Reservoir Flood Plans – Towards Implementation

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SYNOPSIS. The Water Act 2003 established a new role for the Environment Agency as the enforcement authority for the Reservoirs Act 1975 in England and Wales. Further change is heralded with the introduction of reservoir flood plans (or emergency action plans).

The Department for the Environment Food and Rural Affairs (Defra) is producing guidance on technical standards for reservoir flood plans entitled an *"Engineering Guide to Emergency Planning for UK Reservoirs"* ('the Guide'). Reservoir flood plans, which will be used in emergency planning by Local Resilience Forums, will increase awareness of the extent of potential inundation areas from reservoirs and the challenges faced by all those involved in managing and communicating flood risk.

The current programme for introducing reservoir flood plans is to carry out a public consultation and impact assessment on the proposals, led by Defra, in autumn 2008, followed by the Ministerial direction and the introduction of the formal requirement for reservoir flood plans in spring 2009.

This paper provides a review of the current developments made towards completing the Guide and the major changes which will result from the requirement to produce reservoir flood plans. It also highlights the issues which arose during the earlier informal consultation process.

INTRODUCTION

Following the Water Act 2003, responsibility for reservoir safety in England and Wales was transferred to the Environment Agency. As the enforcement authority, the Environment Agency is responsible for assuring the safety of the nation's 2,100 reservoirs by enforcing the Reservoirs Act 1975. The Environment Agency aims to work alongside reservoir undertakers (operators, users and owners), supporting them in meeting the requirements

Ensuring reservoir safety into the future. Thomas Telford, London, 2008

of the Reservoirs Act 1975. This role is carried out by the Reservoir Safety team, based in Exeter.

The Environment Agency is not directly responsible for the safety of reservoirs. Reservoir undertakers are responsible for ensuring safety, compliance with the law and assessing the flood risk posed by their reservoirs. As described in Hope (2006) the Environment Agency is responsible for enforcing the Act by making sure that undertakers fully comply, warning and ultimately prosecuting those that don't.

The Environment Agency has compiled a register, which can be viewed at its Area offices, of reservoirs in England and Wales to which the Reservoirs Act 1975 applies (those capable of holding at least 25,000m^3 of water above lowest natural ground level). Known as 'large raised reservoirs', these are owned by some 772 businesses and individuals, and include 185 flood storage reservoirs, which the Environment Agency itself owns and operates. An investigation has recently been concluded into a further 320 existing reservoirs, 119 of which are now subject to the Act (Goff & Hope 2008).

RESERVOIR FLOOD PLANS

Flooding from reservoirs can be caused by an uncontrolled breach of the dam, perhaps caused by over-topping during a severe rainfall event. The consequences of this kind of flood could be catastrophic. However, the chance of a dam failing is considered to be 'low'. The average age of dams in Great Britain is over 110 years and there are between four and six emergency drawdowns of reservoirs each year (this action is seen as a last resort to prevent dams failing).

Great Britain is arguably behind the rest of the developed world in producing reservoir flood plans (or emergency action plans) for reservoirs. Under the Water Act 2003 undertakers must produce flood plans for their reservoirs where directed by the Secretary of State.

Defra is the government department responsible for reservoir safety. Defra is currently funding the production of an "Engineering Guide to Emergency Planning for UK Reservoirs". This work, carried out by Atkins, will set out the requirement for flood plans in detail and how it will be applied to the different categories of reservoirs. A consultation on the government direction is expected to be published by Defra during autumn 2008 and the direction will be given to undertakers in spring 2009. It is expected that undertakers will have five years to prepare and submit compliant reservoir flood plans.

The draft proposals, developed in 2006, envisaged that the reservoir flood plan would include some or all of the following, depending on the consequences of the reservoir failing:

- on-site emergency plan. To set out what the undertaker would do in an emergency to try to prevent the dam failing.
- full dam breach and inundation analysis. To provide a plan of the area inundated and information on velocities and depths of flow.
- plan for liaising with external organisations. To define and test channels of communication between the undertaker and the Local Resilience Forum.

On-site emergency plan

An on-site plan should make sure the undertaker is prepared for an emergency at the dam. The aim of preparing and maintaining an on-site plan is to:

- identify ways of preventing the dam failing in an emergency or incident and to make sure that methods are in place, that they are workable, and staff understand what to do;
- show what to do to delay the dam failing (if it cannot be prevented) and reduce the amount of water released so that work can be done off-site to reduce the loss of life and damage caused

Undertakers will be able to use the on-site plan to:

- brief staff and subcontractors who are unfamiliar with the dam, so that they can help to prevent the dam failing in an emergency;
- set out what steps to follow, and any other information needed to manage an emergency.

The on-site plan must be kept up-to-date. Staff and external organisations, who have a role to play in the emergency, also need to be trained and to practice carrying out the plan.

Last year the Environment Agency produced a guide to help undertakers prepare and maintain an on-site plan which can be downloaded from www.environment-agency.gov.uk/reservoirsafety. Undertakers are advised to produce on-site plans immediately, if they haven't already, rather than waiting until it becomes a regulatory requirement.

Inundation analysis

The inundation analysis will model the effect of a dam breach and the flood water passing downstream to establish the consequences of a dam failing. It

will identify property and critical infrastructure that could be affected. It will also provide information on depth and velocity of flow which will help in emergency planning and in assessing casualties.

Most water companies and a few other reservoir undertakers have carried out inundation mapping to identify the extent and consequences of a dam failure leading to release of impounded water. Generally, this information is paper-based and varies in standard. Although this information has, in many cases, been available for some years, Defra/CPNI (Centre for the Protection of National Infrastructure) previously advised that it must be kept confidential.

It has now been agreed, however, that the existing inundation maps should be released to Category 1 responders under the Civil Contingencies Act 2004, but that the full information should only be used for emergency planning at this stage. This early release of information does not affect the plans in progress to introduce the formal legal requirement (under the Water Act 2003) to produce reservoir flood plans, but is a useful pilot process.

Following a request from Defra in March 2008, it is now proposed that simplified inundation mapping will be carried out nationally by the Environment Agency to provide a baseline assessment of all reservoirs falling within the Act. This will ensure consistency, confirm dam categories (ICE 1996), allow emergency planners to identify effects on critical infrastructure, and identify the area of influence for future town and country planning. Under the proposal undertakers will not have to provide maps for all dams, but they may have to provide more detailed information and analysis for the highest risk dams.

The Environment Agency awarded a contract to Mott MacDonald and JBA Consulting for a trial inundation mapping project in May 2008. The trial is being carried out in North West England, supported by Government Office North West, to define the specification for this work. This work is being carried out under the Environment Agency Strategic Flood Risk Mapping Framework

The incident at Ulley reservoir in 2007 brought a number of issues to the fore. Although Ulley was a category C reservoir, there was significant infrastructure downstream, including two high pressure gas mains, electricity pylons, a sewage treatment works, a substation, an ‘A’ road and the M1 motorway. During the incident three communities were evacuated as a precaution. The reservoir has now been classified category A. Local and Regional Resilience Forums hold details of the type and location of critical

infrastructure. Whilst some of this information may be available to the public (through OS maps, Google Earth etc.), it will not always be obvious.

Critical infrastructure will affect the categorisation of the reservoir. The flow chart in Figure 1 shows the process for populating the maps and how the issues that arise might be resolved. This proposed method will ensure a consistent approach to categorising dams. It will inevitably lead to a number of reservoirs being re-categorised. However, the project still has to resolve how accurate the maps should be (which will impact on costs) and how/if undertakers can appeal against re-categorisation of their asset by a third party based on information that by its nature, must remain confidential.

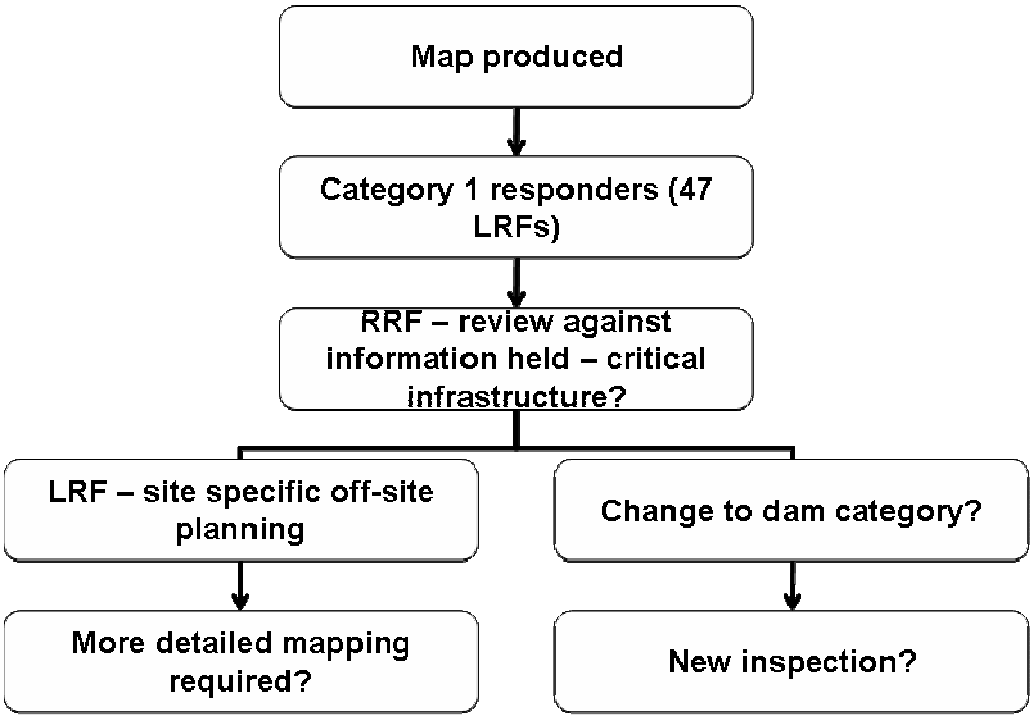

Figure 1: Process for population of inundation maps with critical infrastructure.

Developing inundation maps will allow emergency planners to provide a site-specific response which is more useful than the general advice already provided in the National Risk Assessment for major dam failure (H44). This information will be used to identify whether further, more detailed mapping is needed.

To gain the greatest benefit from the proposed national mapping exercise, discussions have been held with emergency planning representatives to identify the level of information needed for emergency planning purposes.

Dambreak analysis

The accuracy of current dambreak inundation mapping is variable – depending greatly upon assumptions made, models used and topographic and modelling data resolution. In particular, assumptions for dam failure, including breach modelling, can contribute greatly to the overall uncertainty. For example, the IMPACT project (Morris & Hassan 2005) demonstrated that uncertainty in modelling dam breach (for the Tous case study used) was responsible for up to 50 per cent of the uncertainty in extreme flood level prediction further along the valley.

More recent work has been carried out under Task 6 of the FLOODsite project, addressing the modelling of breach initiation and growth. FLOODsite report T06-06-03 *"Breaching processes: a state of the art review"* gives a summary of current state of the art methods, along with details of key developing areas (for breach prediction) and current 'best practice' models.

As part of the inundation mapping trial, Atkins with HR Wallingford will be reviewing dam break modelling as a whole, and as used in the UK, in order to advise on the most appropriate modelling techniques to use. This will be incorporated into the Engineering Guide and the specification for Environment Agency national inundation mapping.

Off-site emergency planning

Off-site emergency planning is being carried out under the Civil Contingencies Act 2004. Part 1 of the Act provides a statutory framework for civil protection at the local level, which applies across the UK. It sets out clear expectations and responsibilities for front line responders to make sure they are prepared to deal effectively with emergencies. It divides local responders into two categories:

a) Category 1 responders - central to most emergencies (for example emergency services police, fire, ambulance, local authorities, NHS bodies, Environment Agency).
b) Category 2 responders (for example Health and Safety Executive, transport and utility companies) - required to share information and co-operate with Category 1 responders as part of emergency planning.

Category 1 and 2 responders form Local Resilience Forums (LRFs), which help co-ordinate emergency planning, training and exercises locally. Category 1 responders have a duty to carry out risk assessments and produce a Community Risk Register covering their area. LRF members will have to

assess the need for, and carry out, detailed off-site emergency planning for those reservoirs posing a significant risk. It is anticipated that this role will be led by upper tier local authorities (County or Unitary Councils).

The risk of a dam failing is a combination of the likelihood of failure and the consequences of it happening. Assessing the likelihood of any dam failing is difficult. The dam failing due to overtopping would be as a result of a flood greater than the spillway capacity (unless it is blocked). This is a relatively low level of risk compared to other hazards. In practice, an earthfill dam is more likely to fail as a result of leakage or piping, rather than overtopping or perhaps due to a spillway failure (as at Ulley). No dams have failed causing deaths in England and Wales since the Reservoirs (Safety Provisions) Act 1930 came into force, but recent evidence given to the Pitt Review (Hinks & Mason 2007) suggests the risk of dam failure resulting in loss of life in the UK could be as low as 1 in 45 years.

Whilst there are a number of incidents each year, where reservoirs have to be drawn down to prevent the dam failing, we can make limited conclusions about the chance of dams failing. Following instruction from Defra, the Environment Agency has recently introduced a post-incident reporting procedure to share lessons learned from reservoir incidents. This process was jointly developed with Halcrow Group Ltd and is starting to provide much needed information. However, reporting is voluntary and the database is still in its infancy. A copy of the first annual report can be found on the Environment Agency's website.

Whilst undertakers have information on the condition of dams, this has not generally been ranked in terms of severity of risk. Risk ranking has certainly not been applied between undertakers. This contrasts with the situation in other developed countries, for example in Australia where Stewart et al (2007) describes how Portfolio risk assessment informs prioritisation and funding of dam safety upgrading projects. Portfolio risk assessment is also applied to the regulation of dams. See www.damsafety.nsw.gov.au.

An Interim Guide to Quantitative Risk Assessment (QRA) was produced by Defra to address this problem. The Environment Agency is sponsoring an overhaul of the interim QRA Guide as part of the Reservoir Safety Research and Development Programme. Once developed, this will allow a more accurate assessment of the risk to our dams.

RESPONSE BY LOCAL RESILIENCE FORUMS

LRFs have prioritised their response to dam failure against the other risks in their area based on generic advice. Currently LRFs are not informed about the probability of individual dams failing.

The extent to which Category 1 responders will prepare detailed off-site emergency plans for dam failure will depend on how high they believe the risk to be, compared to other emergencies they may have to deal with. Therefore, LRFs across the country may respond differently to potential dam failures. Their response can range from:

- detailed plans setting out their response for individual dams to
- a standard emergency plan for all dams setting out roles and responsibilities of everyone involved.

If a detailed plan is produced, it will fit within the group of emergency plans set out in the Civil Contingencies Secretariat document *Developing a Multi-Agency Flood Plan* (CCS 2008).

The police are normally responsible for co-ordinating major emergencies and deciding whether to evacuate the local area. This control is exercised through the Gold, Silver and Bronze Command structure. The Defra project is seeking to address how this is reflected in the specification for reservoir flood plans.

The need to have and share information was reinforced in the "lessons learnt" report following an exercise on a dam failure in a major northern city in December 2006. One of the key findings from silver control was that emergency plans "need to be shared between responding organisations".

PLANNING GUIDANCE

Inundation maps will help to make decisions about land use planning policy. Although the likelihood of inundation is low, the following important elements need to be considered:

- safety of people within buildings
- safety of buildings
- safe entry and exit from buildings
- emergency services being able to evacuate or rescue people from buildings
- location of critical infrastructure.

Inundation maps will also provide a vital link between developers, planners and the reservoir undertaker, so that the undertaker is more closely involved in the planning process.

This is important because the category of the dam can change as a result of development. If this happens, the undertaker can face significantly higher

costs (for example constructing a larger spillway) after the next inspection unless these costs are identified and perhaps borne by the developer.

As a result of lobbying, flooding from reservoirs has now been identified as a potential flood risk in the recently published Planning Policy Statement. Appropriate guidance principles are currently being developed.

RESPONSE TO FLASH FLOODING

Flooding from a dam failure is similar in some ways to flash flooding from small catchments as a result of intense rainfall.

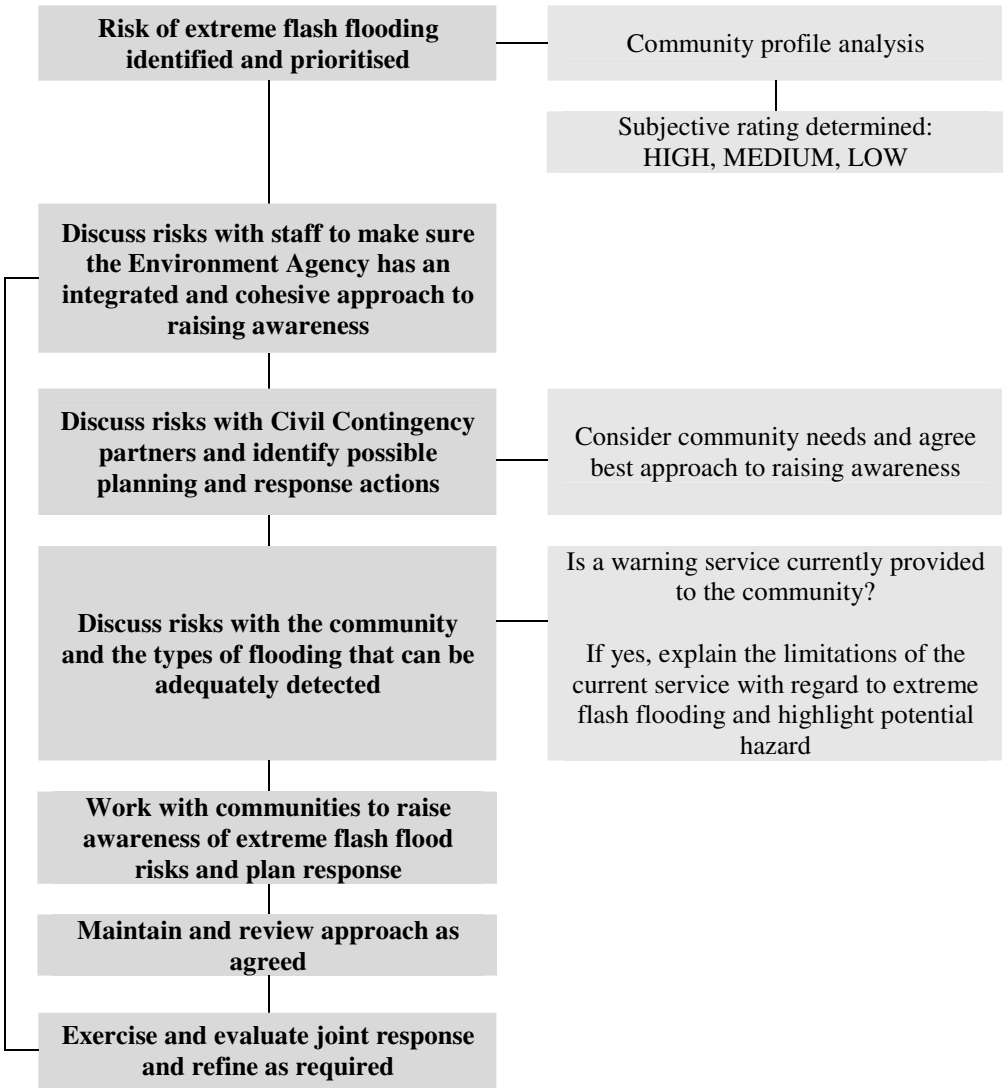

Figure 2: Procedure for flash flooding

The Environment Agency has developed a procedure for identifying rapid response catchments and involving communities at risk to raise awareness

and recommend suitable mitigation measures. A similar process may be appropriate for catchments below dams.

The Environment Agency's policy is to make sure that all those living, working, and on holiday in areas at risk from extreme flash flooding are made aware of the hazard and know what actions to take if flooding occurs. Work in communities situated in catchments that could suffer from extreme flash flooding is set out in Figure 2 and will be mainly focussed on planning and raising awareness.

ENVIRONMENT AGENCY ROLE

The information in a reservoir flood plan will have a considerable impact in Environment Agency Area offices. The Environment Agency's role in relation to reservoir flood plans can be summarised as follows:

- as enforcement authority the Reservoir Safety team will be responsible for examining and accepting completed plans from undertakers and taking action against those who do not prepare them;
- providing information to undertakers to help them prepare inundation analyses;
- producing reservoir flood plans as an undertaker;
- using the information on areas that could flood to inform flood incident management and development control;
- as Category 1 responders, to help prepare emergency plans covering the off-site effects of potential reservoir flooding.

In parallel with the Defra project the Environment Agency has its own project to make sure it has internal processes in place to manage each of these roles. The organization is also developing a training package for its staff, panel engineers and undertakers.

THE PITT REVIEW

The Pitt Review interim report (Pitt 2008) contains two interim conclusions that directly relate to reservoir safety.

IC62 "The interim conclusion of the Review is that the Government should implement the legislative changes proposed in the recently published Environment Agency biennial report on reservoir safety."

The key changes proposed are outlined below:

- **Better risk-based definition of a reservoir within the Act -** At present the definition is purely volumetric, based on a minimum

capacity of 25,000 m^3 of water. A definition of reservoirs falling within the Act that takes into account the consequences of a dam breach is required.

- **Funded powers to act at reservoirs with no owner -** At present there is a gap in the law, so that reservoirs that are situated on land that is disclaimed following business failures have no legal owner and, therefore, no legally responsible reservoir undertaker, unless the Crown chooses to exercise its right as 'keeper of last resort'. The Crown does not always choose to take ownership in these circumstances.
- **Mandatory post-incident reporting -** Defra has charged the Environment Agency with keeping a database of incidents, so that lessons can be learned and disseminated to the reservoir industry, but at present the system is voluntary. Undertakers may not always choose to inform the Environment Agency about emergency incidents at their reservoirs, for commercial or other reasons. It is believed that it would be in the public interest for it to be made mandatory for reservoir undertakers to report their emergency incidents to the Environment Agency.
- **More flexible enforcement powers -** At present, enforcement options are prosecution, formal caution or warning letter. The Government's Macrory Review is bringing in a variety of alternative intermediate enforcement penalties, such as administrative fines and reputational sanctions. The Environment Agency believes that applying these options to reservoir safety will make enforcement more efficient and more effective.
- **Better quality inspection reports –** The Environment Agency believes that there should be a quality review process for inspection reports, managed by a professional and technical body such as the Institution of Civil Engineers.
- **Better enforcement powers for reservoir flood plans -** There is currently no statutory requirement for a panel engineer to sign off a reservoir flood plan. Neither is there a power for the enforcement authority to serve notice on a reservoir undertaker to prepare a reservoir flood plan, nor to exercise reserve powers to prepare one on behalf of an undertaker and recover the costs of doing so.

IC63 "The interim conclusion of the Review is that all reservoir undertakers should be required by Defra to prepare inundation maps and share them with Local Resilience Forums to improve Community Risk Registers and emergency planning."

In his speech to RUSI Critical National Infrastructure Conference on 16 April 2008 Sir Michael Pitt called for critical infrastructure operators and

security organisations to be more open about the risks that exist. He observed that a masonry dam had inundation maps, which showed that a school was in the path of a flood should the dam fail, but the head teacher is unaware of the risk and no escape routes have been prepared because the maps are not available to the public. He concluded that we need to move to a situation where we are making more effort to communicate risk accurately and debate risk in a more public way.

COMMUNICATION STRATEGY

The many strands of this project need to be supported by a comprehensive communication strategy. This will range from the formal impact assessment before the new regulatory requirement is introduced, to making sure that public access to inundation maps does not cause unnecessary alarm. This is seen to be fundamental to the success of the system.

This communication strategy will cover both internal and external needs and extend to specifying and implementing training courses for reservoir panel engineers, undertakers and relevant Environment Agency staff.

The strategy will build on the experience of other countries. For example, in Switzerland inundation maps have been in the public domain for a number of years and they have recently been introduced in Spain. De Cea Azanedo et al (2007) highlight that communicating information to the public at risk was the most complex part of implementing emergency action plans for dams in Spain.

WAY FORWARD

This paper has outlined most of the issues being developed. By forging a strong working relationship with those who will be using the reservoir flood plans, a practical and workable specification and process can be developed.

Whilst there will always be a minor risk from both extreme floods and dam failure, this project will make sure that emergency action plans are in place to further improve the safety of our reservoirs and those that live and work near them.

ACKNOWLEDGEMENTS

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