

Development of Flood Plans for Large Raised Reservoirs in England and Wales

Die Entwicklung von Flutplänen für große Speicher in England und Wales

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Abstract

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. Transferring this regulatory role from 136 local authorities has had a significant impact on the regulated community. The imminent introduction of reservoir flood plans, post-incident reporting (*Warren et al 2006*), and a review of current regulations is set to herald further change.

There are over 2,000 reservoirs in England and Wales to which the Reservoirs Act 1975 applies (those capable of holding at least 25,000 cubic meters of water above lowest natural ground level). These are owned by some 710 businesses and individuals. The average age of dams in England and Wales is over 110 years and there are at least six emergency draw downs of reservoirs each year. (This action is seen as a last resort to prevent dam failure).

Great Britain is arguably behind the rest of the developed world in producing reservoir flood plans (or emergency action plans) for reservoirs. In its role as policy lead, Defra is funding production of a publication entitled "*Engineering Guide to Emergency Planning for UK Reservoirs*".

Producing reservoir flood plans for use by the emergency planning community through Local Resilience Forums will mean those involved in managing and communicating flood risk will be much more aware of the extent of potential inundation areas from reservoirs.

While current knowledge and techniques for the process of inundation mapping is subject to further development, work is also underway to develop a strategy for reservoir safety research and to identify a work programme for the next 10 years.

This paper highlights the current stage of development of reservoir flood plans and its impact on the reservoir industry in England and Wales.

Zusammenfassung

Das Wassergesetz von 2003 hat für die "Environment Agency" die neue Rolle geschaffen, dem Talsperrengesetz von 1975 in England und Wales Geltung zu verschaffen. Die Verlagerung dieser Regulierungs-Aufgabe von 136 lokalen Behörden hatte eine erhebliche Wirkung auf das Gemeinwesen. Die bevorstehende Einführung von Überflutungsplänen, Störfall-Berichten (*Warren et al 2006*) und eine Überarbeitung bestehender Regelwerke ist der Vorbote weiterer Neuerungen an.

In England und Wales gibt es mehr als 2000 Talsperren, die unter das Talsperrengesetz von 1975 fallen (Stauinhalt mindesten 25000 m³ über der ursprünglichen Talsohle). Diese Talsper-

ren sind im Besitz von etwa 710 Firmen und Privatpersonen. Das Durchschnittsalter der Talsperren in England und Wales beträgt mehr als 110 Jahre. In jedem Jahr muss mindestens sechs mal eine Talsperre notfallmäßig abgesenkt werden, was als letztmögliche Maßnahme zur Verhinderung des Versagens gilt.

Was die Erstellung von Überflutungs- oder Katastrophenplänen für Talsperren angeht, dürfte Großbritannien dem Rest der entwickelten Länder hinterher hinken. In seiner Vorreiterrolle unterstützt DEFRA die Erstellung einer Publikation mit dem Titel *“Engineering Guide to Emergency Planning for UK Reservoirs”*.

Die Erstellung von Überflutungsplänen für den Gebrauch durch den Katastrophenschutz sorgt dafür, dass die Kräfte, die sich mit dem Managen und Kommunizieren von Hochwasser-Risiko zu befassen haben, wesentlich besser über das Ausmaß möglicher Überflutungen aus Talsperren informiert sind.

Während sich die Kenntnisse über die Erstellung von Überflutungsplänen laufend weiterentwickeln, sind auch Bestrebungen im Gange, eine Forschungs-Strategie für Talsperrensicherheit zu entwickeln und ein Arbeitsprogramm für die nächsten 10 Jahre aufzustellen.

Dieser Beitrag beleuchtet den gegenwärtigen Stand der Entwicklung von von Überflutungsplänen und deren Einfluss auf die Talsperrenbranche in England und Wales.

Introduction

The reservoir industry within the UK is currently undergoing a period of major change. The Environment Agency, as one of the organisations responsible for making sure our reservoirs operate safely and are properly managed, is involved in developing and implementing strategies to successfully achieve that change.

Two and a half years ago in a monumental move brought about as the result of the Water Act 2003, responsibility for reservoir safety in England and Wales was transferred to the country's leading public body for protecting and improving the environment – the Environment Agency.

As the new enforcement authority, we are responsible for assuring the safety of the nation's 2,000 reservoirs by enforcing the Reservoirs Act 1975. It is our aim to work alongside reservoir undertakers (operators, users and owners), supporting them in meeting the requirements of the Reservoirs Act 1975. We are already recognised as a firm but fair regulator and we are working with the reservoir industry to improve overall reservoir safety. This new role is being implemented by a “National Once Only Service” Reservoir Safety team, based in Exeter.

We are 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)* we are responsible for enforcing the Act by making sure that undertakers fully comply, warning and ultimately prosecuting those that don't.

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

We have compiled a register of over 2,000 reservoirs in England and Wales to which the Reservoirs Act 1975 applies (those capable of holding at least 25,000 cubic meters of water above lowest natural ground level). These are termed Large Raised Reservoirs (LRR). These are owned by some 710 businesses and individuals, including 167 flood storage reservoirs, which we own and operate ourselves. We are also currently investigating whether a further 315 reservoirs that are currently unregistered should be subject to the Act.

The public can view this register at our Area offices. For further details please see www.environment-agency.gov.uk/reservoirsafety.

Reservoir flood plans (RFPs)

Great Britain is arguably behind the rest of the developed world in producing reservoir flood plans (or emergency action plans for reservoirs). As shown in **Figure 1** this effectively means that the 'Risk Response' box as part of the risk management process is incomplete.

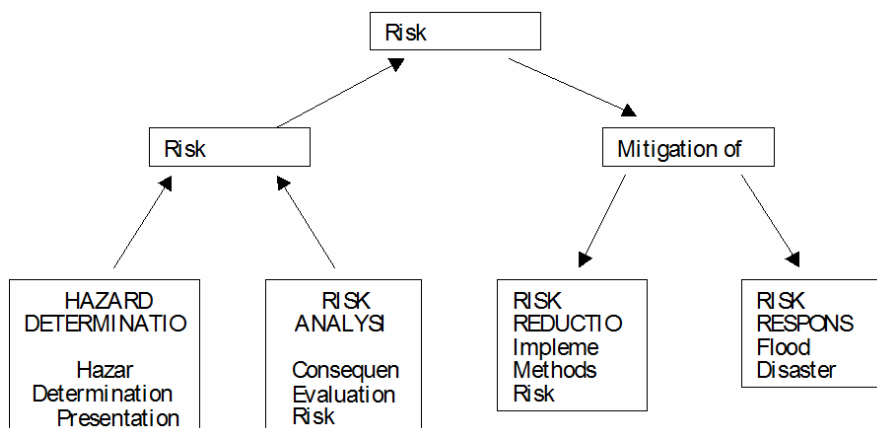


Figure 1: Risk management process

Under the Water Act 2003 undertakers must produce flood plans for their reservoirs where directed by the Secretary of State.

Defra is currently funding the production of an *"Engineering Guide to Emergency Planning for UK Reservoirs"*. When complete and agreed, the Secretary of State will issue the direction to undertakers to produce plans.

It is anticipated that the reservoir flood plan will include the following:

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

It is proposed that there should be regular exercising and training to maintain reservoir flood plans to make sure that residual risk is managed.

Off-site emergency planning will be carried out under the provisions of the Civil Contingencies Act 2004. Part 1 of the Act provides a new statutory framework for civil protection at the local level, which applies across the whole of United Kingdom. It sets out clear expectations and responsibilities for front line responders at the local level to ensure that they are prepared to deal effectively with the full range of emergencies. It divides local responders into two categories:

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

Category 1 and 2 responders together 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 LRF area.

What do we mean by “risk”?

Risk is commonly defined as: Risk = likelihood of failure x consequence.

“Flood risk” is the combination of the probability of a flood event and its potential adverse consequences.

The reservoir industry has traditionally used the following consequence classification from “Floods and Reservoir Safety, ICE 1996” for impounding reservoirs, see below:

Risk category	Notes (Reference: Floods and Reservoir Safety; ICE 1996)
A	At least 10 lives at risk and extensive property damage
B	Fewer than 10 lives at risk but extensive property damage
C	Negligible risk to human life but property damage
D	No significant risk to life or property

When allocating our resources using a risk-based approach, we have used the above consequence classification. For example, we have targeted category ‘A’ non-compliant reservoirs as a priority. We have also found it useful to use this for non-impounding reservoirs and service reservoirs for this purpose.

The following shows the distribution of reservoirs in England and Wales by consequence category, see below:

Risk category	Number of LRRs	% of total number of LRRs
A	670	33
B	286	14
C	324	16
D	217	11
Not Applicable (Note 1)	107	5
Unknown (Note 2)	406	20
Totals	2010	100

Note 1 - Historically, only impounding reservoirs have been assigned a risk category. Although this has changed, and the risks posed by all reservoirs are now being considered, some non-impounding and service reservoirs have not yet been assigned a risk category.

Note 2 - Section 10 Inspection Reports, in which risk category information is normally supplied, are not available for all reservoirs (because the Reports that do not contain measures in the interests of safety do not have to be submitted to the Enforcement Authority).

The inundation analysis will show the consequences of a dam failing. It will identify property and infrastructure that could be affected. It will also provide information on depth and velocity of flow so an assessment of casualties can be made and help in emergency planning.

Assessing the chance of any dam failing is far more difficult. The dam failing due to overtopping would be as a result of a flood greater than the spillway capacity, that is a return period of about 10,000 years for a category A reservoir or the Probable Maximum Flood (P.M.F). This gives a relatively low level of risk compared to other hazards.

In practice, a dam is more likely to fail as a result of leakage or piping. Currently we are not able to assign any meaningful return period to this type of event, since there have been no failures of dams causing loss of life in England and Wales, since the Reservoirs (Safety Provisions) Act 1930.

Whilst there are a number of incidents each year, which require drawdown of reservoirs to avoid dam failure, we can draw limited conclusions about probability. We have developed and recently introduced a new post-incident reporting procedure after consultation with the industry. This will give us much needed information. However, reporting is voluntary and the database is still in its infancy.

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 various 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 assessments is also applied to the regulation of dams. See www.damsafety.nsw.gov.au.

Response by Local Resilience Forums

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 be determined by their perception of the risk, compared to other emergencies which may arise in their area of responsibility. Their response can range from simply monitoring to establishing a high priority for risk response and allocation of resources by using the following process to derive planning assumptions, see **Figure 2**.

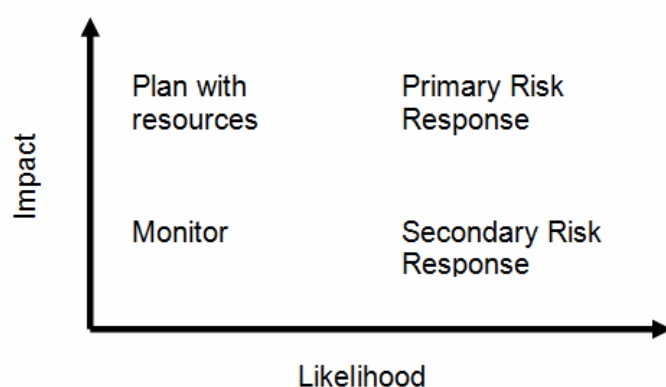


Figure 2

Therefore there will be an inconsistent response among LRFs to potential dam failures across the country. The response can range from:

1. detailed plans setting out the response of the local responders for individual dams to
2. a standard emergency plan for all dams setting out roles and responsibilities of all parties.

The Police will normally take the overall co-ordination role during major emergencies and are responsible for deciding whether to evacuate the local area. The current Defra project is seeking to address how this is reflected in the specification for reservoir flood plans.

The need to have and share this information was reinforced in the “lessons learnt” report following an exercise on a dam burst 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 planning policy. Although the chance of inundation is low, the following important elements need to be considered:

- safety of people within buildings
- safety of buildings

- people being able to safely enter and exit buildings safely
- emergency services being able to evacuate or rescue people from buildings.

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

In some instances, the category of the dam can change as a result of development. If this happens, the undertaker could face significantly higher costs (for example increased spillway capacity) following the next inspection.

As a result of our lobbying, flooding from reservoirs has now been identified as a potential flood risk in the recently published Planning Policy Statement 25 (PPS) December 2006. Appropriate guidance principles are currently being developed.

The following pyramid (see **Figure 3**) considers the increasing scale of response to flash flooding and the upper section of the pyramid can be adapted to reservoir flood plans.

The response should take an informed view and be proportionate to the risk. This is a further illustration of “work in progress”.

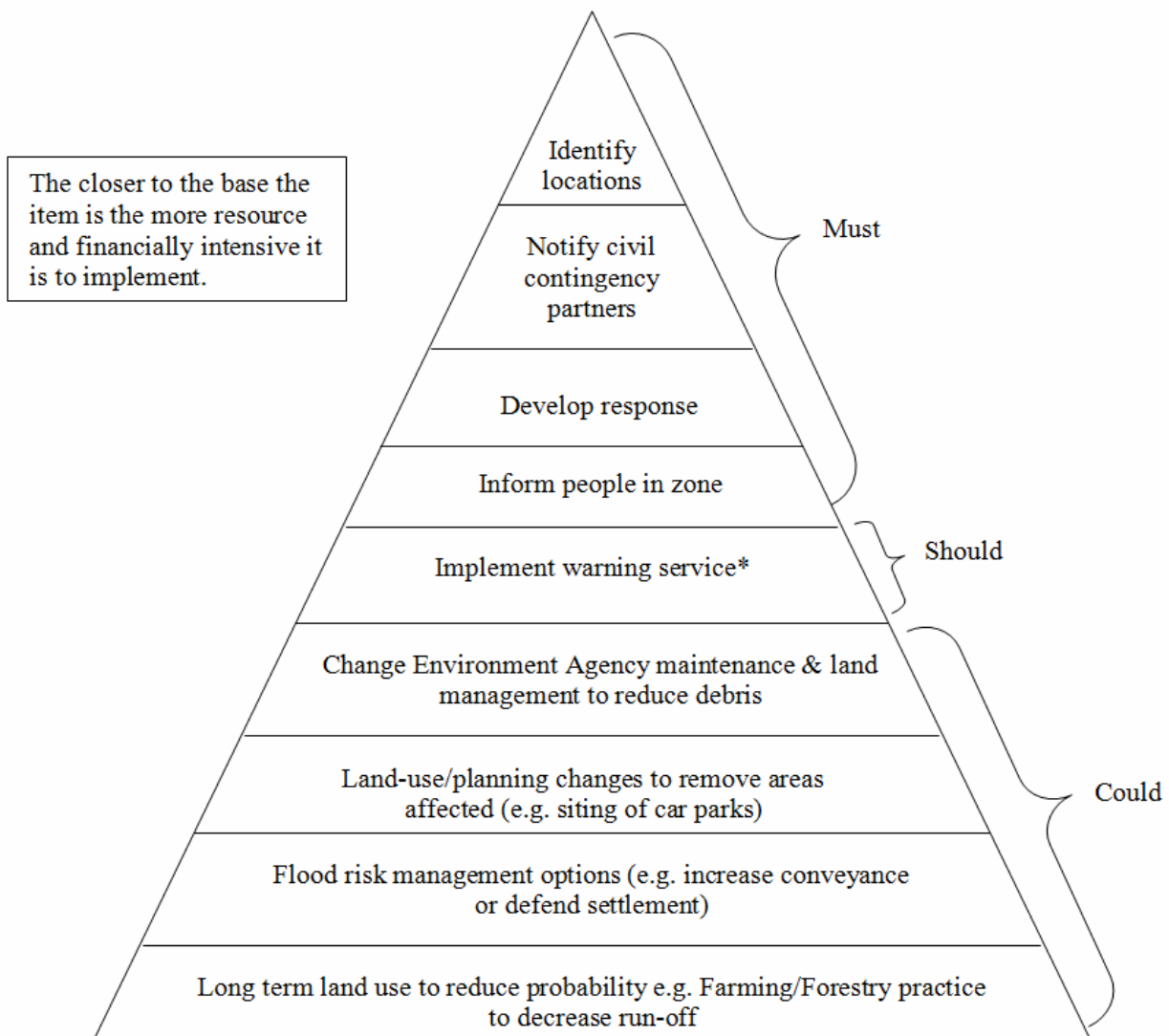


Figure 3: Increasing scale of response to flood risk.

International practice

The advances made and lessons learnt by other developed countries in specifying and establishing emergency planning for reservoirs, in the form of emergency action plans (EAPs) are worth considering.

In the **USA**, the Federal Emergency Management Agency (FEMA) has produced guidelines for emergency action planning for dam owners as described in FEMA (1998). FEMA recognised that a significant proportion of state-regulated dams; 83 per cent of the 22,000 high or significant hazard dams, did not have emergency action plans (EAPs).

EAPs cover training, exercising, updating plans and regular communications. The regulatory authority is encouraged to become fully involved in developing and approving the EAP. Communities that could potentially be affected are also involved. This has been seen as both essential and challenging.

Certain websites openly contain inundation maps; for example those published by the Association of (San Francisco) Bay Area Governments (ABAG). However, this information has caused tensions with the Department for Homeland Security who have expressed concerns in the wake of 9/11.

In most European countries the requirements for EAPs are well established. In **Switzerland** for example, dam inundation information is freely available. This includes information on the depth of potential flooding displayed in public buildings, restaurants etc. From the evidence of the public debate that featured in press reports immediately after the devastation of New Orleans by Hurricane Katrina, the public are fully involved with EAPs for dams.

Involving people is highly challenging, due to the need to strike a sensitive balance between alerting people and causing unnecessary alarm. In **Finland**, innovative ways of raising public awareness are evident – for example DVD's featuring an emergency exercise are freely distributed.

In the paper to the International Commission on Large Dams (ICOLD) conference last year, "Implementation of Emergency Action Plans in **Spain**", De Cea Anzañedo *et al.* (2006) the authors acknowledge "The most complex aspect of the implementation process is the Communication Plan for the population at risk (requiring greater emphasis) to sociology and psychology than engineering."

Arguably, this task was made easier in Saxony, **Germany** where EAPs were introduced after the devastating flash flooding in August 2002 which killed some 20 people. Horlacher & Pohl (2006) describe the extensive work to establish EAPs and reflect the challenging process to involve the public.

Existing Inundation Information

Most water companies and some 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 understandably to differing standards. Although this information has, in many cases, been available for some years, the advice from Defra was that it must be kept confidential.

At a recent meeting organised by Defra and attended by representatives from Water UK, it was agreed that the existing inundation maps should be released to Category 1 responders under the Civil Contingencies Act 2004. However, the full information should only be used for emergency planning only at this stage. This early release of information does not affect the plans in progress to introduce the formal requirement to produce reservoir flood plans, but is effectively a useful pilot process.

Working with the Civil Contingencies Secretariat of the Cabinet Office, we are currently drafting standard letters requesting information from undertakers. We are also preparing a supporting "Questions & Answers" document.

Environment Agency procedures

The impact of the information provided by an inundation map following the formal requirement to produce a reservoir flood plan in an Area office is considerable, for example, from informing emergency response to providing planning advice.

Our roles in relation to reservoir flood plans can be summarised as follows:

- as enforcement authority our national 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 analysis and consequence assessment;
- producing reservoir flood plans as a reservoir undertaker (we are currently the undertaker for 167 reservoirs);
- using the information on areas that could flood to inform flood incident management and development control;
- as Category 1 responders under the Civil Contingencies Act 2004, to help prepare emergency plans covering the off-site effects of potential reservoir flooding.

We are currently producing guidance and instructions for compiling metadata files to cover this new source of data and updating existing processes and work instructions.

Reservoir safety research and development needs

Reservoir safety research and development (R&D) has previously been managed by the Water Supply and Regulation Division of Defra. From Jan 1 2007 this responsibility transferred to the Flood Management division. A suitable governance structure for reservoir safety R&D is being established in parallel with the existing structure for Flood Risk Management R&D.

Atkins have been commissioned by Defra to review research needs in the area of reservoir safety and to propose a strategy for future work. It is intended that this strategy will link with similar international programmes of work.

Of particular interest to reservoir flood plans is the IMPACT project. Morris & Hassan (2005) describe work, which identified that current modeling of flooding from dam breaches was producing errors of up to 50 per cent. Further work has been carried out under the FLOOD site

programme Task 6 modeling breach initiation and growth. The HR-BREACH model will be one of the three to be assessed by USBR on behalf of the Canadian based Dam Interest Safety Group.

As part of the newly formed Atkins team, HR Wallingford will be reviewing dam break modelling as used in the UK in order to advise on the most appropriate modelling techniques to use. This will be incorporated into the Defra guide.

Communication strategy

This paper deliberately concentrates on the issues to be addressed in defining the specification and processes for reservoir flood plans.

The many strands of this project need to be supported by a comprehensive communication strategy. This will range from the formal regulatory impact process to making sure that public access to inundation maps does not cause unnecessary alarm.

This communication strategy will cover both internal and external needs and extend to specifying and implementing a training course for reservoir panel engineers. It will also build on the lessons learnt by others.

Way forward

This paper has outlined most of the issues under development. By forging a strong working relationship with those who will be using the reservoir flood plans, we can develop a practical and workable specification and processes.

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

The views expressed in this paper are the personal views of the author and not necessarily those of the Environment Agency.

The author would also like to express his appreciation of the sterling efforts and continued support of the Reservoir Safety team, without whose help so much could not have been achieved in such a short time.

Appendices

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