of the structure. This will inform decisions with respect to the monitoring, surveillance and maintenance of the reservoir.
- Keep well-maintained archives of existing structural record drawings/documentation.

Panel engineers (for statutory reservoirs) should:

- Review the provisions for water level monitoring and alarm systems, including power backup arrangements
- Review the adequacy of overflow arrangements
- In the absence of design documentation, seek to understand the original design concept through structural investigation where appropriate

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