Canal & River Trust

Toddbrook Reservoir

Spillway Options Report

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Contents

Appendices

1 Introduction

1.1 Purpose of this report

This report outlines the repair works at Toddbrook dam to address damage to the auxiliary spillway following the incident that occurred on 1st August 2019. It describes the process taken to identify, evaluate and select a shortlist of sites for the spillway works, to be consulted on with the community and stakeholders. It describes criteria upon which the options have been reviewed and provides justification of these shortlisted concept options to be taken forward for final option selection and design. The design phase will include detailed development to work out the exact location, dimensions, construction and appearance of the final option based on further studies and analysis. The report explains what will happen in the next phases of the project.

Appendix A provides some background information about dams and reservoirs and reservoir safety legislation.

In assessing the options to create a shortlist, the application of best practice design to deliver the safest option was paramount, whilst giving consideration to maintaining and enhancing local amenity and to the impacts during construction.

1.2 Roles and responsibilities

The key roles and responsibilities of the organisations forming the Toddbrook project team and carrying out the work described in this report are:

Canal & River Trust - reservoir owner and operator;

Arup - Civil engineering consultant appointed by Canal & River Trust (the Trust) to carry out design work;

Kier - Civil engineering contractor appointed by the Trust to carry out construction work;

Mott McDonald – providing a Qualified Civil Engineer appointed by the Trust – responsible under the Reservoirs Act for inspecting the reservoir and overseeing the design and construction of the repair works; and

Project Steering Group - Senior members of each organisation, including dam engineers, both familiar with *and* independent of the management of Toddbrook reservoir who meet regularly to review the project. They provide feedback to the project team and ensure there is collaboration amongst everyone working on the project.

2 Toddbrook Reservoir repair project

2.1 Toddbrook Reservoir

Toddbrook reservoir is owned and operated by the Canal & River Trust (the Trust). It was completed in 1840 by building a dam on the Todd Brook, to supply water to the Peak Forest Canal. The dam is 24m high and made of earth with a central core of 'puddle clay' to make it waterproof. At Toddbrook, up to 1,238 million litres of water can be stored in the reservoir, which is about the same as 500 Olympic sized swimming pools.

Figure 1. Toddbrook Reservoir key features

Flows from Todd Brook enter the reservoir at the inlet. At the inlet weir, some water is channelled into the bywash channel which runs around the northern edge of the reservoir, so that some flow can be sent straight into the River Goyt. There are two outlet pipes laid through the dam into the canal feeder channels that run through the park, these are used to supply water into the canal.

Figure 2. Toddbrook Dam key features

At Toddbrook there are two spillways so that any flood waters, that flow into the reservoir, can be taken away towards the River Goyt. These are to stop flood water from overflowing the earth dam and washing it out. The primary spillway was built at the same time as the dam and allows excess water to flow into the bywash channel which runs along the toe of the dam and into the River Goyt. The auxiliary spillway was added in 1970 to increase the amount of water that could safely overflow from the reservoir. The auxiliary spillway was built over the centre of the dam and is set at a slightly higher level than the primary spillway, so water doesn't flow over it as often as the primary spillway.

2.2 Benefits

The Trust recognise the benefits that Toddbrook Reservoir provides and is committed to maintaining these where possible. Toddbrook Reservoir is a key water resource to the Trust, supplying over 30% of the water required to the Peak Forest and Macclesfield Canals. The reservoir and surrounding land provide important public amenity to the town of Whaley Bridge. The community enjoy the benefits of the reservoir, surrounding parkland and public rights of way, and local groups such as the sailing club benefit from access to the water. The importance of the reservoir to the environment is highlighted by its designation as Site of Special Scientific Interest (SSSI).

2.3 2019 incident

Following two heavy rainfall events at the end of July 2019, water levels rose in the reservoir and water flowed down the auxiliary spillway. The second more severe rainfall event was estimated to have the likelihood of happening of around once every 100 years. Some of the concrete slabs on the spillway were damaged and the earth dam underneath was exposed, making it vulnerable to washout and collapse. As a precautionary measure, over 1500 people and businesses were evacuated. Emergency works were completed straight away. These were:

- repairs to the damaged concrete spillway;
- using pumps to lower the water level in the reservoir; and
- changing the inlet weir so that as much water as possible was sent around the reservoir in the bywash channel instead of into the reservoir, which would still receive water during high flows.

After the incident an independent Panel Engineer carried out a full inspection of the reservoir (in line with the Reservoir Act). His report provided a set of statutory recommendations to make sure that the dam will be safe. The main recommendation from the report was to make improvements to the reservoir spillways. As it will take time to design and build these improvements, some temporary repairs have been carried out on the auxiliary spillway, and pumps remain in place to keep the water level in the reservoir low. This means that if a large flood happened before the new spillway was built, the dam can be safe.

2.4 Project objectives

Given the nature of the incident at Toddbrook Reservoir in August 2019 and the need to evacuate the town of Whaley Bridge, the Canal & River Trust and its partners are clear in the objective of identifying and constructing a design solution that uses the latest techniques and best practice to ensure that public safety is maintained whilst complying with the requirements of the Reservoirs Act 1975 (see Appendix A for information about reservoir legislation).

The main goals for the repair project are to:

- make the dam, reservoir and community downstream safe by designing and constructing the project to latest industry standards and best practice;
- maintain a secure water supply for the canals fed by Toddbrook Reservoir;
- complete the works in a timely fashion to minimise disruption to the people of Whaley Bridge and surrounding areas;
- make it easier to inspect, operate and maintain the dam to allow it to be kept safe in the future;
- work to identify the optimal solution with the least impact both during future operation and during construction; and

- ensure that the local community and key stakeholders have appropriate opportunities to be involved in development and implementation of the project.

As well as the work described in this report to make improvements to the reservoir spillways, the scope of Arup's design work also includes:

- improve the speed at which water can be drained from the reservoir in an emergency;
- carry out checks to make sure the dam remains stable if there was an earthquake; and
- identify if community improvements, including green energy options, are feasible.

3 Development and appraisal process

3.1 Method

The project team has adopted an iterative and thorough development and appraisal methodology to work towards identifying a preferred option to be developed for detailed design in line with best and usual industry practice. The Qualified Civil Engineer is involved in all stages of this process and must be satisfied throughout that the work being carried out meets reservoir safety requirements. The process that is being used is illustrated in Figure 3. Section 4 of the report describes how the methodology is being implemented.

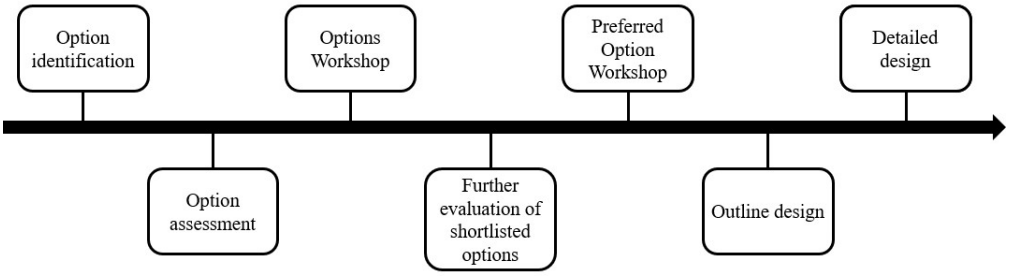

Figure 3. Development and appraisal process

3.2 Design standards

Toddbrook Reservoir provides more than 30% of the water supply needed to operate the Peak Forest and Macclesfield canals. The Trust therefore require the maximum water level in the reservoir to be the same as it was before the 2019 incident.

Reservoir industry guidance and standards are being followed in the design of the spillway options. The Qualified Civil Engineer stated that the spillway at Toddbrook Reservoir must be designed to be able to safely pass the Probable Maximum Flood. This is the most severe possible flood that could be experienced, which has a much higher volume than the flood experienced in 2019.

This means that the option of managing the water levels in the reservoir to be able to accommodate floods, for example by lowering the water level before a storm, is not feasible as a long-term solution. The spillway needs to be a large structure to be able to safely move the overflowing water away from the dam. Information about reservoir spillways is included in Appendix A. Reservoir spillways normally include a weir in the reservoir, over which water flows into a spillway channel which is normally sloped. The energy in the water is reduced in a stilling basin before flows are discharged into a channel or river downstream.

Nowadays, industry standard is that reservoir spillways are built out of reinforced concrete as this durable material is best able to resist the forces of the water as it leaves the reservoir. This is the approach being taken for the design at Toddbrook Reservoir. It is recognised that large concrete structures can have a significant environmental and visual impact, so it is key that the project team work to minimise these impacts on the environment.

4 Options development and appraisal

4.1 Option identification

Arup studied all available information about the dam, reservoir and surrounding area to fully understand the requirements of the spillway improvements and to establish the constraints on the site. These constraints included existing structures, land ownership, environmental and geotechnical considerations. This understanding was used to identify a long list of potentially feasible options to improve the spillway. The process resulted in the identification of thirteen concept options. Sketches were developed to show indicatively where the spillway structures could be located, based on high level calculations to determine approximate sizes. It should be noted that each option was a concept design, rather than a detailed design. The concept designs provided enough information to assess the feasibility of the option presented.

The thirteen concept options identified are listed in Table 1. *Note: The terms left and right are used as if you were standing on the dam looking downstream towards Whaley Bridge town. For example, the sailing club is at the left-hand end of the dam and the football club is at the right-hand end.*

Table 1: Summary of longlist options for the overflow improvements

Option	Description
1	Re-Build the dam
2	Discontinue the dam
3	Side channel spillway at location of existing primary spillway
4	New spillway at the left-hand end of the dam in the location of the sailing club
5	New bathtub spillway at the left-hand end of the dam
6	New spillway over the centre of the dam
7	Repair the existing auxiliary spillway
8	Replace the existing auxiliary spillway
9	Right hand side Shaft Spillway, tunnel under dam
10	Right hand side Shaft Spillway, tunnel under abutment
11	Left hand side Shaft Spillway, tunnel under dam
12	New side channel spillway at right hand end and chute around the dam
13	New side channel spillway at right hand end and chute through woodland

Each of the options is described in more detail below. Please refer to Appendix A for explanations of the different types of spillways.

4.1.1 Options involving major changes to the dam

Two options were identified that would result in major changes to the dam. **Option 1** involved the **re-building of the dam** (upstream of the existing one), around which a new side channel weir spillway would be provided.

Option 2 was to **discontinue the dam**, which means reducing the height of the dam to significantly reduce the amount of water that can be stored behind it. This is usually achieved by cutting a large notch into the dam as illustrated in Figure 4. This would mean the reservoir volume and surface area would be significantly less than existing. A spillway would still be required.

Figure 4: Example of a reservoir discontinuance project

4.1.2 Options using the existing auxiliary spillway

Two options were identified which involved using the existing auxiliary spillway location. **Option 7** was to **repair the existing auxiliary spillway** and refurbish the existing primary spillway. **Option 8** was to construct a **new spillway in the location of the existing auxiliary spillway** with enough capacity that the existing primary spillway could be abandoned. A new stilling basin would be constructed in the park downstream of the spillway channel.

4.1.3 Shaft spillway options

Three shaft spillway options were considered in different locations. These would be sized to allow the existing primary and auxiliary spillways to be abandoned. It could be possible to retain the primary weir, but this would not reduce the tunnel size significantly. Figure 5 shows a typical arrangement of a shaft spillway weir, water overflowing into the shaft and through a tunnel to discharge downstream of the dam.

Figure 5: Example of Shaft Spillway Overflow within reservoir

Figure 6 provides an indication of the location of the shaft spillway options. **Option 11** included a **shaft spillway at the left-hand end of the dam**, with a tunnel under the dam discharging into a stilling basin in the park. Options 9 and 11 involved **shafts at the right-hand end of the dam**, **Option 9** with a tunnel under the dam and **Option 10** with a tunnel around the right-hand end of the dam. Both included stilling basins in the park.

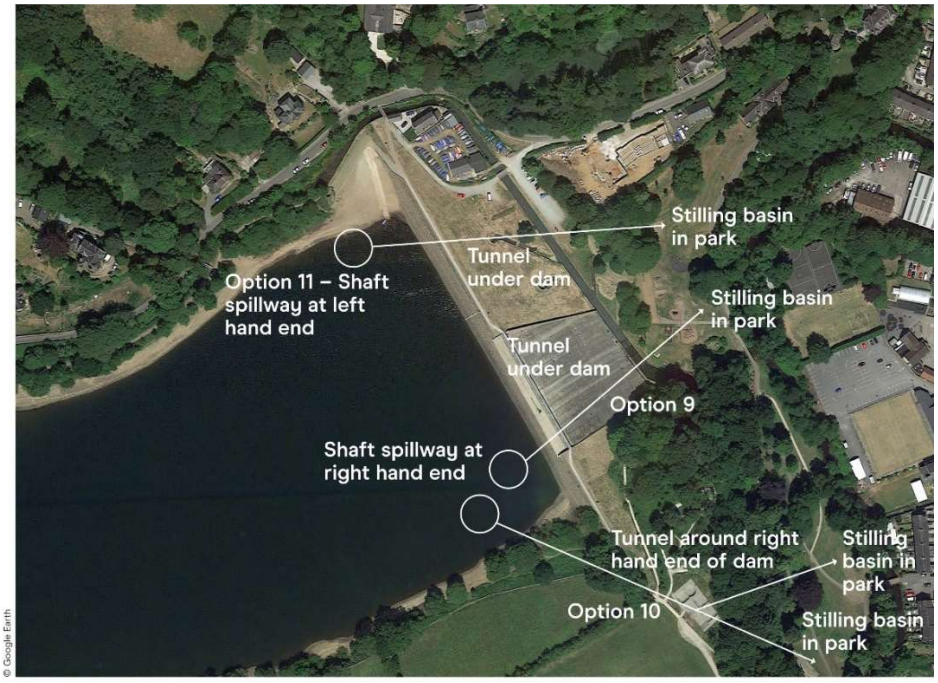

Figure 6: Diagram to indicate locations of shaft spillway options

4.1.4 Side channel weir options

Three side channel weir options were identified. The side channel weir is perpendicular to the dam as illustrated by Figure 7. Figure 8 indicates the location of the side channel weir options. **Option 3** involved a new **side channel spillway at the existing primary spillway** at the left-hand end of the dam and abandonment of the existing auxiliary spillway. This would mean that the existing spillway chute at the left-hand end of the dam would need to be widened and deepened significantly to increase the capacity. A stilling basin would be required in the park.

Option 12 was a **side channel spillway at the right-hand end of the dam**, discharging into a **spillway chute that would be constructed through the dam and then through woodland** in the Memorial Park. **Option 13** also had a **side channel spillway at the right-hand end of the park**, but discharging into a **spillway chute around the end of the dam** that took a route over the football fields before curving through the Memorial Park woodland. For the right-hand options, stilling basins would be required and the primary and auxiliary spillways would not be retained.

Figure 7: Example of a side channel spillway

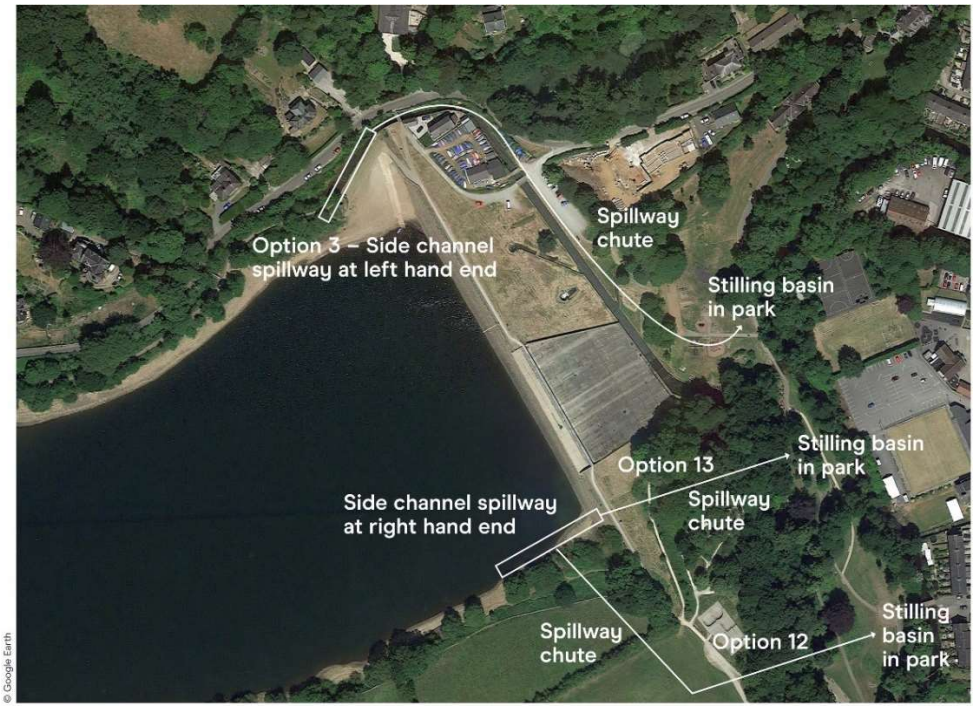

Figure 8: Diagram to indicate locations of side channel spillway options

4.1.5 Spillway locations on the dam

Two options were considered that involved weirs that were parallel to the dam, in a similar arrangement to the existing auxiliary spillway. The locations of these options are indicated on Figure 9. **Option 4** was a **spillway at the left-hand end of the dam** and would discharge into a spillway chute at the location of the sailing club. **Option 6** was a **spillway on the central part of the dam,** to discharge into a spillway chute over the area where the existing outlets discharge to the canal feeder channels. For both these options, stilling basins would be required and the existing primary and auxiliary spillways would be abandoned. Figure 10 illustrates a typical arrangement of these options.

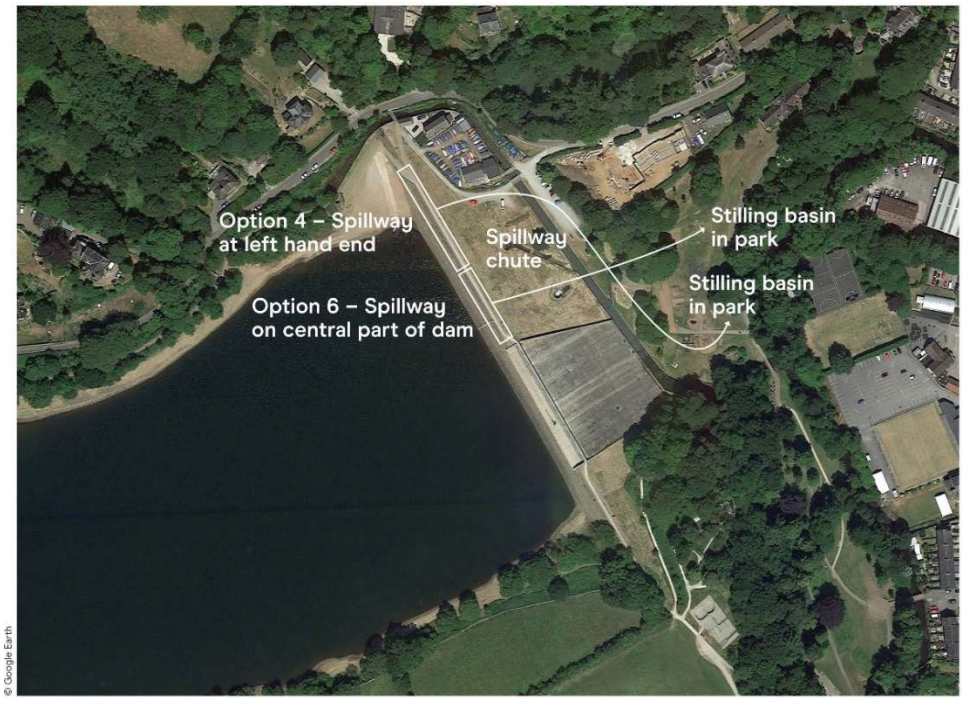

Figure 9: Diagram to indicate locations of spillway options on the dam

Figure 10: Example of a spillway located on a dam, with stilling basin at the downstream end

4.1.6 Bathtub weir option

Option 5 considered **a bathtub weir option at the left-hand end of the dam**. This would replace the existing primary and auxiliary spillways. Figure 11 provides an example of a bathtub weir structure. The bathtub weir arrangement

protrudes into the reservoir and would discharge flows into a spillway chute into a stilling basin located in the park below as indicated in Figure 12.

Figure 11: Example of bathtub spillway within reservoir

Figure 12: Diagram to indicate location of bathtub option

4.2 Options assessment and criteria

Each of the longlist options identified was reviewed against assessment criteria. The project team agreed the assessment criteria, these were informed by the project objectives and constraints and based on industry practice. Arup used available data including drawings, reports, surveys and investigations that had previously been carried out at the reservoir to inform the assessment process. Kier provided estimated construction costs for each of the options. The agreed assessment criteria are outlined in this section.

4.2.1 Dam and reservoir safety

The fundamental objective of the project is to make the dam, reservoir and downstream community safe by designing and constructing the works to industry standards and best practice. The spillway must be able to safely move flood waters from the reservoir towards the River Goyt without affecting the safety of the dam. The dam and the water held behind it are a hazard and although the likelihood of failure of the dam is low, the consequence of that failure would be large due to the position of the dam upstream of Whaley Bridge. This risk is managed by making sure that the spillway works are designed to minimise that risk of failure, and by making sure the dam can be inspected regularly and maintained properly. To allow the spillway to be easily inspected and maintained, it will be designed to allow inspection without needing to use specialist equipment, if possible.

4.2.2 Stakeholder and community impacts

The habitat and open space that surrounds the reservoir is well used and provides value to the local community. A key consideration in assessing options is to ensure that the impact on the community is minimised as much as possible during construction and operation of the spillway. The reservoir and surrounding land are owned and used by a variety of groups, clubs and individuals. These include Whaley Bridge Sailing Club and Football Club. The Memorial Park, which includes the play park, is located below the dam around the River Goyt and these are an important leisure facility for the people of Whaley Bridge. The public rights of way in the park are used daily.

Constraints associated with wider stakeholders such as local boaters and boating businesses, the local planning authority, Natural England and the Environment Agency were also identified and considered.

4.2.3 Technical and physical constraints

The physical constraints on the site were studied together with the topography of the land. These influence where the spillway can be located. Hydraulic considerations also need to be taken account of, to ensure that the channels can be designed to contain the flows required. The spillway design needs to make sure that the other repair works required can be designed and built.

To understand the geotechnical or ground conditions all available historic reports, surveys, drawings and investigations were studied. This included gaining an understanding of the type of ground, likelihood of groundwater, the position of mine drainage works and historical ground movement and slips.

4.2.4 Environmental impacts

One of the key environmental constraints is the reservoir's designation as a Site of Special Scientific Interest (SSSI) due to the presence of a rare moss species in the muddy zone around the reservoir edge. The reservoir and surrounding habitat are also known to support breeding birds as well as other species, such as bats.

Whilst the reservoir is not designated for heritage, the Trust recognises the cultural value that the reservoir provides to the local community and is keen to retain heritage features where possible (e.g. the bywash channel and valve houses).

Following the identification of the key environmental constraints, a review of the options was undertaken considering the potential impact on environmental aspects such as ecology, visual impact, heritage value, community, noise and air quality.

The reservoir repair works will inevitably result in some impacts on the environment, however, the design will seek to avoid or reduce the impacts as much as possible, as well as providing enhancements to the environment and community.

4.2.5 Planning and land ownership considerations

The Trust own some of the land around the reservoir. Agreement would be needed from landowners for any options where the spillway system is not on land owned by the Trust. Consideration was given as to whether EIA and planning permission would be required.

4.2.6 Health and safety

The new spillway needs to be safe to operate and maintain. The spillway will be designed to industry regulations and best practice to minimise risks to health and safety. This includes the safety of the public using the area around the spillway; people carrying out the construction; and people who are operating, inspecting and maintaining the spillway.

4.2.7 Construction access and ease of construction

The water level in the reservoir is being kept at a low level now so that if a significant storm occurred, the flood waters could be stored in the reservoir below the level of the spillways. The Trust have pumping arrangements in place and have carried out works to change the auxiliary spillway so that water would only go over the existing spillways in a very severe storm. These temporary safety measures need to be kept in place whilst the new spillway is constructed, so the design needs to allow for this.

Kier provided advice about how the options could be constructed, as some options may be more straightforward to construct and involve less temporary work than others. Access to the reservoir for construction traffic is also a key consideration. All options for access are likely to have a significant impact on the local community, so the Trust and Kier have started discussions with stakeholders to identify feasible options for these, together with identifying mitigation measures to minimise the impacts.

4.2.8 Estimated construction cost and time to build the works

Kier provided estimated budget construction costs for each of the options. These took account of the likely time to build each option.

4.3 Option Workshop

An Options Workshop was held in August 2020 and was attended by representatives from the project team: the Trust, Arup, Kier and the Qualified Civil Engineer. The workshop used an iterative process to compare options against agreed assessment criteria and eliminate less feasible options, to arrive at a shortlist of options.

The Options Workshop had the following objectives:

1. agree the process undertaken in identifying a longlist of options;
2. agree criteria to appraise the options;
3. evaluate options and select a shortlist for further consideration and consultation; and
4. enable all participants to provide constructive comment and challenge on the development and appraisal process, including its findings, and to identify any areas that may require further consideration.

4.3.1 Longlist evaluation

The Options Workshop format comprised a series of iterations which resulted in the longlist being narrowed down to a shorter list, and then further narrowed to a shortlist of options.

The first action in the workshop was to review the longlist and eliminate any unsuitable options. Arup presented the thirteen concept options and the initial review that had been carried out of these against the assessment criteria. The team in attendance discussed and considered the advantages and disadvantages of the thirteen options and rejected the least viable options. The team agreed at this stage to **take forward options that minimised risks to reservoir and dam safety whilst retaining the function of the reservoir** as a means of supplying the canal, providing amenity value to the community and being safe to operate, inspect and maintain. Seven options were removed from the assessment process at this stage. Table 2 lists these options and the main reasons that they were rejected.

Table 2: Options discarded as a result of assessing the longlist

Option	Main reasons discarded	Details
Option 1 - Dam rebuild	• Loss of water resource to supply canal • Environmental effects • Reduction in amenity value • Significant construction project	This option would reduce the amount of water that could be stored in the reservoir as the new dam would be constructed upstream of the existing one, and so affecting the ability to supply sufficient water to the Peak Forest canal. This would reduce the surface area of the reservoir which would likely have a significant effect on the SSSI and available space on the reservoir to provide an important leisure amenity in Whaley Bridge. This option is a huge construction project, involving large volumes of earth moving and construction of new spillways.
Option 2 - Dam removal	• Loss of water resource to supply canal • Environmental effects • Reduction in amenity value • Significant construction project	This option would reduce the volume of water that could be stored in the reservoir by significantly lowering the water level by removing a large part of the dam. This would mean it would be unlikely that water could be supplied to the Peak Forest canal from Toddbrook reservoir. The reservoir surface area would be reduced significantly which would impact the SSSI and reduce amenity value. The option would involve large volumes of earth moving and would be a significant construction project.
Option 6 - New spillway over the centre of the dam	• Higher risks to reservoir safety than other options • Physical constraints	This option would need significant work to extend or move the outlet pipes from the reservoir and would be built over mine drainage works, other locations did not have these challenges. Although the spillway would meet modern design standards, it would still be located on the dam, so there would be a higher residual risk to reservoir safety than other options.
Option 7 - Repair the existing auxiliary spillway	• Unacceptable risk to reservoir safety • Difficulty in retaining flood protection during construction	This option was considered unviable as the design has already failed. Again, this option could result in a higher remaining reservoir safety risk as the spillway is located on the dam. It would also be more difficult to retain temporary flood protection during construction.
Option 9 – Right-hand side shaft spillway, tunnel under dam	• Public safety risk • Risk of blockage due to safety grille • Tunnel would normally be flooded • Confined space – more difficult to inspect and	The outlet of the tunnel could be a risk to public safety, a security grille would be required on the tunnel exit to prevent access. This increases the risk of debris getting trapped in the tunnel and blocking flows. The tunnel from this option under the dam would need to be constructed at a low level so the tunnel would normally be flooded, with potentially stagnant water when the reservoir is not overflowing. This confined space would need to be pumped out to allow inspection and

	maintain than open channel options • Higher estimated construction cost	maintenance. The estimated construction costs were higher than other options.
Option 10 – Right-hand side shaft spillway, tunnel under abutment	• Public safety risk • Risk of blockage due to safety grille • Risk of poor ground conditions • Discharge location opposite properties • Higher estimated construction cost	The outlet of the tunnel could pose a public safety risk, a security grille would be required on the tunnel exit to prevent access, which could increase the risk of blockage by debris getting trapped in the tunnel. The tunnel under the right abutment could be at a higher level than Option 9 so would not normally be flooded, but there is the risk of poor ground conditions in this area. The tunnel discharge location is opposite residential properties. The estimated construction costs were higher than other options.
Option 12 - New side channel spillway at right-hand end and chute around the dam	• Impact on community facilities • Higher estimated construction costs than similar Option 13	This option was discarded as, although it has some of the benefits of Option 13, the length of spillway channel required was longer and was considered to have a greater impact on the park and sports ground. The estimated construction costs are also higher than Option 13.

4.3.2 Shorter list evaluation

The second part of the workshop focussed on assessment of the remaining six options. The options were discussed and challenged and assessment criteria agreed for the scoring of the options. The assessment process recognised that some of the impacts were common to all thirteen options, for example, all will require access for construction, and all will impact on the park in some way. This assessment resulted in the rejection of the four most unsuitable options. Table 3 lists the four options removed from the process and the main reasons why they were not shortlisted.

Table 3: Options discarded as a result of scoring remaining six options

Option	Main reasons discarded	Details
Option 3 - New spillway in location of existing primary spillway	• Physical space constraints – road, house, utilities • Construction challenges • Impacts during construction – noise, vibration, road closures	This option involves providing a new weir in the location of the existing primary weir. Whilst this option is favourable from a reservoir safety perspective, as the spillway will be located off the dam, the existing primary weir/bywash channel would need to be substantially widened and deepened to be able to safely discharge the design flows. The land and space available for this work is limited by Toddbrook Lodge and Reservoir Road. This would result in significant design and construction challenges in terms of maintaining the road and utilities laid beneath it, and the impacts on residents during construction due to road closures and

		proximity of construction to residential properties.
Option 4 - New spillway at the left-hand end of the dam at the location of the sailing club	• Risks to reservoir safety of wider channel through dam • Higher estimated construction cost • Impact on sailing club and parking area • Difficulty in retaining flood protection during construction	This option involves constructing a weir along the crest of the dam and therefore a wide spillway channel located within the downstream part of the dam on the left-hand side. To reduce the risks to reservoir safety, the width of excavation in the dam would ideally be minimised. The estimated construction cost of this option was high compared to other options. This option would mean the sailing club would need to be moved to a different location. The existing parking area and access to the dam would be lost. The wide channel could have a significant visual impact and is close to the boundary of the new houses so likely to require a large retaining wall. It would also be more difficult to retain temporary flood protection during construction than other options.
Option 8 - Replacement of existing auxiliary spillway with a new spillway	• Higher risks to reservoir safety than other options • Difficulty in retaining flood protection during construction • More difficult to design for safe inspection and maintenance	Although for this option the existing spillway would be replaced with a new one, designed to modern design standards, it would still be located on the dam, so there would be a higher residual risk to reservoir safety than other options where the spillway can be constructed away from the dam. It would also be more difficult to retain temporary flood protection during construction than other options. The stilling basin that is required downstream would impact on the play park. The steepness of the spillway would mean that inspection could be difficult, unless steps were provided in the spillway.
Option 11 - New shaft spillway, located at the left of the reservoir, tunnel under the dam	• Risk to reservoir safety of tunnelling under dam • Public safety risk • Risk of blockage due to safety grille • More difficult to inspect and maintain than open channel options • Higher construction risks associated with tunnelling and ground conditions • Higher estimated construction cost	Tunnelling under the dam could reduce the ability of the ground to support the dam above. The exit from the tunnel and the stilling basin would impact on the park and a security grille would need to be provided on the tunnel exit to discourage access. Debris from the reservoir could get caught on this screen causing blockage, which could be difficult to remove, especially during a flood event. Unauthorised access into a tunnel could pose more risk to the public than an open channel. Shaft spillways are more difficult to inspect and maintain than open channel spillways as they require specialist equipment to enter the tunnel and inspect the shaft, and this can only be done when the reservoir is not full. The construction risks associated with tunnelling are greater than for an open channel structure, with the risk of unfavourable ground conditions. The tunnel would need to be designed to avoid the canal feeders and mine drainage workings. The estimated

		construction cost of this option was high compared to other options.

4.3.3 Shortlisted options

The outcome of the evaluation carried out in the options workshop was the selection of two shortlisted options. These are illustrated in the figures below that were developed for the public consultation. For the purposes of the public consultation, the options were labelled (from left to right looking downstream) as Option A and Option B:

- **Option A (Option 5) - new bathtub spillway at the left-hand end of the dam with spillway channel passing through the dam and the park**; and
- **Option B (Option 13) - new side channel spillway at right-hand end of the dam, with spillway channel through the Memorial Park woodland.**

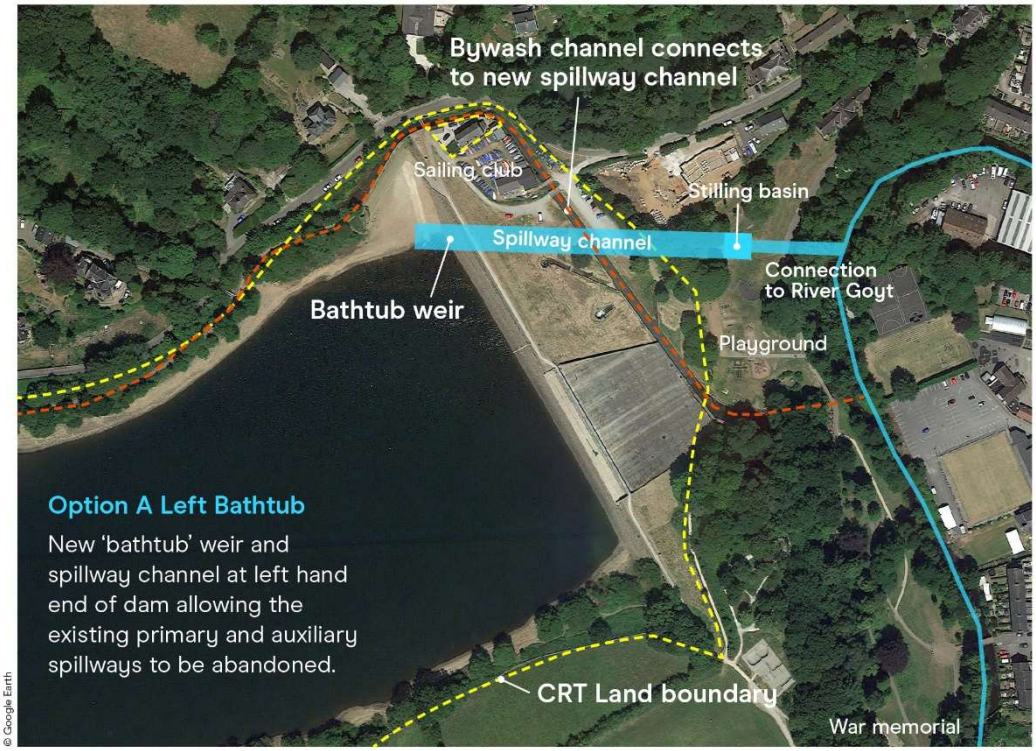

Figure 13: Option A (Option 5)

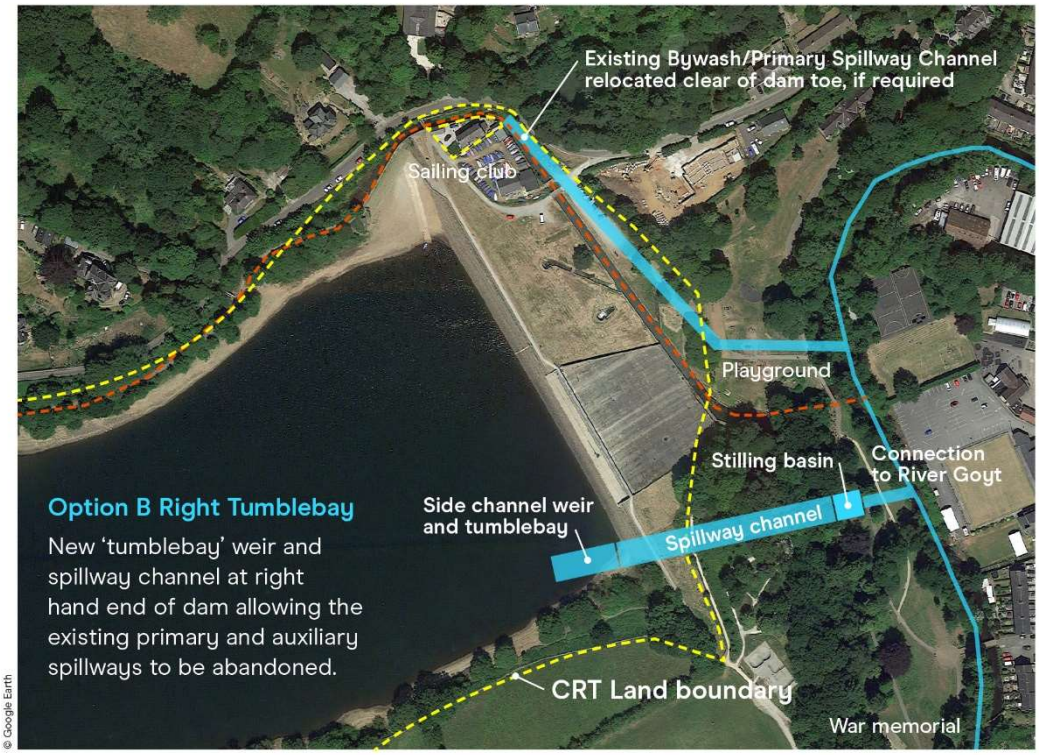

Figure 14: Option B (Option 13)

These two options were shortlisted because they perform best when considering the key objective of reservoir safety in combination with other assessment criteria as described below.

Key points arising from the evaluation of **Option A (**Option 5) against the assessment criteria outlined in section 4.2 are described below:

- **Dam and reservoir safety:** The bathtub weir and spillway channel can be designed so that they are built onto the natural ground under the dam, to reduce the risk to reservoir safety. By using a bathtub weir arrangement, the spillway channel through the dam can be narrower than Option 4. The discharge from the spillway is away from the dam.
- **Stakeholder and community impacts:** Option A will impact on Toddbrook sailing club as the position of the bathtub weir is in the vicinity of the boat launching area and the spillway channel construction could impact on the buildings and boat storage. The new spillway will also impact on the park. An access bridge would need to be provided at the dam crest and existing public rights of way in the park re-routed.
- **Technical and physical constraints:** Option A would need to be designed to take account of existing structures in the area including bywash channel; reservoir outlet pipes and canal feeders; mine drainage workings; and new houses.
- **Environmental impacts:** The spillway channel would impact on the park and would result in the loss of some trees. It would have a visual impact which the design would seek to minimise. The option has a low impact on ecology and protected species.
- **Health and safety:** The spillway channel would not be as steep as the existing auxiliary spillway and could be designed to allow safe access for inspection and maintenance.

  The new channel and outlet structures will introduce a risk to public safety in the park and would need to be designed to minimise these risks.
- **Construction access and ease of construction:** A site compound and access for construction vehicles will be required, ideally to the left-hand end of the dam for this option. Work would be done to identify the optimal access route and position for a site compound.

  The construction sequence can be planned so that the new spillway can be constructed whilst maintaining existing flood protection provided by the existing primary and modified auxiliary spillways.
- **Estimated construction cost:** The estimated construction cost of Option A was lower compared to some other options.

Key points arising from the evaluation of **Option B** (Option 13) against the outlined in section 4.2 are described below:

- **Dam and reservoir safety:** The spillway channel will be constructed largely on natural ground at the right-hand end of the dam to reduce the risk to reservoir safety. The discharge from the spillway is away from the dam.
- **Stakeholder and community impacts:** Option B will impact on the cycle track and Memorial Park. An access bridge would need to be provided at the dam crest and existing public rights of way in the park re-routed.

- **Technical and physical constraints:** Option B would need to be designed to take account of the ground conditions, steep slopes and buried pipes in the park.
- **Environmental impacts:** The impact of the weir location on the SSSI would need to be managed. The spillway channel would impact on the park and would result in the loss of a significant number of trees and potential for associated impact on ecology and need for protected species licences. This option would have a visual impact which the design would seek to minimise.
- **Health and safety:** The spillway channel could be steep due to existing steep slopes so steps may need to be included to allow safe access for inspection and maintenance.

  The new channel and outlet structures will introduce a risk to public safety in the park and would need to be designed to minimise these risks.
- **Construction access and ease of construction:** A site compound and access for construction vehicles will be required, ideally to the right-hand end of the dam for this option. Work would be done to identify the optimal access route and position for a site compound.

  The construction sequence can be planned so that the new spillway can be constructed whilst maintaining existing flood protection provided by the existing primary and modified auxiliary spillways can be maintained, but the temporary pumps would need to be moved to a different location before construction could start.
- **Estimated construction cost:** The estimated construction cost of Option B was lower compared to the other options.

4.4 Further evaluation of shortlisted options

Following the workshop, work is being carried out to further investigate and evaluate the two shortlisted options.

This includes:

- carrying out public consultation and engaging with stakeholders to understand their views on the options to identify how these could be addressed in the designs;
- carrying out ground investigations and reviewing the results to understand the ground conditions better;
- carrying out topographical surveys of the land and using this to better understand the location of the spillways and the landscape impacts;
- assessing construction site access and compound options to identify those with the least impact;
- reviewing available information about water levels in the River Goyt and the interaction of the spillway outlet channels with the river; and
- preparing more detailed construction cost estimates.

4.5 Preferred option workshop, outline and detailed design

When the shortlisted options have undergone further investigation and evaluation, a second workshop will be held by the project team to review all of the additional information that has been gathered. The team will use this information to further evaluate the options and to work towards selecting a preferred option for the spillway improvements.

Once a preferred option is selected, Arup will prepare an outline design. This will provide more detail about how the spillway will look and operate.

Finally, detailed design will be completed by Arup and used by Kier to build the spillway.

5 Summary and next steps

Work has been done to identify options to improve the reservoir spillways, investigate these and narrow them down to select two shortlisted options.

The site constraints were reviewed and a longlist of options was created, and concept designs produced. Assessment criteria for the options were identified to meet the goals of the project. Arup worked with the Trust and Kier to reduce the longlist to a shortlist of options, overseen by the Qualified Civil Engineer.

The shortlisted options for the new spillway at Toddbrook Reservoir are:

- Option A - new bathtub spillway at the left-hand end of the dam with spillway channel passing through the dam and the park; and
- Option B - new side channel spillway at right-hand end of dam, with spillway channel through the Memorial Park woodland.

Further work is being done to investigate the two shortlisted options. This work includes:

- engaging with the public and stakeholders to understand and take account of their views on the options;
- investigations to understand the ground conditions better;
- surveys to check the topography of the land;
- further investigation of access and construction site compound options; and
- more detailed construction cost estimates.

The information gathered, including feedback from the public consultation, will be used to help to select a preferred option.

Once a preferred option is selected an outline design will be prepared by Arup. This will provide more detail about how the spillway will look and operate. The layout and dimensions of the preferred option will change, when compared to the concept, as additional information will be available and taken into consideration in the design process. Finally, detailed design will be completed by Arup and approved by the Qualified Civil Engineer, and then used by Kier to build the spillway.

Alongside work to design the spillway, Arup will complete designs for other safety improvement and repair works to be constructed by Kier.

Once the Qualified Civil Engineer is content that the spillway and other works have been addressed, consent will be given to permit the reservoir to be refilled.

Appendix A

Introduction to dams and reservoirs

A1 Introduction to dams and reservoirs

A1.1 Dams and reservoirs

A **dam** is a structure built across a stream or river to confine and control the flow of water. Dams vary in size and construction from small earth embankments to high massive concrete structures. A **reservoir** is the water stored behind a dam for uses including water supply, irrigation, flood storage and hydropower. Sometimes, the term **reservoir** is used to describe both the water, dam and associated structures.

Spillways are structures that either form part of a dam or are found just beside one. They are used, when a reservoir is full, to pass flood water safely and in a controlled way over, around or through a dam. At the top of the spillway is a **weir** which controls the level at which the water starts to flow down the spillway. Some common types of spillways are described below. Further information and photographs can be found on the British Dam Society website:

https://britishdams.org/about-dams/dam-information/spillways-and-outlets/

Side channel spillways are used mainly with embankment dams. They are located just upstream and to the side of the dam. The water flows over the spillway weir into a side channel tumble bay. Then it flows down a chute and towards the river downstream of the dam.

Figure A - 1: Example of a side channel spillway

A **shaft spillway** is a hollow shaft or tower that sits within the reservoir. The water flows over the top of the shaft and down into a tunnel that is laid under or through the dam. The tunnel then exits downstream of the dam.

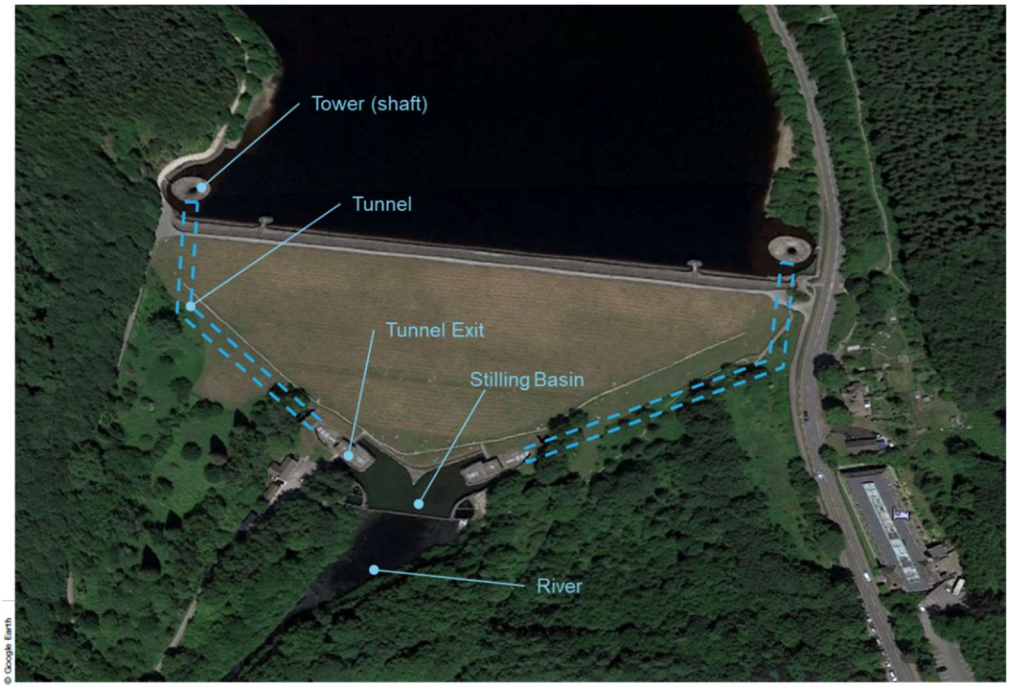

Figure A - 2: Example of shaft spillway

An **overflow spillway** is constructed as part of a dam. The spillway section is lower than the other sections of the dam allowing water to flow over its top and down its front face. These are more usually found on concrete dams than on earth embankments.

A **bathtub spillway** is a structure that protrudes into the reservoir in the shape of a bath. The water flows over the top of the bathtub into the centre and then down a chute and towards the river downstream of the dam.

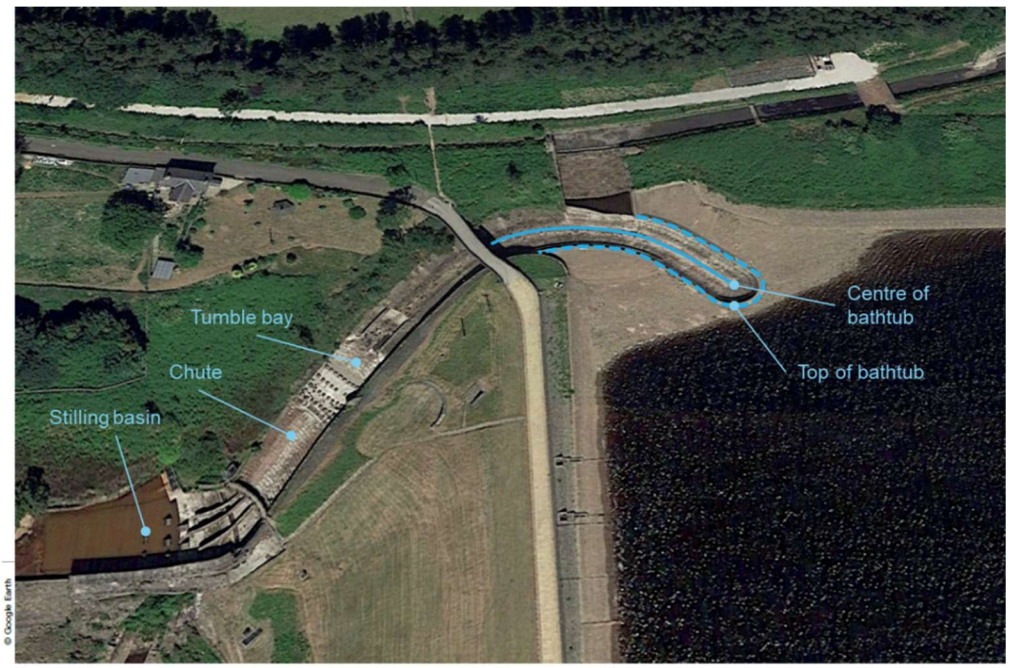

Figure A - 3: Example of a bathtub spillway

Most spillways have a **stilling basin** at the downstream end. This structure removes the energy from the water before it is discharged into the river downstream.

Some dams have more than one spillway. The **primary spillway** will be lower than the other spillways and water will overflow over this first. Other **auxiliary spillways** may be present at a higher level and so will not operate as frequently.

Other **outlets** may be built under, through or around the dam, to release water from the reservoir for different uses.

A **bywash channel** allows some of the flows that could enter the reservoir to be diverted around the reservoir and discharged into the river downstream, maintaining flow in the river.

A1.2 Reservoir safety legislation

Reservoirs in England are regulated under the Reservoirs Act 1975, as amended by the Flood and Water Management Act 2010, which is enforced by the Environment Agency. The Act covers the safety of all large raised [above ground] reservoirs that can hold at least 25,000 cubic metres of water.

The Act makes reservoir **owners** and **operators** legally responsible for the safety of their reservoirs. Under the Act, there are Panels (or groups) of civil engineers who are responsible for checking the safety of reservoirs and their dams. These engineers are only appointed to the Panels by the Secretary of State (Defra) if they are well qualified and experienced in reservoir safety matters.

Dam owners are required to employ members of the Panels to act as **Qualified Civil Engineers** to:

- oversee the design and construction of new reservoirs; and
- oversee the design and construction of repairs or changes to reservoirs.

Dam owners are required to appoint Panel Engineers to:

- inspect the reservoirs at intervals of not more than 10 years, or for example after an incident; and
- make regular checks on safety in between these inspections including reporting annually.