Pebley Reservoir (Derbyshire) Emergency Drawdown Exercise

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SYNOPSIS. This paper details the exercising of an on-site emergency drawdown plan carried out at Pebley Reservoir. It highlights the lessons learnt, compares the use of submersible and suction pumps and recommends a frequency for future exercises.

INTRODUCTION

The Canal and River Trust (CRT), a charitable body, was set up in 2012 to look after the navigations in England and Wales which were formerly the responsibility of the British Waterways Board. The Canal and River Trust is responsible for 72 statutory reservoirs. Each reservoir, except for a handful presenting minimal risk, has an On-Site Emergency Drawdown Plan (EDP).

In response to the Defra consultation in 2009, British Waterways suggested that an appropriate time frame for a large undertaker to exercise their emergency plans would be one desk exercise every two years and a site exercise every five years. The most recent site exercise was in 2008 at Lower Foulridge Reservoir as reported in the paper *Exercising of Emergency Draw-down Plans*[1] presented at the Strathclyde BDS conference in 2010. Subsequent changes to BW's framework contractor and to the organizational structure of the company led to the decision that a further full site test would be beneficial within the suggested five year timescale. In November 2011 a full exercise of an on-site emergency drawdown plan was carried out at Pebley Reservoir.

PEBLEY RESERVOIR

Pebley Reservoir is situated between Sheffield and Worksop to the east of the M1 motorway in North Derbyshire. The reservoir was built in 1776 to supply water to the Chesterfield Canal, which it still does via a feed into Harthill Reservoir. It is classified as a Category A reservoir. The embankment dam reaches a maximum height of 8.5m and has an average crest width of 4m along its 160m length. The reservoir impounds 280,000m³ of water. Water control is via a spillway channel at the eastern

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end of the dam and via a low level timber and stone box culvert near the centre of the dam, as indicated in Figure 1.

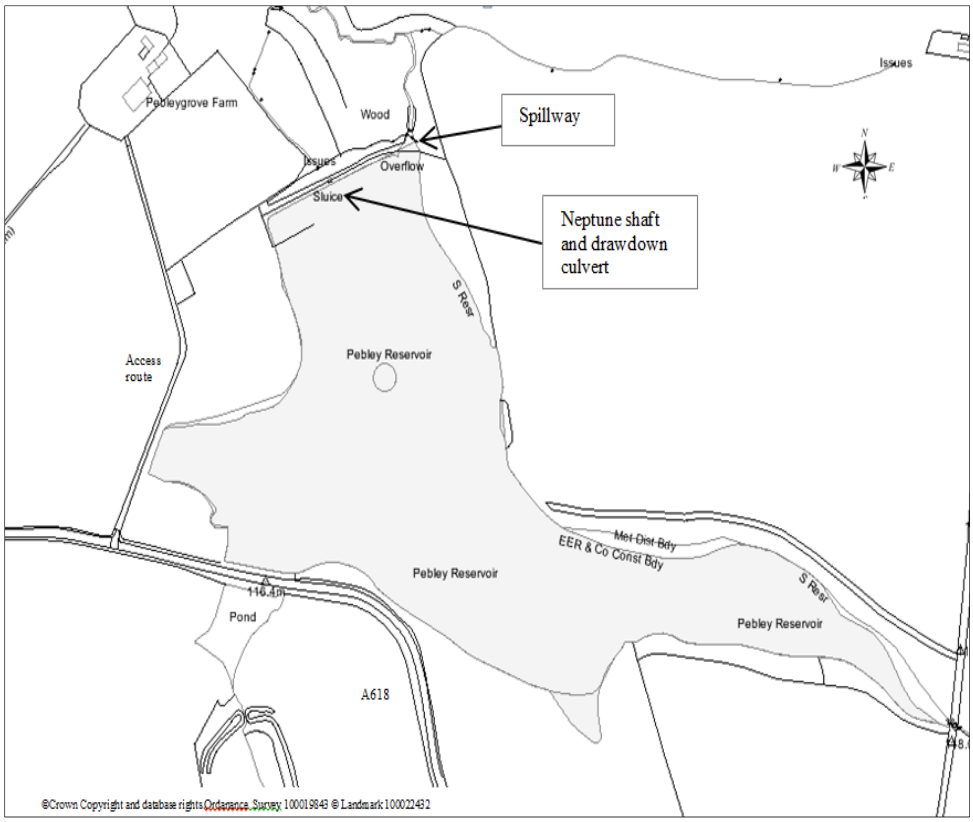

Figure 1. Pebley Reservoir Layout

The most recent S10 inspection in 2010 made some recommendations in the interests of safety, the most pertinent to the exercise being the requirement to repair or replace the timber and stone box culvert within four years. This was significant for two reasons. Firstly, the condition of the culvert prevented the safe use of the valve and culvert to drawdown water levels, a restriction included in the current version of the EDP. Secondly, in order to investigate the condition of the culvert it was necessary to draw the water level in the reservoir down and this provided an opportunity to combine the need for that drawdown with the desire to exercise an EDP.

AIMS OF THE EXERCISE

The overriding aim of the exercise was to test the existing plan and procedures and to make improvements from any lessons learnt. The aims can be considered to be either generic or specific in their nature.

Generic Aims of the Exercise

The generic aims for the exercise were:

- to test the emergency call-out procedures for CRT staff and for the Framework Contractor staff from May Gurney;

- to test the control and sufficiency of the EDP document;
- to give confidence to the Undertaker;
- to reinforce relationships and improve communication; and
- to identify and communicate opportunities for improvement.

Specific Aims of the Exercise

The specific aims for the exercise were:

- to test the specifics of the EDP for Pebley Reservoir;
- to pump the reservoir down to 50% of total volume within five days as set out in the EDP for a Category A reservoir that is inspected weekly, and to then continue to 39% of total volume to enable a CCTV survey to be safely carried out; and
- to compare the deployment, use and performance of submersible and suction pumps.

THE EXERCISE

The exercise took place on 31st October 2011. The preparatory works included informing senior staff, arranging for CRT observers to be present and inviting representatives from Derbyshire County Council Emergency Planning Unit to observe. On the evening before the exercise the farm and angling club that share the access route to the reservoir were informed, and a key for the gated entrance was obtained. All other participants were unaware that it was not a real event until they arrived on site and were briefed on the scenario.

The Scenario

The basic scenario was that there was water "gushing" out near the toe of the dam and there was a whirlpool in the reservoir. These defects were located midway between the drawdown culvert and the spillway.

Day 1 - Commencing the Exercise and the Initial Response

At 0400 hours a call was placed to CRT's Freephone Canals emergency call handling service, provided by West Midlands Ambulance Service. CRT's call-out system was implemented and the local Duty Supervisor responded by calling back the call originator and then sending two operatives to site, as is normal procedure for any call-out. Due to the potential risks associated with a reservoir she also escalated the issue to her line manager, and between them decided it would be appropriate for them both to attend site.

The regional Duty Engineer, who was about a two hour drive away, was also contacted by the Duty Supervisor to pre-warn him that a potential major incident had occurred. Initial contact was made using the pager system, but this failed to fully wake the Duty Engineer, though a phone call five minutes

later was successful *[learning point - more annoying pager alerts at night would be advisable]*. The early warning gave the Duty Engineer the opportunity to download the latest EDP from the CRT intranet. He decided to familiarise himself with the plan, whilst waiting for confirmation from site that there was a major issue.

At 0505 one BW operative arrived on site to find the access gate (not CRT access) locked and waited for the second operative to arrive with the access key (stored at Harthill Reservoir some five miles away). The key, however, did not fit. The Angling Club change the key annually and there was no formal process for including the Trust in the issue of new keys. The gate is only locked in the hours of darkness and since the CRT had not had access problems during normal operational hours, they had not realised there was a problem. The key obtained by the observers from the angling club the previous night was used to open the gate *[learning point - a system for ensuring that the key is the current one is needed]*.

The operatives walked to the crest, though with only one barely adequate torch between them, and were presented with the exercise scenario *[learning point – better torches for call out teams]*. The Duty Supervisor and her line manager arrived on site and relayed the scenario by telephone to the Duty Engineer, without making him aware that it was an exercise.

The Duty Engineer attempted to contact Paul Howlett, the BW Reservoir Supervising Engineer (RSE) for Pebley Reservoir on his mobile phone number without success (Paul, aware of the exercise, had turned his mobile off to see if his home number would be used,. When it was not, he turned his mobile on and returned the call) *[learning point - plans need to emphasise that home numbers, if in the EDP, are to be used]*.

May Gurney, CRT's framework contractor, was paged at 0600 and arrived on site at 0735 having already called the out of hours emergency number for SLD Pumps Ltd to prewarn them. The EDP in May Gurneys possession was an old copy, with no reference to not being able to use the valve to release water *[learning point – improve control of EDPs to framework contractor]*.

Within about four hours of the initial call being received the main personnel were on site with labour from both the waterway and from May Gurney also in attendance. Delivery options with pump suppliers had been discussed and the information that would be needed to base subsequent decisions upon had largely been gathered.

Logistics and Communications

By 0820 the Duty Engineer, May Gurney Agent and the RSE were considering options for pump deployment and use of the draw off valve and culvert. The initial decision to be made was whether or not to utilise the

draw off valve and damaged outlet culvert. The outlet valve at Pebley Reservoir provides initially 0.10m³/s (360m³/hr) of the 0.44m³/s (1584m³/hr) required to achieve the planned five day drawdown to 50% of volume. The RSE's response was not to use the valve, since it could make the situation worse. This was a relatively easy decision to make in an exercise scenario. In a true emergency would that decision be so easy?

Having determined that the requirement was for pumps only, the attention turned to what types of pumps and the logistics of placing them, particularly since it became evident that the pump landing and launching location identified in the plan, whilst being conveniently just off the access track, was then across ground that was not suitable. The location selected during the exercise was from the side of the A618 road that passes within a few metres of the reservoir. For the exercise this required some temporary traffic management to be installed, in a real emergency the road would be closed. The EDP was evidently written without having a true emergency situation in mind, using instead an access that would not affect the main road *[learning point - plans to consider what would happen in a real emergency situation, including road closure and diversion route information]*.

At this point the scenario was reinforced with information that the condition of the dam crest could not be guaranteed in the vicinity of the leakage. Access across the dam crest was then restricted. In a real emergency, access to the spillway could be obtained across 3rd party agricultural land (not easy in times of heavy rainfall as is the likelihood in an emergency situation). There was also the possibility of moving personnel and discharge hoses by boat to the far bank; though the risk of using a boat in a near failure, or overtopping situation would require an on site risk assessment with some difficult judgments to be made. For the practicalities of the exercise it was decided to lay some hose along the dam crest to outfall into the spillway and some to outfall into the discharge channel (which in this scenario would have been accessible).

By 0900 the Duty Engineer had commenced contacting the listed contacts in the EDP. One stipulation in the plan is that CRT Director approval is required prior to informing the emergency services; the initial call to the CRT Director went to answerphone. In a real emergency would a Director withhold such approval*? [learning point - this is being reviewed with the intention of allowing the most senior CRT personnel on site the freedom to make that initial contact with the Emergency Planning Unit]*.

At 0900 Paul Howlett called the Reservoir Inspecting Engineer, Jonathan Hinks, via the switchboard at Halcrow (in a real emergency this call would have been made earlier). Jonathan was expected in the office later, and since there was no mobile or home number listed in the EDP it was left at

that. The call was later returned by another Halcrow Inspecting Engineer *[learning point – the Reservoir Inspecting Engineers home contact numbers need to be in the EDPs (work and some mobile and home numbers are available on the Environment Agency website)]*.

Figure 2. 8” Submersible Pump and Floatation Unit

By 0910 the first submersible pump and three wagons of hoses were on site and floats were being connected to the pumps as shown in Figure 2.

The waterways commenced lowering Harthill Reservoir and opening sluices on the Chesterfield Canal to prevent consequential flooding, and also set about inspecting and clearing the feeder channels.

Derbyshire County Council Emergency Planning Unit representatives arrived on site around 1100. Discussions ensued as to the best time to contact them in the event of a potential emergency. They would prefer an early “heads up” call in order that the specific or general off-site emergency reservoir plan can be placed on standby, with subsequent escalation if necessary. They may be able to assist with road closures, diversion routes, vegetation management , provision of fire service pumps for example *[learning point - the existing EDPs do not include an early contact, perhaps through a fear of losing control, but this needs to be changed with emergency planning units being informed early and updated regularly]*.

Launching and Positioning Pumps

By 1300 there were three 6” and two 8” submersible pumps, floats and numerous wagon loads of hoses on or having already been delivered to site. In addition, a wheeled excavator and a large dive boat were in position on the road, next to the reservoir edge. Numerous deliveries were delayed, due to the EDP having an incorrect post code but also the entrance to the

reservoir not being obvious from the main road *[learning point- check post codes but also include in the EDP for temporary signs to be erected indicating route for vehicles from main roads]*.

With most personnel at the launching location it was observed that a flat bed wagon carrying hoses had been driven fully across the dam crest over the potential breach location. With hindsight some warning fencing should have been erected as part of the exercise to highlight the theoretical hazard. In a real emergency controlling movements into hazardous areas would be essential, though difficult with so many operations taking place *[learning point – exercise planning should include for use of warning fencing to restrict access to areas considered dangerous in the exercise scenario]*.

At 1400 there was a major intervention in the exercise. Whilst the preference in the EDP was for submersible pumps, floated into the reservoir, there is a practical problem in terms of using them for an exercise where levels are to be drawn down. This is that with water levels down, the pumps would not be able to be recovered until the reservoir had refilled sufficiently to refloat them and gain boat access to recover them. This would not be a consideration in a real emergency, but the cost of six months hire and remobilisation to recover pumps is difficult to justify for an exercise.

The exercise was then amended to install just one 8” submersible pump for two days and to investigate the deployment and performance of suction pumps commencing on day 2 of the exercise. The launching of the submersible pump is shown in Figure 3.

Figure 3. Launching of Submersible Pump and Flotation Unit

The location of the submersible pump was selected from the hydrographic information which was available to the observers, but not part of the EDP or

readily available to those on site. Placing pump heads in a location where they will not need to be subsequently moved is an important consideration. If the integrity of the dam diminishes, it will become a more difficult decision to place personnel at risk to move pumps *[learning point - if hydrographic information is available then it should be referenced or included in the EDP and made available prior to locating pump heads]*.

By 1445 the 8" submersible was in place with 6" hoses being connected. (only 6" hose had been requested). Generators, lighting and fuel bowsers arrived by 1620 and 13 hours into the exercise at 1710 the 8" submersible was discharging down the spillway channel.

There were still numerous hoses to be laid and connected but it was generally agreed that had this been a real emergency that four 6" and two 8" submersible pumps would have been in operation by 0100 hours (21 hours into the exercise), if not earlier. It was estimated on site that these would have delivered around 0.55m³/s (1980m³/hr) compared with the EDP requirement of 0.44m³/s (1584m³/hr) to be delivered by seven 6" pumps. If the 1980m³/hr capacity had been installed then an initial drawdown rate of at least 100mm every five hours would have been achieved. One of the main restrictions to progress was access both to and around the site. If the main road had been closed, as it would in a real emergency, then progress would have been much swifter.

Day 2 - Suction Pumps

With the scope of the exercise changed to deploying suction pumps on the crest of the dam there was, not surprisingly, a distinctly different atmosphere to the more hectic previous day. The initial water level for the exercise was 570mm below TWL (81% volume), so the reservoir only needed to be dropped by 83,293m³ to reach the 50% level. It was then decided to deploy five pumps rather than the full seven, to reach the 50% limit in five days, rather than match the full pumping capacity in the EDP.

Trakway matting was laid, welfare cabins arrived (the previous day's welfare having been provided by welfare vehicles) and hoses were being connected by a reduced labour force. Pumps were arriving from 1520 onwards, having travelled from depots as far flung as Peterborough, London and Glasgow, most on very large vehicles which caused logistical problems. The first suction pump to be set up is shown in Figure 4 below.

The pumps heads were placed using the dive boat (still on hire from the previous day), though could have been done from the crest of the dam. The locations for the heads was chosen to make them easy to recover but also to provide the level of drawdown required for the subsequent CCTV works. In a real situation they would have been located in deeper water to ensure they could continue to operate as water levels were reduced.

The first two pumps were running at 1640 and discharging to the drawdown outlet feeder channel, as shown in Figure 5 below. By 1710 a third pump was discharging to the spillway channel.

Figure 4. Suction Pump Set Up

Figure 5. Discharge Hoses

The fourth suction pump would not prime due to a suction hoses collapsing. This hose was replaced and the pump was working by 1730. The fifth pump was not installed since it became too dark for the dive boat to continue working. The lighting that was provided was mainly illuminating the crest and access, and not the water *[learning point - lighting is needed*

everywhere, including the areas of the dam at risk of breaching, in this case the toe where the water was exiting and the water in front of that location].

Days 3 to 7 – Drawdown

By Day 3 there were five 6“ suction pumps working and the 8” submersible was demobilised. Pumping continued until Day 7 to enable the CCTV survey of the outlet to be undertaken. The site was fully demobilised on Day 14, following completion of the CCTV works.

The total cost of the exercise was £70,000, though it should be remembered that this includes the cost to reduce the water level to enable the survey work to be carried out which would have been incurred without the exercise.

DRAWDOWN RATES

The EDP requires that the volume of impounded water is reduced to 50% of the maximum capacity within five days. The plan detailed five 6” pumps, with an additional two 6” pumps if the drawoff culvert could not be used. Since the starting volume was at 81% of the total capacity it was calculated that five 6” pumps would be sufficient to meet that target, and deploying more than five for the purpose of the exercise would incur additional cost for negligible learning benefit. Figure 6 below shows the progress of the drawdown, with the 50% level being reached on day 5, in spite of the first and second day being disrupted by the change from submersible to suction pumps.

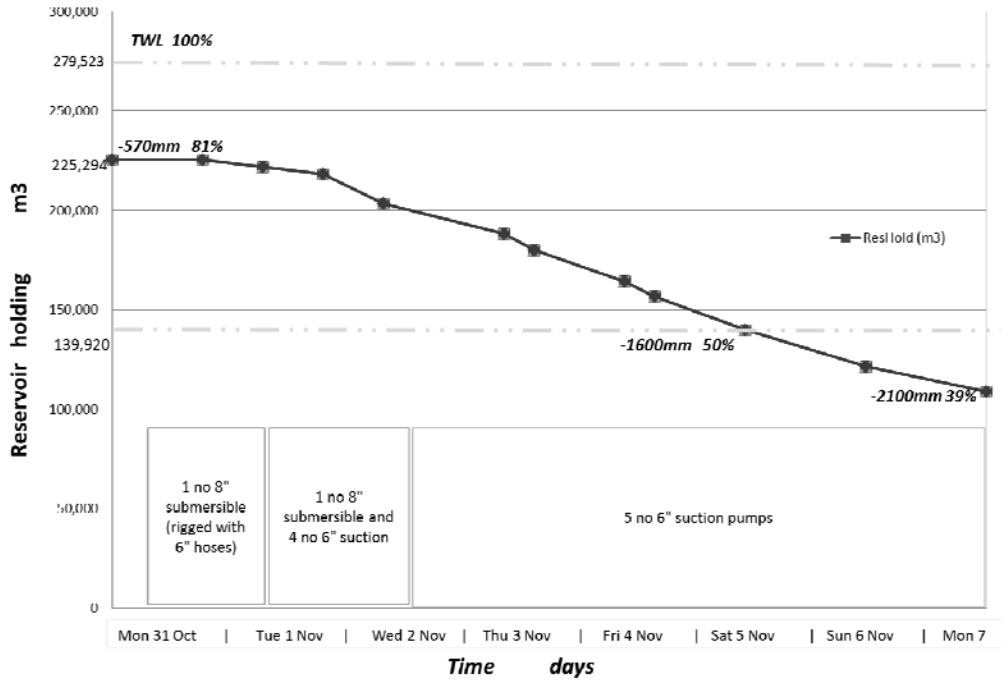

Figure 6. Drawdown record

The number of pumps required at each reservoir is based upon the following assumption of pumping capacity, which has been in use for a number of years within BW:

"for a "typical" reservoir with a maximum total head of up to 6m:
6" submersible pump (8" suction) 0.055m³/s
8 " submersible pump (10" suction) 0.097m³/s
10" submersible pump (12" suction) 0.250m³/s"

Pebley Reservoir is fairly typical in terms of head and distance to outlets and hence the opportunity to test this assumption was taken. The pumping capacities achieved are shown in Figure 7. The 8" submersible was rigged using only 6" hosing which will have reduced its efficiency. The assumptions appear to be valid, but the efficiency of suction pumps has been improved in recent years, and can be assumed to be comparable to the same size of submersible pump at up to 6m heads.

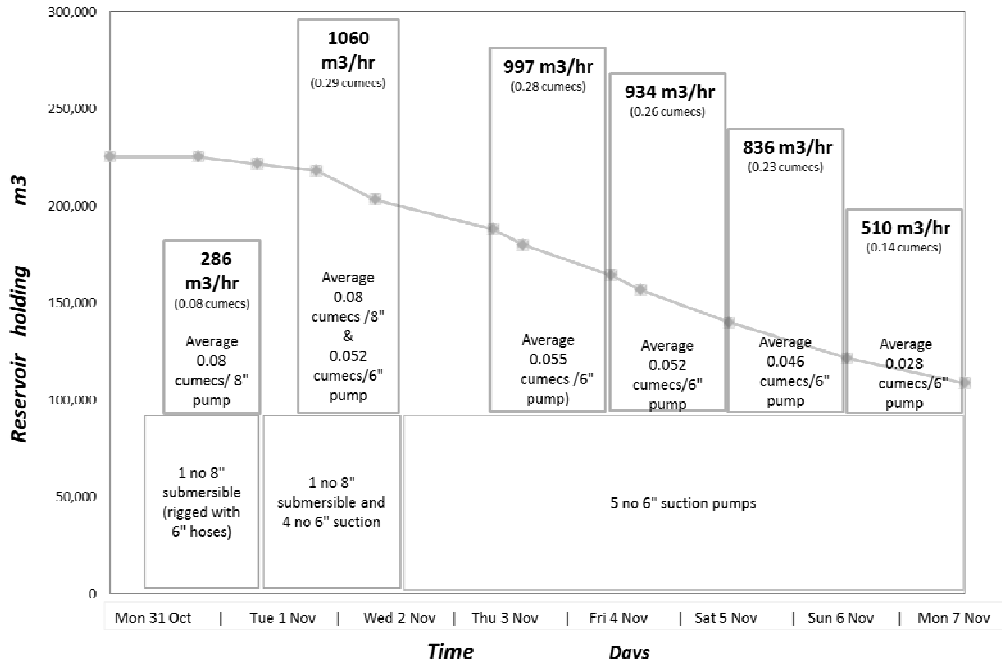

Figure 7. Pumping Capacities

PUMP COMPARISONS

Submersible or Suction Pumps

CRTs preference has been towards using electric submersible pumps for emergency drawdowns since once they are in place and pumping they are more efficient than suction pumps. They do though require equipment to lift and launch the pump and flotation unit and ideally a boat to position and then connect them. In addition the generator packs can not be too far away

from the pump to limit the voltage drop, but also because the availability of the electrical cabling may be limited.

Modern self-priming suction pumps are quicker to set up that submersible pumps. They are though less efficient as heads increase and are limited to a maximum 9m head. There is less risk when deploying them on a reservoir when compared with submersible pumps, since the risk of personnel and boats to be on the water is removed.

In a real emergency it will be a case of using whichever is more readily available and can be safely deployed. It is suggested that initial drawdown would commence sooner using suction pumps if they are available. It may then be that they are supplemented with more efficient submersibles, particularly once there has been time to assess the integrity of the dam and the risk to personnel deploying them.

LESSONS LEARNT

The exercise was regarded as a success by all participants. It proved the workability of the EDP but also highlighted various lessons to be learnt, as outlined below:

Pebley Reservoir EDP – Specific Lessons

- Procedure for obtaining access key to gate is required;
- amend launching point to the main road and include road closure and diversion route in plan information; and
- correct post code.

Generic to BW Procedures, Guidance and EDPs

- Better torches for call out personnel;
- emphasise the use of home telephone numbers;
- review plans, considering what would happen in a real emergency, would, for example, roads be closed and available for access, parking, launching of equipment etc;
- make early contact with emergency planning units, with a system of escalation agreed;
- remove strict requirement for CRT Director approval to be given prior to making contact with emergency planning units;
- Inspecting Engineer home numbers to be included in EDPs;
- include or reference availability of hydrographic maps to assist pump head location;
- provide more lighting to more areas , especially those that need to be monitored for dam safety reasons during an emergency; and
- sign access routes to the reservoir from main roads.

Pumps

- Whilst plans may express a preference for submersible or suction, reality is that in a real emergency it will be a case of using whichever is more readily available and can be quickly and safely deployed. In the initial stages this is likely to be suction pumps; and
- the pump outputs assumed by CRT are realistic.

Management of the Exercise

- Simulating increased levels of stress and time and resource pressure is difficult; it may be that the use of visual reminders will reinforce the scenario. Fencing to demarcate unsafe areas and perhaps photographic examples of the scenario as it develops (such as photographs of large leaks and past reservoir failures) on general display may help to reinforce the scenario.

FREQUENCY AND TYPE OF FUTURE EXERCISES

The Canal and River Trust has carried out full on site exercises, with deployment of resources, in 2008 and 2011. Both of these provided useful learning points for the improvement of EDPs and general procedures and processes. Whilst further exercises would be likely to raise some local learning points it is considered that the main generic learning points have been highlighted during these exercises.

It is considered that the next full on site exercise should be no sooner than in six years time, though perhaps earlier if major organisational changes take place. It is proposed that an exercise is carried out every two years that will require call out staff to attend site, but will not include field deployment of resources. This will test the call out systems and the theoretical availability of pumps, without incurring large costs.

An additional undertaking is that CRTs Framework Contractor, May Gurney is asked to review the EDPs for CRTs reservoirs that require pump deployment. This shall include a site visit to assess the practicality of access and pump deployment, since this appears to be the main shortcomings in the current plans that are prepared by CRT staff.

REFERENCES

[1] Brown D. Gardiner K. and Williams N. (2010). Exercising of Emergency Draw-down Plans. *Managing Dams: Challenges in a time of change - Proceedings of the 16th British Dam Society Conference, Strathclyde.* Thomas Telford, London