

Reservoir Safety Action Group - Research and Development

September 2016

The Environment Agency is responsible for reservoir safety R&D for England and Wales and established a Reservoir Safety Theme Group to manage this work under the Flood and Coastal Erosion Risk Management R&D Programme.

The Reservoir Safety Theme is managed by **Chrissy Mitchell** and **Tony Deakin** of the Environment Agency through the Reservoir Safety Advisory Group (RSAG). RSAG is chaired by **Andy Hughes** from Atkins and draws on expertise in government, industry and academia.

1. Reservoir Safety Research Strategy



2. Dam and reservoir conduits. Inspection, monitoring and repair



3. Drawdown capacity for reservoir safety and emergency planning



4. Design, Operation & Adaptation of Reservoirs for Flood Storage



5. Grouting in Dams



6. The Performance of Grass and Soil in Resisting Erosion



7. Assessing reservoir capacity limits



8. Investigating the Structural Safety of Cracked Concrete Dams



9. Future Priorities



Stay in touch by subscribing to the joint programmes bi-annual newsletter
PRODUCTS ARE FREE TO DOWNLOAD FROM HERE

<http://evidence.environment-agency.gov.uk/FCERM/en/Default/FCRM/Subscribe.aspx>

1. Reservoir Safety Research Strategy

SC130003

The Reservoir Safety Research Strategy has been reviewed and updated, replacing its 2007 predecessor. It identifies;

- new challenges presented to reservoir managers and operators through severe weather events;
- developments in methods and materials;
- changes in legislation;
- the consequences of climate change.

The strength of the five year Reservoir Strategy is that it is inclusive and transparent in the way that research priorities are identified. Mott MacDonald have led the review and successfully consulted with reservoir professionals from across the industry.



Pontsticill Reservoir

The Strategy will be free to download from the joint programme website Autumn 2016.

2. Dam and reservoir conduits. Inspection, monitoring and repair

SC120001 (CIRIA ref: C743)

Conduit (tunnels, culverts, pipe) problems have led directly to a significant number of dam failures and incidents. The mechanisms and modes of failure are well understood, but now, thanks to this research we also have a comprehensive guide. The work was carried out by CIRIA in association with the Environment Agency and funded through a consortium.

The guide covers a wide range of aspects to conduits such as;

- a description of types of conduit commonly associated with UK reservoirs;
- a description of failure modes for reservoir conduits (which often operate under large hydraulic heads);
- visual inspection techniques;
- monitoring techniques (measurements);
- non-intrusive investigations;
- intrusive investigations;
- maintenance and repair.

The final report is currently available as a free download from CIRIA at:

http://www.ciria.org/News/CIRIA_news2/Dam_and_reservoir_conduits.aspx



Image courtesy of CIRIA

3. Drawdown capacity for reservoir safety and emergency planning

SC130001

In England and Wales some 1.2 million people live and work in the direct flood path of reservoirs in the event of a failure. The average age of these structures is 120 years and the possibility of a catastrophic failure inevitably increases with age. The risk of such an emergency varies depending on a range of factors including dam type and age, reservoir infrastructure, and the level of maintenance and competency of operation.

A key factor in avoiding and minimising the impact of such a catastrophic failure is the ability to draw down a reservoir in the event of an emergency, thus lowering pressures on the dam structure and reducing overall downstream impacts in the event of failure.

This research provides for the first time, a common practice for assessment of the capability to draw down a reservoir safely in an emergency, in the event that structural problems are identified with the asset.



Northumbria (www.nwl.co.uk)

The resulting guidance has combined UK and international best practice to provide a consistent and reliable approach applicable to those designing new low-level outlets, those engaged in reviewing reservoir emergency plans and those seeking to increase resilience through increasing the existing drawdown capacity.

The guidance is free to download from the joint programme website Autumn 2016.

4. Design, Operation & Adaptation of Reservoirs for Flood Storage

SC120001



Pickering Flood Storage Area, ICE.org.uk

The Environment Agency has developed new guidance on reservoirs for flood storage. The project, being delivered by Mott MacDonald, addresses a recommendation in Defra's Reservoir Safety Research & Development Strategy (2009).

The new guidance will present the latest thinking in reservoir design and operation to maximise reduction in flood risk, including considerations for adapting existing reservoirs for flood detention, or 'dual use'.

Technical workshops to gather knowledge from the expert community have been undertaken, involving water companies, local authorities, academia and engineering experts. The first on flood storage reservoirs; the second on dual use or adaptation of reservoirs for flood storage. A third workshop dedicated to environmental considerations gained valuable insight from the national expert community.

The guidance has been shaped and reviewed by a dedicated project steering group comprising industry, regulatory and academic experts. It is aimed at a wide range of stakeholders including planners, developers, reservoir owners, asset managers, designers, contractors, regulatory engineers/advisors, environmentalists, educational institutions and the public.

The guidance is free to download from the joint programme website Autumn 2016.



5. Grouting in Dams

SC160017

In the UK there is a long history of reservoir dam construction resulting in many forms of design and methods of construction. Fortunately there have been few catastrophic failures although there are many examples of instances where intervention and emergency rehabilitation has avoided or delayed such an adverse event.

For the purpose of ensuring against leakage from dams, and all that can follow if uncontrolled or undetected, grout injection methods are usually employed to provide a seal or barrier as with a grout curtain cut-off. In broad terms grouting methods may be employed in the body of the dam, in the shoulders, in the foundations or in the natural ground underlying the dam all for the purpose of providing water tightness.

The project will provide for the first time, a UK a reference standard in the form of a thoroughly researched and comprehensive best practice guidance report on grouting in dams applicable to both reservoir embankments and concrete. It is likely that the project report will also provide guidance that is applicable to levees and other such water retention structures.

This research is currently being led and procured by CIRIA and is expected to start in Autumn 2016



6. The Performance of Grass and Soil in Resisting Erosion

SC140006



USA (Bottom) & Netherlands (Top)

One of the ways in which an embankment dam or flood embankment can fail is through failure of the grass cover and erosion of the embankment soil, whether via overflowing, overtopping or internal erosion. The rate of erosion and hence the speed of failure and nature of any flood hydrograph generated by a release of stored water depends upon the performance of the grass cover and the soil erodibility.

This project will provide improved guidance on the performance of grass cover and for understanding and guidance on predicting soil erodibility; considering resistance to erosion on flood banks, reservoir banks and coastal defences.

A programme of field testing will provide an open database of parameters to update grass performance relationships

This project is currently being procured and is expected to start Autumn 2016.



7. Adopting a Risk Based Approach for Small Raised Reservoirs

Defra led



This research will review the regulatory impact of phase 1 of the Flood and Water Management Act (2010) and improve the evidence base related to the number and risk posed by reservoirs in England with a capacity between 10,000m³ and 25,000m³. This evidence will feed into future decision-making about the regulatory approach to small reservoirs. The project is likely to provide the following:

- Provide evidence to feed into a Post Implementation Review of the implementation of the first phase of the FWMA 2010 reservoir provisions. This will focus on the impact and effectiveness of the regulatory changes related to the risk assessment of Large Raised Reservoirs over 25,000m³.
- Provide evidence on the number of smaller reservoirs with a capacity below 25,000m³, including those in cascade, and the level of risk they pose.
- Review the methodology related to the risk based approach, including consideration of probability for assessing reservoir risk.

This research is currently being led by Defra and is expected to start in autumn 2016.

8. Investigating the Structural Safety of Cracked Concrete Dams

CEATI: T122700

The assessment of cracks in dams considers the specifics of the design and construction of each dam and its environment; no two dams are the same. Consequently, no simple general rules can be defined. A report has been written which includes;

- a listing of potential 'root causes' of cracking in dams;
- for each cause, a description of the cracking mechanisms and various forms such cracking may take leading to a 'crack classification' system;
- an approach for linking the cracks to potential failure modes.
- a number of examples of cracked concrete dams, including masonry, CVC and RCC gravity and arch dams, and buttress dams
- the root causes of cracks in these dams due to a range of common mechanisms such as drying shrinkage; hydrostatic loading; foundation and abutment behaviour; thermal responses; freeze-thaw effects; chemical expansion and degradation; effects of multi-stage construction and dam raising; earthquakes; corrosion of rebar, anchors and embedded parts.



These causes are discussed in terms of potential failure modes, leading to the identification of key performance indicators to help owners focus their surveillance and monitoring programmes and risk mitigation measures.

This project was delivered through collaboration between members of the Dam Safety Information Group (DSIG) and can be found on CEATI's website: www.ceati.com/projects/publications/publication-details/?pid=0226



Future priorities – Can you help?

The following have been identified as R&D priorities within the new reservoir strategy and are looking for support or funding.

1. Extreme Flood Hydrograph Estimation & Probable Maximum Precipitation / Flood estimation (PMP/PMF)
2. Embankment transitions
3. Management of trees and vegetation on embankment dams
4. Investigate the selection, operation, evaluation, repair, maintenance and replacement of gates and valves
5. Managing reservoir leakage and seepage
6. Methods for dam break analysis
7. Reservoir Monitoring and Surveillance
8. Geophysical methods for reservoir safety investigations
9. Flood management and other considerations for discontinuance
10. Structural Safety of Cracked Concrete Dams - Identifying and managing cracks in concrete dams
11. Spillway Protection and Remedial Works
12. Sediment management in reservoir operations
13. Maintenance regime best practices
14. Particle-scale soil research and modelling to assess the vulnerability of UK dams to internal erosion and time to failure
15. Guidance on preparing and exercising on-site emergency plans
16. Degradation of reservoir related materials in the UK
17. Investigating a standard methodology for estimating loadings on wave walls of various shapes
18. Guidance on use of geotextiles in reservoirs
19. Updated breach inundation methodology
20. Guidelines for the responsible use of reservoir gates such as spillway gates and flood gates
21. Techniques available for improving dam water tightness through various repair techniques
22. Vegetation in reservoir basins, seasonal variation and management
23. Design of debris screens
24. Research and development of guidance on effective management structures for reservoir safety
25. Application of modern safety standards to old dams
26. Forensic opportunities at discontinued dams
27. Research into joint probabilities of wave and reservoir rise at reservoirs
28. Research to support the RARS Tier 3 probabilistic risk assessment
29. Grass varieties for various applications and maintenance
30. Revised guidance for the seismic risk to dams in the UK
31. Effect of climate change on operation of reservoirs.
32. Guidance on underwater surveys
33. Behaviour of populations in a dambreak scenario
34. Determination of the residual life of grouted post-tensioned anchors in dams
35. Development of regional flood coefficients (e.g. Francou-Rodier or Creager values)
36. Guidance on design and construction of homogenous fill dams
37. Specification for Dams
38. Vehicle loadings on dam embankments
39. Methodologies for estimating ice loading on dam structures in the UK
40. Security against terrorism
41. Guidance on anchoring systems for floating islands
42. Reservoir rim stability



Please get in touch if you would like to find out more, shape the research, share any local initiatives you are involved in or identify any research needs.

Dr Chrissy Mitchell Ph.D. MSc. BSc. FRGS, FCIWEM, C.Geog, C.Sci, C.Env, CWEM
Senior Specialist, Flooding and Communities, Environment Agency

Email: christabel.mitchell@environment-agency.gov.uk

Mobile: 07733 308743

Website: <http://evidence.environment-agency.gov.uk/FCERM>

