The Discontinuance of Hameldon Reservoir

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SYNOPSIS. Hameldon reservoir does not have an Undertaker and its condition has gradually deteriorated over the recent years. This deterioration was such that it was causing concern about the overall integrity of the embankment dam. This paper describes the reservoir, a brief resume of its history, how the Environment Agency became involved and under what powers the Agency has operated. The paper also discusses the remedial options reviewed before concluding with an update on the recent construction works.

INTRODUCTION AND BRIEF HISTORY

Hameldon reservoir is located at an elevation of 337.7 mAOD in moorland to the east of Accrington in Lancashire. It is thought that the reservoir was originally constructed in order to supply water to a (now demolished) mill further down the valley into Accrington. A draw off tower is in the reservoir, suggesting that a piped water supply was available in the past. The tower is now inaccessible and the route and outlet of any pipework is unknown.

The reservoir was formerly part of the Manor of Accrington Old Hold, and was recently owned by a property developer. When the developer went into liquidation the reservoir was not claimed by any creditor and thus it escheatedt[1] to the Crown as owner of last resort. In such instances, the Crown (the Duchy of Lancaster in this case) is legally entitled to choose not to exercise its right of ownership, and thus not take responsibility as Undertaker under the Act.

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[1] Escheat - To revert to the feudal Lord or state. In this case the Crown, in the form of the Duchy of Lancaster.

Managing Dams: Challenges in a Time of Change. Thomas Telford, London, 2010

Both the previous Enforcement Authority (Lancashire County Council) and the current one (Environment Agency) have appointed Panel Engineers to Inspect and Supervise the reservoir. During this period negotiations with the Duchy of Lancaster were undertaken to try and persuade them to take on the role of Undertaker.

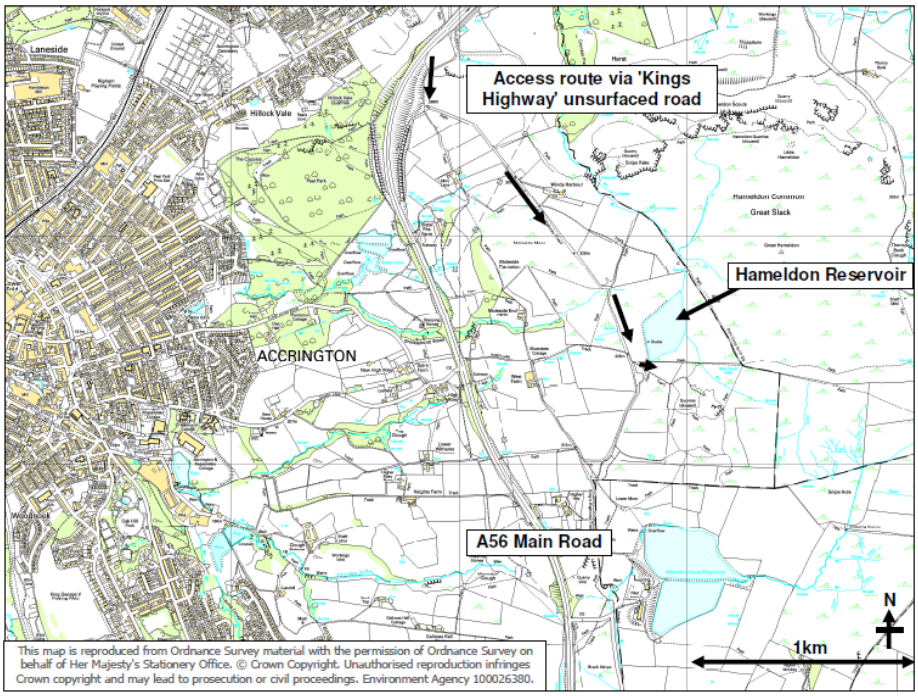

Figure 1. Location plan of Hameldon Reservoir

It can be seen in Figure 1 that the reservoir is approximately diamond shape in plan with the two arms of the earthfill dam forming the northwest and southwest sides. The combined overall length of both arms of the dam is 380m. The dam is approximately 8m high at its highest point located at the corner between the two arms and has a downstream slope of approximately 1V:2H. The reservoir is an impounding reservoir but with only one small distinct watercourse running into it. It appears to be generally fed by surface and sub-surface flows off the adjacent moor. There were no drawings or any records to indicate the dam construction details.

Previous Inspecting Engineers estimated the retained volume of water in the reservoir to be about 135,000m^3. There are three separate small masonry overflow spillways with different sill levels and lengths, two at the south end, and one at the north end of the dam, all leading immediately to relatively small square section stone culverts. A masonry outlet valve shaft is located near the upstream toe of the dam but there was no safe access to

the top of the shaft and, strangely, no indication of any bottom outlet at the downstream toe or beyond the toe area.

Local farmers had arranged water supply pipes to take water from one of the spillway channels to their farms for both domestic and farm use. The reservoir storage itself served no purpose. However some horses, kept in the field around the reservoir, used it for drinking water.

STATUTORY INSPECTIONS

The Environment Agency appointed Inspecting and Supervising Engineers. Under normal circumstances this would be done under Section 15 of the Reservoirs Act 1975; however the absence of an undertaker meant that these powers could not be invoked. The Environment Agency took the view that while it would strictly be acting beyond its powers it would not be acceptable to take no action and in any event a challenge would be unlikely.

The latest inspection was carried out in March 2008 and the report listed thirteen recommendations in the interests of safety. The majority of these recommendations aimed to improve the level of knowledge of the dam and appurtenant structures in order to better assess the risks posed. However it was evident that there were signs of instability at several locations on the downstream face and some seepage through the dam. The spillway structures were in poor condition and nothing was known of any pipes through the dam. The recommendations also included for survey works, fencing to prevent further damage to the dam by horses, ground investigations and the preparation of an emergency drawdown plan.

Later in 2008 the Supervising Engineer became increasingly concerned with the deteriorating condition of the dam. Longstanding leakage at one point on the northern arm of the dam was increasing, and horses walking up and down the downstream slope of the dam were causing significant surface erosion which, in wet weather, was leading to small slips. All three spillways were regularly becoming blocked by reed growth which was artificially raising the water level up to 500mm above TWL. In addition, there was no operable bottom outlet to reduce the water level in an emergency and the remoteness of the site meant getting mobile pumps to the reservoir in an emergency would also be difficult.

As there were already outstanding measures in the interests of safety, calling for another Section 10 Inspection would not in itself improve the situation. Although not an 'emergency' requiring immediate evacuation downstream, the situation was becoming more serious and the measures in the interests of safety becoming more urgent.

By November 2008, it became apparent that the Duchy of Lancaster was neither willing nor legally obliged to take on the role of Undertaker under the Act. The Enforcement Authority therefore sought legal counsel on whether they could undertake the outstanding improvement works under the powers in Section 16 (Emergency Powers) of the Act. Counsel advised that the Environment Agency does not need to wait until a reservoir is in the process of failing to invoke these powers; they apply where it appears to the Environment Agency that a reservoir is unsafe and that urgent action is required to protect persons and property from an escape of water. Furthermore, the preparation of a reservoir inundation map at this time confirmed that 881 properties in Accrington would be at risk of inundation if the embankment failed. The Environment Agency therefore asked the Inspecting Engineer to consider the options including the discontinuance[2] of the reservoir using its powers under Section 16 of the Act (Emergency Powers). The Inspecting Engineer agreed that the use of emergency powers was warranted as:

1. The reservoir served no significant public function or amenity;
2. The dam was in a very poor condition;
3. The reservoir posed a clear and significant threat to the public; and
4. There was no foreseeable mechanism for improving the safety of the reservoir other than at the public's expense.

After significant high level legal discussion, Defra accepted that the Environment Agency as Enforcement Authority had the power to act to undertake these safety works. Discussions are still ongoing to resolve funding.

The Environment Agency immediately started sending a maintenance team to the reservoir on a weekly basis to keep the spillways clear and assess/ monitor the dam condition. Concurrently, an options study was procured by the Environment Agency and undertaken by Halcrow Group Ltd. in late 2008, with subsequent discontinuance works undertaken in 2009.

THE OPTIONS STUDY

The aim of the options study report was to describe and evaluate the options which would address the safety risk presented by the reservoir. These options ranged from remedial works (to maintain the current water level) to the discontinuance of the reservoir to various levels. The outline design and

[2] Discontinuance under the Act is achieved by carrying out works to reduce the raised reservoir volume to less than 25,000m^3.

data collection for the study took place from September 2008 to December 2008, with a final report issued in January 2009.

To assist in the outline design of these options a topographical survey of the crest and downstream face of the dam was carried out by Halcrow Group Ltd. A CCTV survey of the culverts was attempted but with limited success due to access problems. An ecological risk assessment was carried out to identify risks associated with the development of the options, including an ecologist's walkover and a biological records search.

Options were assessed over a 50 year life cycle to account for the varying residual maintenance requirements. Three main options were considered:

Option 1: Make safe and maintain

Option 2: Complete discontinuance of the reservoir, with a full height notch (with varying routes of diversion channels)

Option 3: Discontinuance with mid-height notch spillways

Option 1

This option was largely based on the 'recommendations in the interests of safety' (and also the 'other measures recommended to be taken') in the last Section 10 Inspection Report (Warren, 2008). Some of these recommendations were already being actioned by the Environment Agency including the removal of reeds from near the southern spillway, and the rebuilding of the northern culvert under the access road to allow more flow from the northern culvert/ spillway.

The remaining works included;

- Reconstruction of spillways and the southern culvert,
- Ground investigation of the dam,
- Repairs of the damage to the downstream face of the dam, and
- Replacement of the valve penstock and bridge to the valve tower.

Option 2

This option involved the complete drawdown of the reservoir followed by the excavation of a notch in the dam at its lowest point, to ensure no storage above natural ground level (i.e. discontinuance of the reservoir under the terms of the Act). In the absence of information on the upstream face, this location was assumed to be coincident with the lowest point on the downstream toe, approximately 40m to the northwest from the central corner between the two arms of the dam.

The size and lining of the notch was designed to pass the Probable Maximum Flood (PMF) flow without erosion (or collapse) of the side slopes. Reinforced grass lining was specified to a height of 0.6m above the notch invert to protect the exposed dam fill from the PMF flows, but the lowest 0.3m of the slopes and the invert were specified to be lined with a stone-filled reno-mattresses to protect against erosion by base flows.

The design of the notch was 1.7m wide at its invert, with side slopes set at 1V:3.5H which led to a maximum width at the crest level of approximately 58m. A factor of safety against rotational slips of 1.3 was required in order to ensure that the side slopes were stable and would not slump into the notch and cause blockage. The amount of material to be excavated from the notch was estimated using 3D CAD to be approximately 5,600m^3. To minimise disposal and compensation / land purchase costs, this material was to be deposited around the upstream side slope within the reservoir.

Within Option 2 various routes were considered to re-connect the outflow from the notch to the existing culverts. The simplest route was to connect the notch to the northern culvert with one diversion channel. However, the existing predominant outflow from the reservoir was from the southern spillways which connected to the southern culvert, since the southern spillway was around 400mm lower than the northern.

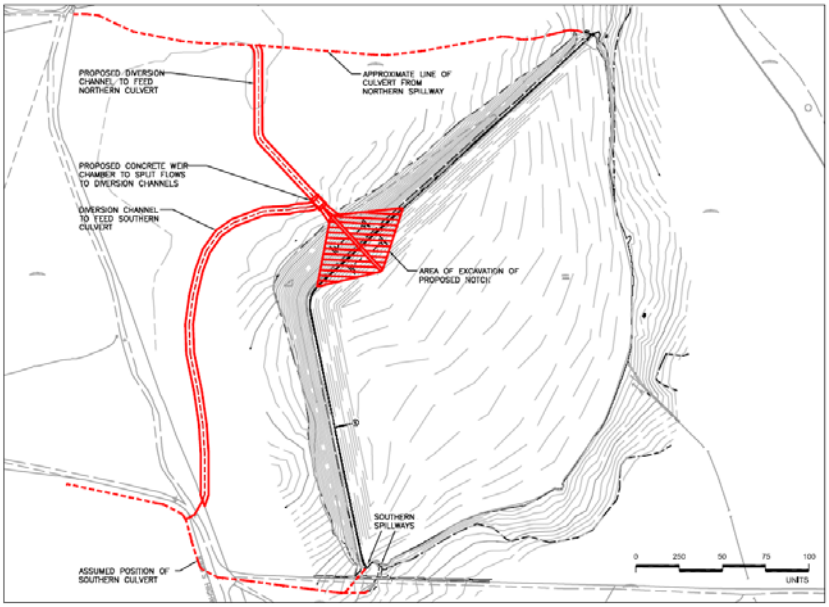

Figure 2. General Arrangement of Preferred Option in study (2a) (full height notch with diversion channels to north and south culverts)

To maintain an approximation of the existing flow regime, Option 2a included a new concrete weir chamber near the notch which would split the water flows to mimic the original split between the northern and southern spillways as shown in figure 2.

As well as the notch and diversion channels these options included for the demolition of the valve tower, since its public safety risk would increase if the reservoir was to be emptied.

Option 3

This option involved the excavation of two smaller notches through the dam, one in each limb, with diversion channels leading to the existing culverts. The invert levels of the notches were to be set at the level which would limit the water stored in the reservoir to less than 25,000m^3, in order to remove the reservoir from the ambit of the Act. The design of the invert lining and side slopes of these notches was the same as the full height notch in Options 2 but the total volume excavated would be less at 1,500m^3.

Option Costs

The cost of the remedial works to the reservoir was estimated with a 20% contingency. The initial capital and Present Value (PV) costs of the remedial works options were estimated as follows:

Option	**Description**	**Capital works cost**	**PV cost over 50 years**
1	Maintain and make safe the reservoir	£218.9k	£423.9k
2	Discontinuance, with notch to breach full height of dam, and with 1 diversion channel discharging to the northern culvert	£234.9k	£234.9k
2a	Discontinuance, with notch to breach full height of dam, and with 2 diversion channels discharging to northern and southern culverts	£278.2k	£278.2k
2b	Discontinuance, with notch to breach full height of dam, and with 1 diversion channel discharging to the northern culvert, and a collector drain upstream of the reservoir to discharge into the southern culvert	£268.7k	£268.7k
3	Discontinuance, with notches at mid-height of dam, to reduce storage of water to less than 25,000m^3.	£211.2k	£211.2k

Comparison of Options

Although Option 2, involving the full height notch, was the most expensive in terms of capital works, it was the preferred Option as;

- The residual risk presented by the reservoir was completely removed,
- There were no long term maintenance requirements i.e. the Environment Agency could essentially 'walk away' from the site,
- Maintenance of the diversion channels could be handed over to those who would benefit from them, such as the farmers who used the reservoir outflows to supply their livestock.
- The risk to public safety presented by the empty reservoir would be more easily managed than the other options that would leave the reservoir full or partly full.

Of the three variants of the full height notch option, the arrangement of flows through the weir chamber and diversion channels in Option 2a presented the closest approximation to the existing flow regime and as such was the preferred Option. The recommendations of the options study were also consistent with the recommendations of the Inspecting Engineer. The general arrangement of Option 2a is shown in Fig 2.

RISKS TO THE PROJECT

The study, and the project in general, were complicated by a number of issues and these are discussed in the following sections.

Lack of drawdown facilities

The route of the existing outlet pipe was unknown, the condition of the valve was unknown and the valve tower was inaccessible. Given these issues the drawdown of the reservoir had to be achieved solely by the use of pumps. A drawdown plan, including calculations of pumping rates and costs, was prepared during the development of the options study. In November 2008 the Inspecting Engineer recommended the drawdown of the reservoir be carried out as soon as practicable. However, the drawdown was delayed until after the study due to the issue of the existing informal use of the reservoir for water supply.

Existing Use of Reservoir Water

At the time of the study, three properties downstream of the reservoir were believed to be benefiting from the reservoir by extracting water from either the northern or southern culverts. The understanding of existing water supply routes was partly based on information provided by the residents. This information was summarised on a drawing provided by the Environment Agency (Fig 3).

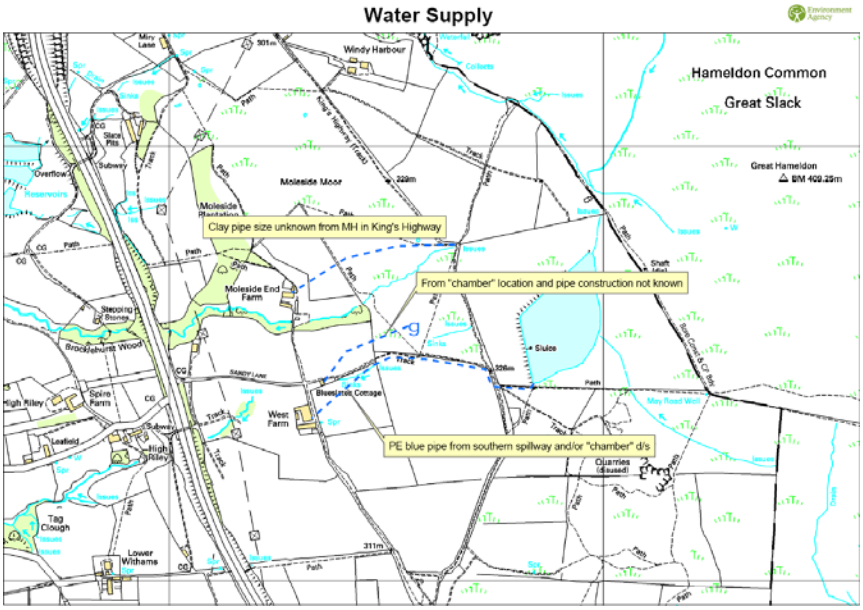

Figure 3: Assumed water supply route to properties downstream of Hameldon reservoir

Of the three properties, the southernmost (West Farm) had the most obvious feed from the reservoir water, with all domestic (to three residents) and livestock supply (up to 200 cattle) coming from a single pipe tapping the southern culvert. As most outflows exited through the southern culvert, the reservoir clearly provided a secure and reliable all year supply to this property, and a drawdown plan would have to include alternative provisions for when the reservoir level dropped below the southern spillway. While the outline designs for the preferred option had included the permanent diversion channels which would pass inflows to the culverts again, the attenuation benefit of the reservoir would be permanently lost. There were also concerns that the quality of the reservoir outflow water would be impaired due to the loss of the reservoir's function in settling out solids and metals. Overpumping to the southern culvert during the drawdown (to maintain the supply) was thought to be of limited use since the water quality would deteriorate with depth.

At the time of the study in late 2008, legal advice from within the Environment Agency was sought to establish any legal responsibilities towards the properties in the event of the removal of the benefit of the reservoir. This advice indicated that there was potentially an obligation to provide compensation to landowners for the loss of benefits following emergency works to reduce the reservoir risk. The Environment Agency intended to provide an alternative water supply during the course of the

works, restoring the natural water supply upon discontinuance. Unfortunately it was found that without the settling effect of the reservoir the natural water was not of potable quality.

Disused mineshafts

A mining report provided by the Coal Authority indicated that the northern half of the field enclosing the reservoir contained several recorded mineshafts, predating the reservoir (with some shafts recorded within the reservoir itself). Two recorded shafts were near the proposed northern diversion channel, the route of which was constrained by topography (as it followed an existing gully thought to be formed by the old stream).

Lack of Information about the Reservoir

With no record drawings available and no survey information for the upstream face and reservoir floor topography, many of the calculations of quantities and costs were dependent on estimates based on assumed contours.

Planning Considerations

Planning permission was not required as the planning department of the local authority (Hyndburn Borough Council) confirmed that the remedial works to reduce flood risks were considered as permitted development. However, the planning of the final state of the reservoir and the location of excavated material were constrained by the need to minimise land-take and therefore compensation to the landowner who owned the field enclosing the reservoir up to the downstream toe of the embankment.

The environmental risk presented by the remedial works was screened as ‘low’ by the Environment Agency’s National Environmental Assessment Service (NEAS) meaning that public consultation of a scoping document was not required.

Public Safety of Reservoir after Works Completion

At the time of the study, the priority in terms of public safety was to remove the risk presented by the reservoir. An initial Public Safety Risk Assessment was produced by the Environment Agency’s Project Manager. The most significant risk that this identified was the potential deep silt that would be exposed once the reservoir was empty.

A further risk to public safety was that the drawdown of the reservoir could affect groundwater and therefore the stability of the disused mineshafts, some of which were near public footpaths. These mineshafts were to be monitored during the drawdown.

DISCONTINUANCE OF THE RESERVOIR

Following some delays with the provision of temporary/alternative water supplies to the affected properties the drawdown of the reservoir started on 29 July 2009. (The construction of diversion culverts began shortly after). The excavation of the notch was also delayed for the same reasons and did not commence until 28 October 2009.

Figure 4. Reservoir emptied, notch cutting works commencing

Figure 5. Reservoir emptied, notch cutting works commencing

Given the remote location of the reservoir and its elevation it suffers the full effect of the weather and as winter progressed it became harder and harder to work with the material being excavated from the notch. Ultimately the Environment Agency was left with no choice other than to close the site down in mid December 2009, leaving the pumps on site to ensure that water levels were kept drawn down over the winter. Site works are expected to recommence in the late spring 2010.

CONCLUSIONS

The Environment Agency reports that there are presently three registered reservoirs which fall into a similar category as Hameldon and with an aging stock of disused reservoirs and the possibility of legislative change we may find that we are having to deal with more cases such as this. This particular project demonstrates the wide variety of problems that can arise in the planning and execution of reservoir discontinuance. The following conclusions can be drawn:

- The main delays to the discontinuance were due to the provision of alternative water supplies to the affected farms. Misleading information from the farmers initially indicated that three properties took their water from the reservoir. In reality only one farm took water direct from the reservoir but this only came to light towards the end of the water supply options appraisal stage. If a similar situation were to be encountered it would be worth completing a desk study and investigations (e.g. dye tests) early so that a full and complete understanding of the reservoir and its associated elements is developed before the situation becomes an 'emergency'.
- The water supply issues resulted in delays to the earthworks and ultimately in the Environment Agency undertaking earthworks in late autumn/ winter. This is not the best time of year to be undertaking these works, especially given the site location, and ultimately the decision had to be made to stand down for the winter. As of the end of 2009 the works are not complete but the notch has been formed to 5m below the crest and the dam is no longer capable of holding more than 25,000m^3.
- The simple discontinuance of a reservoir, i.e. the excavation of a notch to prevent it holding more than 25,000m^3 of water, appears quite straightforward when considering the works in isolation. This is far from the case as there are a number of issues that have come to light, as discussed above, some of which presented legal questions that were difficult to resolve for instance issues relating to water supply and prescriptive rights.
- Funding for projects of this nature comes from the public purse. The Environment Agency as enforcement authority for the Reservoirs Act has the legal power to address problem sites but is not funded to do so.

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