# Advice note following the Toddbrook Reservoir incident, August 2019

## Introduction

This note summarises the lessons learnt from the Toddbrook incident. It provides important technical advice and recommended actions for reservoir managers and engineers to consider when reviewing the safety of their reservoirs. It is based on the findings of the reports published on 16 March 2020:

- independent review led by Professor David Balmforth, commissioned by the UK Government;
- report into root cause and failure by Dr Andy Hughes, commissioned by the Canal & River Trust (CRT).

All reservoir managers and engineers should read through both reports.

## Incident at Toddbrook dam

At the end of July 2019, following a period of heavy sustained rainfall, water began to cascade down the auxiliary spillway of Toddbrook dam in Derbyshire. On 1 August 2019 this flow of water triggered the partial collapse of the concrete slabs forming the spillway chute. A major incident was declared, which led to the evacuation of over 1,500 local residents immediately downstream of the reservoir. Emergency works were initiated to prevent a catastrophic failure of the reservoir. This was the first major incident at a UK dam in over a decade. In September 2019, the UK Government announced an independent review to ensure that the learning from what happened at Toddbrook is used to inform reservoir safety. A separate technical investigation into the incident was

commissioned by the CRT, as part of their legal obligations under the Reservoirs Act 1975.

## Lessons learnt and potential risks

Both reviews concluded that poor design was a key factor in the partial collapse of the spillway. They identified that erosion caused by water getting under the spillway crest and through joints and cracks in the spillway slabs, contributed to the collapse. The reports consider the likely theories of how the void space underneath was created. The main causes and contributing factors identified by the reports are summarised here, to share the learning and ensure the right steps are taken to improve reservoir safety.

In relation to reservoir design:

- A spillway crest with no adequate seepage cut off, or equivalent, into the top of the main dam clay core could lead to long term seepages through the fill material above the clay core. This could create a flow path with the potential to cause settlement and erode earth fill material beneath the spillway chute.
- Transverse joints between spillway slabs need to have adequate dowel bar connections and water bars. Joints need to be sealed by water-bars, be able to articulate and feature an adequate shear connection. Both the longitudinal and the transverse joints need to be able to accommodate the movement of slabs, otherwise there is a risk of cracking and the lifting of spillway slabs, under pressure, during spillway operation.

- Concrete spillway slabs need to be of adequate thickness. Modern practice would require a slab of minimum 300mm thickness, founded on a 75mm thickness layer of blinding concrete.
- Spillway slabs need to be designed with two layers of reinforcement, to control surface cracking and for structural purposes. This makes the slabs watertight and gives them inherent strength.
- Sufficient under-drainage is needed to allow seepage flows to escape without eroding embankment fill material, particularly if combined with a lack of seepage cut offs.
- As-built drawings need to include any changes made during construction from the original design drawings. This will help to better understand any changes to how spillways will operate.
- Earth embankments do settle over time, which could lead to gaps forming beneath or adjacent to rigid structures, like spillways, allowing water ingress which could lead to internal erosion.

In relation to reservoir maintenance:

- A lack of structured, planned and routine maintenance can lead to spillway deterioration. For example, long periods of plant growth can open joints and cracks in spillway slabs. If these are left unsealed it can lead to the injection or penetration of flow into the fill material below.
- The presence of embedded rock plums in spillway chutes can provide locations where the kinetic energy of water flow in the spillway can stagnate leading to locally high

pressures. This pressurised water can lead to injection into local cracks and joints in the slabs and erode the embankment fill below.

- Downstream drainage relief holes need to be checked for blockages as part of a regular maintenance plan. This is important to allow seepage flows to escape without causing excessive hydraulic pressure underneath the spillway slab.

## Actions for reservoir managers

1. Be aware of the vulnerability of spillways to poor maintenance and repair. You are responsible for the safety of your reservoir(s) at all times and regular maintenance and repair of spillways at appropriate intervals. Do not wait for your appointed construction engineer, supervising engineer or inspecting engineer to draw matters to your attention. Be prepared to commission inspections more frequently than the specified legal minimum.
2. Under the guidance of the supervising engineer, make available an appropriate and well-structured package of information on the reservoir to the inspecting engineer well in advance of a planned statutory inspection. Ensure that all existing design and construction details of any spillway are made available. The inspecting engineer should not have to search out relevant information from archives.
3. Ensure formal inspections include close inspection of spillways. Make the necessary safety preparations in advance to enable such close inspections to take place as a matter of routine.
4. Arrange a formal meeting with the inspecting engineer and the supervising engineer, immediately the inspecting engineer has determined the findings of the inspection and

formulated any recommendations as to measures to be taken in the interests of safety and statutory maintenance. This meeting should take place within one month of the date of the inspection.

5. Respond to draft inspection reports promptly.
6. Complete any outstanding maintenance of spillways urgently and respond promptly to the recommendations of supervising engineers. Ensure adequate maintenance, including the regular and prompt removal of plant growth and the consistent maintenance of any sealant to joints and cracks.
7. Under the guidance of your appointed panel engineers, regularly maintain all existing long-term monitoring equipment on reservoirs, so as to keep the equipment serviceable, and take and record measurements at appropriate intervals. All measurement data should be retained in a usable format in the prescribed Form of Record, for ongoing use by construction and supervising engineers and for use by inspecting engineers at their inspections.
8. Ensure adequate surveillance of spillway works by the following means: regular walkover inspections, utilising rope access as required; surveys; satellite imagery; movement monitoring; ground penetrating radar or other means of void detection.
9. Seek expert advice from your appointed construction engineer, supervising engineer or inspecting engineer if unsure.

## Actions for panel engineers

1. Seek out drawings and records of all spillways and examine thoroughly**.** Consider the causes and contributing factors described as potential risks above and confirm to the

reservoir manager whether any are present. If they are, highlight this in your report or statement to the reservoir manager and recommend appropriate investigations and actions.

2. Do not overly rely on information in previous inspection reports.
3. In the absence of design documentation, seek to validate the design through site investigation and analysis where appropriate.
4. Dedicate special attention and care to the inspection of spillways. Predict potential deficiencies and commission maintenance or improvements to address these when necessary.
5. Inspect spillways closely and by direct access during site visits, with at least one spillway inspection by the supervising engineer every 12 months.
6. Submit the inspection report without delay, following a formal meeting with the reservoir manager, which should take place within one month of the date of the inspection**.**
7. Recommendations as to measures to be taken in the interests of safety should be worded so that they unequivocally convey the seriousness of the risk and the urgency of implementation.
8. Inspecting engineers should make full use of the provision for statutory maintenance when setting out the requirements following an inspection.
9. If appropriate, advise the reservoir manager to temporarily lower the water level in the reservoir where there are concerns regarding the safety and adequacy of the spillway (or any other critical component of the reservoir). Engineers should be mindful of the

potential environmental and flooding impacts on receiving watercourses and consult SEPA about any intended release. This could require an environmental permit, depending on the circumstances.

10. Use all available legislative powers, including:

- for inspecting engineers, short deadlines for safety works where these are considered key for public safety or urgent, specifying early next inspection dates and recommendations to the supervising engineer on the circumstances in which they should call for a new section 47 inspection;
- for supervising engineers, calling for a section 47 inspection when required.

## Next steps

SEPA is working with the Scottish Government to consider the recommendations of the independent review led by Professor David Balmforth, commissioned by the UK Government. A number relate to actions identified above and we advise reservoir managers and engineers to take action now to improve inspection, supervision, operation and maintenance.

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