Post-incident reporting for reservoirs

Annual report 2016

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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Contents

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.

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 research into reservoir safety and incident frequency analysis

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

During 2016 and in previous years we have also received incident reports for reservoirs elsewhere in the United Kingdom and have included these in our annual report. From 2017 onwards the regulatory authorities for Wales, Scotland and Northern Ireland will publish their own incident reports.

Arrangements for reporting

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.

Please report any incident in any of the above categories to reservoirs@environment-agency.gov.uk

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 which came into force on 1 April 2016 make 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 has 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 makes provision for reservoir managers to report incidents occurring at controlled reservoirs. Until the relevant section of the Act comes into operation and the secondary legislation is made, reservoir managers may voluntarily report incidents to the Department for Infrastructure (Rivers) by emailing rivers.registry@infrastructure-ni.gov.uk.

Reported incidents - England

Severity and number of reported incidents in 2016

In 2016 we received information on four incidents in England. These all occurred between 2012 and 2015 but had not previously been reported to us. We also received information on four incidents in Wales. There were no reservoir incident investigations carried out in 2016.

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

2012 incidents

Incident 421	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	9
Incident type	Embankment instability
Incident severity	3

Description

A historical area of instability on the downstream face of an embankment dam was noted as having become reactivated as a tension crack was evident. A precautionary drawdown of the reservoir was completed to 1m below top water level. The area was monitored by installing vibrating wire piezometers. In 2016 works were carried out to remediate the slip area. Steel sheet piles were driven into the foundation at the downstream toe. When excavating the slip material, it was evident that the fill material was of poor quality and saturated. The reservoir was lowered by a further 3.85m before work continued. The slipped material was replaced by rockfill placed over a filter layer. The reservoir level was slowly restored to its normal level. The work was considered successful.

Lessons learned

The nature of fill materials in old dam embankments can vary over the length of the embankment leading to local instability. Areas of instability can become reactivated over time.

Photo 1: 2012 slip

Photo 2: saturated fill material during excavation March 2016

Photo 3: reservoir level reduced April 2016

Photo 4: placing rock-fill May 2016

2015 incidents

Incident 422	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	4
Incident type	Mining
Incident severity	2

Description

A 3m-diameter sink hole at the outer toe area of a flood storage reservoir embankment appeared. The area was excavated and the sinkhole was found to extend to a depth of 2m and connect with a horizontal cavity at the upper surface of the mudstone bedrock. The area was remediated by excavating the damaged area and infilling with free-draining material wrapped in a geotextile fabric. In the following month, three further sink holes appeared, one on the site of the first sink hole and two further sinkholes further from the embankment toe. Further remediation work was carried out and a 1.5m-high berm was added to the outer toe of the embankment to improve its stability. Investigations indicated that the depressions were related to deep coal mining activity. The embankment had recently been raised to offset the impact of settlement caused by the mining. A quantitative risk assessment was carried out and it is planned to further improve the stability of the affected embankment section by driving a row of steel sheet piles on the line of the crest into the bedrock. As the mining has now ceased it is hoped that further movement of the area will be not be significant.

Photo 1: sinkhole at toe of embankment

Photo 2: sinkhole further from embankment toe

Lessons learned

Subsidence due to coal mining can lead to fissuring of the ground surface and may materialise at the ground surface as a row of sinkholes. The movement can continue for many years after the mining has been completed and it can be difficult to anticipate where damage to surface structures might occur. Where safety-critical structures are located in the vicinity of a line of sub-surface movement it will often be prudent to take proactive measures to strengthen structures before the movement

occurs under the structure and to increase the frequency of surveillance.	 Photo 3: berm constructed to aid stability

Incident 423	
Dam type	Earth Embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	3.2
Incident type	Flood overtopping, gate malfunction
Incident severity	3
Description This incident occurred at an on-line flood storage reservoir where the reservoir operation is controlled by two automatic sluice gates. During a flood event, one of the two gates failed to operate after the reservoir had filled. This led to the overflow spillway operating and the flood inundation of many residential houses. A flood warning was provided to the residents. An investigation found that the torque cut off rating for the sluice gate was set too low, resulting in the gate malfunction. **Lessons learned** Mechanical devices at reservoirs must be periodically checked for correct operation. In this case the gate malfunction led to spillway operation under less severe flood conditions than in the design condition. It is possible that had the gate malfunctioned under safety check flood conditions, the safety of the reservoir might have been compromised although the malfunction of one or more gates under such conditions is often allowed for by designers. When building and operating reservoir spillways upstream of residential properties it is desirable to engage with communities downstream to keep them fully informed.	

2016 incidents

Incident 424	
Dam type	Earth embankment
Reservoir legal status	Statutory impounding reservoir
Dam height (m)	10
Incident type	Leakage - embankment
Incident severity	3
Description This incident occurred at an embankment dam which has a long history of leakage associated with mining subsidence for which repairs had been completed in the past. Leakage from the downstream face of the embankment was observed approximately 0.8m below top water level. The reservoir water level was lowered to 1m below top water level in 200mm increments to record the changes in the rate of leakage. The leakage rate quickly reduced when the reservoir level was lowered. **Lessons learned** The exact cause of the leakage is unknown. The reservoir has been maintained at a reduced level. It is understood that possible causes of the leakage include ground disturbance due to the removal of rhododendrons from the upstream face and mining subsidence.	

Reported incidents - Wales

Severity and number of reported incidents in 2016

In 2016 we received information on four incidents in Wales.

2015 incidents

Incident 425	
Dam type	Earth embankment
Reservoir legal status	Statutory reservoir
Dam height (m)	30
Incident type	Failure of scour main within draw-off tunnel
Incident severity	3
Description A hydropower turbine had been operated from a spur off a pressurised scour main. The scour main was located within a concrete-lined tunnel through the dam embankment. A sudden change in the load on the turbine caused a pressure wave to be transmitted through the cast iron scour main. A bypass valve that had been provided in the design to limit pressure rise on load rejection had failed to operate properly. A section of the pipe failed leading to a discharge of reservoir water into the drawoff tunnel. When the pipe failure was discovered, an attempt was made to isolate the scour pipe by closing the single upstream scour valve. Due to unbalanced head conditions across the valve, the valve could only be closed by 90%. A repair of the failed pipe section was carried out using steel pipe sections and flexible couplings. The safety of the reservoir was not considered to be under threat as the tunnel had a thick lining of concrete. No precautionary drawdown of the reservoir was considered necessary but this would in any case have been difficult without use of the scour pipe. **Lessons learned** Although the safety of the reservoir was not considered to be at significant risk, this incident has important lessons for reservoir operators. Investigations found that the failed section of pipe had not failed through a single incident but as a culmination of several waterhammer events whereby crack propagation eventually caused the pipe section to fail. There was evidence that the pipe had been lifted off its saddles due to the waterhammer events. Historical damage was	

evident from the presence of corrosion on the faces of the failed cast iron pipe section. The failed section was located on the underside of the pipe, making visual detection of the cracking difficult to detect. Any historical seepage through the fine cracks would not have been detected on account of larger seepage flows into the tunnel from the drawoff tower. The scour pipe had been designed with a single upstream scour valve such that it was not possible to fully isolate the failed section of pipe. Dealing with water flowing through the scour pipe, and the proximity of a critical raw water supply main running parallel to the scour main, made the logistics of safely repairing the scour pipe much more difficult.	

Incident 426	
Dam type	Earth embankment
Reservoir legal status	Statutory reservoir
Dam height (m)	25
Incident type	Wind, waves, deterioration of upstream face protection
Incident severity	2
Description The upstream face of the embankment dam was protected from wave action by rip rap on the lower section of the face and rip rap overlain with a mass concrete slab on the upper section. Following a two-day period of unusually high water levels and wave action, a hole in the concrete slab was identified. Some material from underneath the slab had been washed out but the embankment fill had been protected by the underlying rip rap layer. It is believed that voiding under the slab had arisen due to settlement of the embankment and that a loss of support had contributed to the failure of the face protection. The reservoir was lowered to allow a repair to be completed. **Lessons learned** Rigid facing systems such as concrete slabs can be effective in protecting the upstream face of a dam from wave erosion. Problems can arise if the slab design cannot accommodate settlement of the underlying fill material combined with wave loadings.	 Photo 1: hole in concrete slab

2016 incidents

Incident 427	
Dam type	Rockfill
Reservoir legal status	Statutory reservoir
Dam height (m)	44
Incident type	Failure of draw-off pipe
Incident severity	3

Description

A review of the condition of the pipework and valves at a large concrete/masonry gravity dam identified a short section of steel pipe on two of the four low level scour mains within the dam body with inadequate pipe thickness. These sections warranted improvement works but could not be isolated from reservoir pressure as they are located downstream of the abandoned original guard valve and upstream of the replacement guard and duty valves. One of these pipe sections was successfully encapsulated with a collar and rendered safe. Due to further deterioration in the condition of the other pipe section It was considered too dangerous to the workforce within the confined space within the dam to complete a similar repair. It was therefore necessary to substantially lower the reservoir and use divers to install a temporary plug at the inlet to the scour main to provide adequate isolation and protection to the workforce in completing the repair work. Had either of the two pipe sections failed, it is unlikely that reservoir safety would have been compromised but the reservoir would have drained in an uncontrolled manner through the failed pipe section.

Lessons learned

This incident demonstrates the value of periodic asset condition surveys on pipes and valves within dams through non-destructive testing and visual assessments. Such surveys can inform asset planning to schedule improvement and remedial works to minimize the risk to reservoir safety, water supply and the safety of those tasked with undertaking the repair or improvement works. Isolation of the scour main was successfully completed using divers but this can be challenging and hazardous work and should be avoided as far as possible through effective asset management.

Photo 1: Short section of steel pipe on the scour pipe

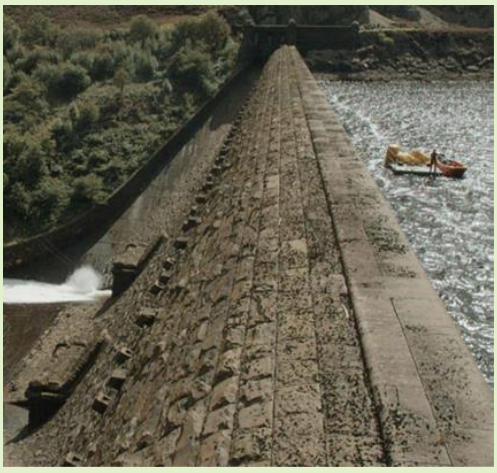

Photo 2: upstream can be seen the diving platform and downstream can be seen one of the scour pipes discharging.

photo 3: from left, inflatable plug, plate and bellmouth.

Incident 428	
Dam type	Earth embankment
Reservoir legal status	Statutory reservoir
Dam height (m)	4.5
Incident type	Inflow flood, erosion by overtopping
Incident severity	2

Description

A subsidiary dam embankment overtopped with floodwater following a period of very wet weather. Some erosion of the dam crest and downstream shoulder occurred at two locations either side of a small masonry overflow spillway. Emergency works were initiated to seal the eroded areas with sandbags, raise the elevation of the dam crest using sandbags and to provide temporary improvements to the spillway using plastic sheeting and sandbags. The reservoir does not feature any operational facilities for lowering the reservoir water level. The provisions for monitoring and surveillance were improved and studies and investigations are planned to improve the flood safety of the reservoir.

Lessons learned

The reservoir was not provided with sufficient spillway capacity and dam freeboard to prevent overtopping of an earth embankment dam in a moderately severe flood event. The event occurred at a reservoir which had only recently been registered under the Reservoirs Act 1975 and where earlier recommendations to improve the spillway capacity had not been completed. The Undertaker responded quickly to make temporary repairs to the eroded areas and to increase the dam freeboard until more permanent works could be completed to improve the flood safety of the reservoir.

Photo 1: Eastern breach location

Photo 2: western breach location, following works to seal the breach

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.

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