Appendix:	8.2 – Engineering Options **Option 2: Reservoir Discontinuance**
Reservoir name:	Cilcain Reservoirs 1 & 2

1. Introduction

The 'discontinuance' of a dam, under Section 13 of the Reservoirs Act 1975 requires an owner to reduce a reservoir's water storage capacity to a volume that is less than 10,000 m^3 (in Wales). In some cases, owners choose to reduce the capacity to say 5,000 m^3 to avoid being subject to the requirements of the Reservoirs Act 1975 whilst some owners will choose to remove, or 'notch', the dam completely with no water then being impounded.

This document provides a high-level assessment of the actions necessary to discontinue the reservoir.

Initially, two discontinuance sub-options have been considered, namely:

Sub-Option 2A – complete removal of the upper dividing embankment and partial removal of the lower reservoir embankment by excavating a full-height notch down to original ground level and which is at least 10m wide at the bottom with 1:3 (V:H) sloping sides cut into the existing embankment; and

Sub-Option 2B - and the complete removal of the entire length of the upper and lower reservoir embankments to original ground level.

After receipt of the bathymetric information on the reservoirs (following a bathymetric survey carried out by NHTB Consulting Ltd) it was decided that **Sub-Option 2B** would not be considered further due to the following:

- Considering the size of the lower reservoir, it was found that removing the entire embankment would not provide a significant additional benefit compared to Sub-Option 2A apart from the reduced visual impact.
- Complete removal of the embankment would likely result in a substantial increase in project costs due to a significant amount of additional excavation, demolition and substantial off-site disposal of material.

Therefore, in light of the above, only **Sub-Option 2A** (partial removal of the embankment) will be progressed further in the sections to follow.

Table 1: Summary of discontinuance options considered

Option ref.	Description	Carried forward?
2A	Partial removal of the lower reservoir embankment by excavating a full-height notch which is at least 10m wide at the bottom with 1:3 (V:H) sloping sides cut into the existing embankment	**Yes**
2B	Complete removal of the lower reservoir embankment to original ground level	**No**

The assessment includes a high-level range of the cost associated with the proposed works along with on-going costs related to monitoring and maintenance activities. The activities discussed in this document are all considered from a dam safety point of view, i.e. to ensure full discontinuance, and also from the perspective of residual downstream flood risk.

2. Dam Structure: Proposed Works to Discontinue

Under this option it is proposed that a full-height notch is excavated in the lower reservoir embankment. The entire dividing embankment is proposed to be removed as part of this option.

It is proposed that the notch width at ground level is no less than 10m wide to allow for trees to pass through during a flood event. Notch side slopes of 1:3 (V:H) are proposed for stability. The excavated embankment material can be relocated or re-used within the reservoir basin to form a channel within the footprint to allow water to safely pass through the discontinued structure. As such, the purpose

would be to restore the area to its pre-reservoir state as much as possible by using the excavated material, which would also ensure minimal (if any) removal of material from the site.

The original natural stream will be excavated along with silt in the reservoir basin to allow the natural stream to follow its original path towards the downstream watercourse.

In addition to the main notch opening a low flow notch channel would be created with a bottom width of approximately 3m, side slopes of 1V:2.5H and an approximate depth of 0.5m, to control low flows up to the 1 in 100 year flood.

For this option it is proposed that all the existing pipework be removed as part of the discontinuance works. It is proposed that the existing main overflow, by-wash channel and downstream masonry channel is retained for this option.

See Figure 2 for a sketch of the proposed Option 2.

3. Residual Dam Structure: Stability

There is insufficient data available without undertaking further detailed investigations to be able to carry out a stability analysis of the retained sections of the dam wall. However, a close inspection of the dam in conjunction with previous condition assessments and annual statements clearly indicate no evidence of immediate untoward movement or distress, raising no concerns of instability.

No further investigations or stability checks are proposed. However, ground investigations would likely be required to ascertain the founding conditions to inform the design of the notch and erosion protection requirements.

4. Proposed New Overflow: Capacity

The works proposed for this option would ensure that inflows from the catchment will flow unimpeded through the discontinued reservoir site and into the existing downstream watercourse, with zero flood attenuation anticipated.

5. Proposed New Overflow: Downstream Flood Risk

A review of the downstream flood risk with the existing reservoir and overflow arrangements (discussed in more detail in **Appendix 4**) indicates that there is a risk of downstream flooding to two unclassified roads, Cilcain road and approximately 20 residential properties during extreme flood events.

The existing reservoir provides negligible flood attenuation for all floods considered. Since a large section of the existing embankment would be removed down to ground level for the discontinuance option, any future catchment inflows will likely pass through the site unimpeded. Therefore, it is anticipated that the site will produce zero attenuation, which will likely result in no change to downstream flood risk compared to the current situation with the presence of the raised reservoir. Therefore, it is considered reasonable to assume that the existing downstream watercourse and downstream structures will be able to accommodate incoming flows without the presence of the entire dam.

6. Emergency Drawdown Capacity

The discontinued reservoir will not require any residual drawdown capacity and it is proposed that the existing scour valve and the outlet pipe be removed as part of the discontinuance works.

7. Managing Reservoir Water Levels During Construction

Use of Existing Facilities

No permanent operable drawdown facilities could be located on site during the site visit of 10th January 2019.

Use of Mobile Equipment

In the absence of any permanently installed drawdown facilities on site, other means of drawdown will need to be considered. The equipment required to draw down the reservoir depends on:

- The inflows coming into the reservoir(s) at the upstream end (pass through flows);
- The amount it is wished to lower the reservoir(s) by (lowering rate).

a) Pumps

Pumps will provide a good solution for reservoir drawdown although these will need to be diesel powered, requiring deliveries of fuel to site, and consideration given to how the pumps are supervised when construction activities are not underway, overnight and at weekends. Table 2 below provides an indication of the sizes and numbers of pumps that would be required to handle normal flows through the upper reservoir and to draw down both reservoirs.

b) Siphons

The use of siphon pipes provides a valuable alternative for initial drawdown, requiring no power once the pipes are primed and operating. Suggested details of the sizes and numbers of pipes is given in Table 2 below. Due to the nature of the siphon operation this approach would not be reliable for drawing down more than the top 1m or so of the reservoir below top water level. Pumps will need to be employed to completely empty the remaining impounded section of the waterbody.

Indicative Capacity Requirements

The calculations in Table 2 provide a high-level indication of the order of capacity that might be required to initially draw down both reservoirs by using mobile equipment. Both pumps and siphons have been considered, although the siphons may only be able to practically remove the top 1m or so of the reservoir depth.

A target rate of 300mm reduction in reservoir level per day has been assumed however this rate will need to be agreed with the QCE for the works and consider possible environmental / ecological and or downstream flooding constraints.

Table 2: Temporary measures for managing reservoir water levels – initial drawdown

Item	**Units**	**Value**		**Source / Comment**
		Upper reservoir	**Lower reservoir**	
Q_{50} inflow	l/s	30	30	Assessment of inflows carried out for this study
	m^3 / day	2,592	2,592	
Area of reservoir, a	ha	0.30	0.65	Flood Assessment (**Appendix 4**)
Suggested target rate, D_i	mm /day	300	300	This can be changed depending on the requirements of the scheme
Maximum volume to be evacuated based on target rate, V	m^3 / day	3,492	3,492	Q_{50} (m^3/day) + 10 x a x D_i
Pumps				
Recommended number of 80mm diesel pumps (Assuming 30 l/sec delivery per pump at 6m head).	nr	2 [5,180 m^3/day]	2 [5,180 m^3/day]	GP80 from Sykes Pumps
Recommended number of 50mm diesel pumps (Assuming 15 l/sec delivery per pump at 6m head).	nr	3 [3,888m^3/day]	3 [3,888 m^3/day]	GP50 from Sykes Pumps
Siphon Pipes (see Note 1)				

Item	Units	Value		Source / Comment
		Upper reservoir	Lower reservoir	
Estimated nr. of 150mm dia. siphon pipes, assuming 40m pipe length.	nr	3 [3,900 m^3/day]	3 [3,900 m^3/day]	High-level hand calculation for siphon discharge
Notes: 1. Due to the nature of the siphon operation this approach would not be reliable for drawing down more than the top 1m or so of the reservoir below top water level.				

Once the reservoir level has been sufficiently drawn down to safely carry out discontinuance works, the incoming flows would have to be diverted. There is a by-wash channel present on site, running from the unnamed stream that originates at Cilcain No. 4 reservoir upstream, around Cilcain No. 1 & 2 reservoirs to the north and finally discharging into the downstream masonry channel on the left abutment of the main Cilcain No. 2 embankment. This channel was likely used as a stream diversion during the construction of both reservoirs and could be used again to divert flows during the removal of the embankments. The channel has a roughly trapezoidal section profile and a high-level capacity check indicates that its maximum flow capacity could be in the order of **3.6m^3/s**.

A temporary coffer dam could be constructed at the existing inlet to the upper reservoir to divert all flows down the by-wash channel during the works. The Q_{10} inflow for the reservoir is estimated to in the order of 0.103 m^3/s, and so it is anticipated that the existing by-wash channel would have sufficient capacity to divert the catchment inflows. Therefore, no additional mobile equipment would be required to divert inflows during construction. Following the removal of the embankments and the reinstatement of the original stream through the dam site, the by-wash channel would be blocked so that all inflows can pass through unimpeded down the valley through the site of the dam.

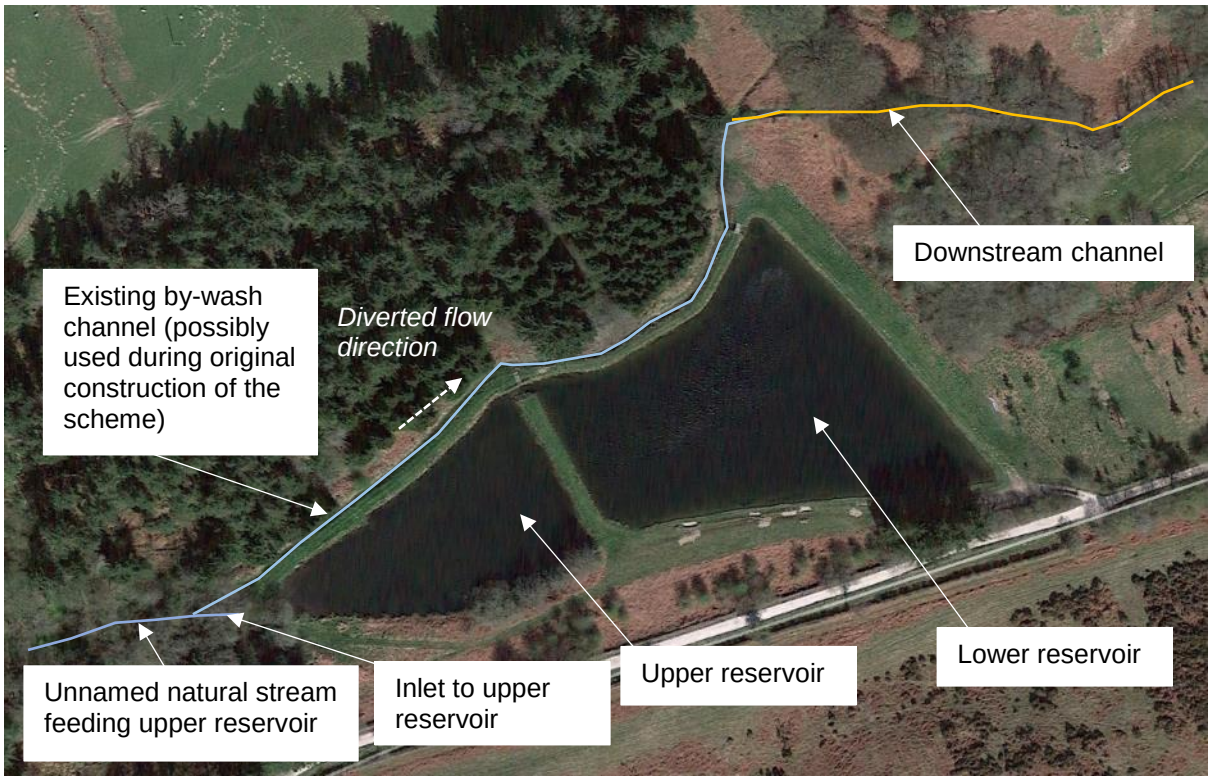


Figure 1: Existing by-wash channel that may be used to divert flows during construction

8. Managing Silt

DCWW commissioned NHTB Consultancy Limited to carry out a bathymetric survey of the reservoir, picking up both the hard and soft bed levels, i.e. determining how much silt is present in the reservoir (see **Appendix 3**). The results showed that there is currently 1,062m^3 and 657m^3 of silt within the

upper and lower reservoir respectively (approximately 7% of the total retained volume). Managing this amount of silt is not considered to be significantly challenging or costly.

It is anticipated that the silt would be dredged and placed within the reservoir site on either side of the natural stream to be excavated through the middle of the reservoirs. Berms consisting of fill material excavated from the main embankment would be placed on either side of the natural stream to retain the excavated silt. Gravel and geotextile lined low-level drainage notches would be constructed at regular intervals through the berms to de-water and consolidate the silt.

The following measures may need to be considered as part of the design for the discontinuance option:

- Silt clearance from natural watercourse;
- Re-vegetation of bankside areas;
- Temporary or permanent measures to retain silt, including:
  - Sediment traps with lowered bed levels;
  - Sediment traps using small raised structures;
  - Detention basins.

9. Access

Refer to **Appendix 1** for existing access conditions and anticipated construction access arrangements.

Temporary access will be required for discontinuance works. The arrangement should be determined by the proposed contractor to suit their choice of plant required for carrying out the permanent works.

10. Amenity, Landscape and Biodiversity

Amenity

The existing amenity value of the impounded body of water will be lost under this option. However, under this option the river (Nant Gain) is allowed to return to its original course and it is proposed that the reservoir basin area is rehabilitated and seeded in order to return it to the natural flora of the surrounding area. The amenity value of the river is retained and with minor works the remaining dam structure and notch can be made to look aesthetically pleasing.

Works are required to ensure that the remaining dam structure is made sufficiently safe: see section 13 below.

Landscape

The removal of a full-height notch which is at least 10m wide at the bottom with 1:3 (V:H) sloping sides cut into the existing embankment will leave approximately 20m length of embankment dam to the left of the notch and approximately 20m to right of the notch. The maximum height of the retained sections of embankment would be approximately 6 - 8m, reducing to zero height where the structure meets ground level at the abutments, visible from both upstream and downstream. Overall the most notable landscape change will be the disappearance of the reservoir footprint, with the river returning river to its pre-reservoir state and still providing a valuable landscape feature.

Biodiversity: potential impacts and mitigation

A Preliminary Ecological Appraisal (PEA) has been carried out by Ricardo Energy & Environment, with a final report submitted to Stillwater Associates Limited on 14th March 2019. The report is included in **Appendix 5**.

The report states that: *'The site and its adjacent habitats are of ecological value and adverse ecological impacts are anticipated if the works are to take place in the absence of mitigation. The scheme proposals have the potential to impact on a European designated site, National designated site, SINC, and notable and protected species such as bats, reptiles, notable plants, breeding birds, fish, water vole and otter.'*

In order to determine the potential for impact in greater detail, and to develop an appropriate mitigation strategy, the PEA report advises that further desk top assessments and/or surveys should be undertaken, to be defined and carried out in consultation with the relevant statutory consultees. The recommended consultations are summarised in Table 3 and the anticipated further assessments or surveys and possible mitigations are summarised in Table 4.

Table 3: Recommended consultations to inform ecological surveys, assessments and mitigation strategy

Designation	Consultee
The Alyn Valley Woods / Coedwigoedd Dyffryn Alun Special Area of Conservation (SAC) [European Designated Site]	Natural Resources Wales
The Alyn Valley Woods and Alyn Gorge Caves Site of Special Scientific Interest (SSSI) [National Designated Site]	Natural Resources Wales
Clwydian Hills (Moel Dywyll to Moel Famau) (Adopted) Sites of Importance for Nature Conservation (SINCs)	Flintshire County Council

Table 4: Recommended assessments or surveys, licences, and possible mitigation measures

Potential feature for which assessment or survey required	Relevant Licences	Possible Mitigation Measures, to be determined in consultation with relevant consultee and following further assessments or surveys
Local sites	None stated as being required	• The access route should avoid impacts to adjacent root protection zones of trees associated with the ancient woodland.
Notable Habitats	None stated as being required	• Measures should be taken to minimise impacts to these habitats.
Bats	Development Licence (European Protected Species Mitigation Licence) from NRW	• Soft demolition of the buildings under licence and in the presence of a licenced bat worker. • No night time working.
Breeding, nesting and wintering birds	None stated as being required	• Avoidance of the breeding bird season (March-August inclusive). If this cannot be avoided a pre-clearance survey should be completed within 24 hours prior to any work taking place. • Measures to minimise disturbance to wintering birds (October to February inclusive).
Badgers	None stated as being required	• Implementation of Risk Assessments and Method Statements (RAMs) during construction may be required e.g. position mammal ramps in deep excavations left open overnight or leave a sloping end in trenches to allow trapped animals to escape. • Undertake a pre-works check to identify any new setts created since the survey.
Dormouse	Development Licence (NRW)	• Fingertip searches of vegetation and sequential directional vegetation clearance starting at the location of the works and working towards suitable connecting habitat, undertaken in late autumn when the risk of dependent juveniles being present is low and dormice may move into adjacent habitat.
Reptiles	None stated as being required	• Implementation of RAMs during construction. • The area will then need to be hand-searched by an ecologist for any remaining reptiles hidden in low-lying vegetation and soil crevices. • Following this, the vegetation can be cut to ground level and soil can be carefully and slowly striped under an ecologist's supervision, allowing any remaining reptiles to become visible for translocation to an alternative suitable location. • All felled and cleared material will be moved out of the working area at the end of each day.

Potential feature for which assessment or survey required	Relevant Licences	Possible Mitigation Measures, to be determined in consultation with relevant consultee and following further assessments or surveys
		• Any works that involve dismantling log-piles would ideally need to be undertaken outside of the reptile hibernation period, which lasts from October to March, inclusive.
Great crested newts	Development Licence (NRW)	• Fencing, trapping and re-locating GCN out of the works area • Destructive searches of any suitable habitat, refuge or hibernacula by an ecologist
Fish	None stated as being required	• Netting may be required to remove the fish and relocate them to a receptor site, which should be identified prior to works.
Otters	Development Licence (NRW)	• Avoid night-time working.

General considerations for the implementation of mitigation measures are to avoid night-time working, adhere to best practice pollution prevention measures, and to use best practice biosecurity procedures at all times.

Biodiversity: enhancement opportunities

The PEA also identifies potential enhancement opportunities that could be considered in conjunction with the discontinuance option. The examples stated are:

- Erection of bird and bat boxes on semi-mature or mature trees on site.
- Incorporation of gravelly substrate at headwaters of outflow stream to provide trout spawning habitat.
- Localised riparian scrub planting to provide resting opportunities for otter.
- Improvements to fish passage.

11. Archaeology and Heritage

A detailed archaeological assessment was commissioned for Cilcain Reservoirs 1 & 2 and the proposed construction access route. The full assessment is given in **Appendix 6**.

The assessment states: *'The archaeological assessment noted that there are 19 features within a 1km radius of the reservoir, two of which date to the Bronze Age, one Roman, one medieval with the rest all of post-medieval date. These indicate a landscape significantly exploited from the prehistoric through to modern times. Only one of these, Greenland House (Feature 14) is within close proximity of the study area. The ruins of the house are set back within the trees and are therefore unlikely to be adversely affected by any discontinuance work at Cilcain…'.*

Therefore, for the discontinuance option there is unlikely to be any adverse impacts in terms of archaeology, and no requirement for an archaeological watching brief.

12. Safety

The following safety improvements are suggested:

- Add signage at each abutment:

  'No Public Access – Danger – Sheer Drop – Danger of Death' (in Welsh and English).

13. Planning and Consents

The works required to discontinue the reservoir are considered to be significant and would have a major visual impact on the site. It is considered possible that planning permission would be required.

- The planning authority is likely to consider the following matters: Change to landscape by removing the footprint of the reservoir;
- Ecology and biodiversity impacts;
- Archaeology;
- Confirmation of negligible change in downstream flood risk.

The presence of a nearby Special Area of Conservation (SAC), Site of Special Scientific Interest (SSSI) and Sites of Importance for Nature Conservation (SINCs) suggest that other third party consents may also be required.

14. Monitoring and Maintenance Requirements

Once discontinued Cilcain Reservoirs 1 & 2 will no longer require any formal supervision or inspections under the Reservoirs Act 1975. However, under this discontinuance option there will be retained sections of the embankment which will require monitoring, and, in time, some maintenance to ensure their integrity and long-term safety.

Suggested monitoring/ surveillance regime and anticipated routine maintenance requirements are summarised in Table 5 and Table 6 respectively.

Table 5: Summary of suggested monitoring/ surveillance for Cilcain No. 2 dam under discontinuance Option 2

Element	Observations	Frequency
Reservoir Level	Not required.	
Drainage and leakage flows	Not required.	
Dam embankment	Walk-over consisting of a visual check of all areas of the retained dam embankment (movement, cracks, settlement), including the abutment and toe areas.	Annually
Overflow	Check that the outlet (10m wide opening and low flow notch) are free of debris and operating as designed.	At every visit
Valves/ Pipework	Not required.	
Fence, Handrailing and Signage	Visual check observing for any damage to fences, handrails and signs.	At every visit
Topographic Survey	Not required.	

Table 6: Summary of routine maintenance for Cilcain No. 2 dam under discontinuance Option 2

Maintenance Task	Frequency
Carry out general maintenance as advised by the Supervising Engineer.	Not applicable
Maintain the condition of pipe work/ metal work and valves, including appropriate preparation (rust removal) and painting/coating.	
Control or eliminate burrowing animals.	Not required
Grass cutting and clearance/ cutting back of vegetation on downstream side of dam, maintaining an approximate 2m distance from the toe of the dam and mitres.	

Maintenance Task	Frequency
Remove vegetation, including pulling of saplings and woody vegetation, from all areas of the dam and outlet/overflow structure.	As and when required to maintain integrity of retained structure and ensure that the notch is kept clear of any obstruction to flow
Repair and maintain signage, handrails (including appropriate preparation and painting/coating) and fences.	As and when required
Repair or filling in of any sheep scrapes or rodent/ burrowing animal holes.	Not required
Operational valve testing, alternating between partial and full tests.	Not applicable

15. High-level Cost Estimation

A high-level costing exercise has been undertaken for each option based on the currently available information and the perceived activities required to deliver each option. The costings have been prepared using data from previously delivered schemes involving equivalent activities as well as industry standard rates for civil engineering projects, with an overall range of the anticipated project cost presented.

Engineering Works

Where appropriate specialist engineering contractors have been approached for advice and budget cost estimates to provide confidence in the overall costings.

Environmental Works

Costs associated with further ecology assessments and surveys, and indicative costs for implementing mitigation measures have been prepared by Ricardo Energy & Environment.

Opportunities for enhancement works have also been identified. These works would be in addition to ecology mitigation and are not required to fulfil the objective of the discontinuance option. Therefore, the costs for potential enhancement works have been excluded in the overall costing for the option.

For the discontinuance options an allowance has been made for managing silt within the permanent works based on the outputs of the bathymetric survey that was commissioned as part of this study.

Future Operation and Maintenance

Future operational costs have been estimated to provide a 'whole-life' project cost over a 40-year timeframe. The future operational costs for this option are expected to be estate costs (maintaining safety and boundaries) only.

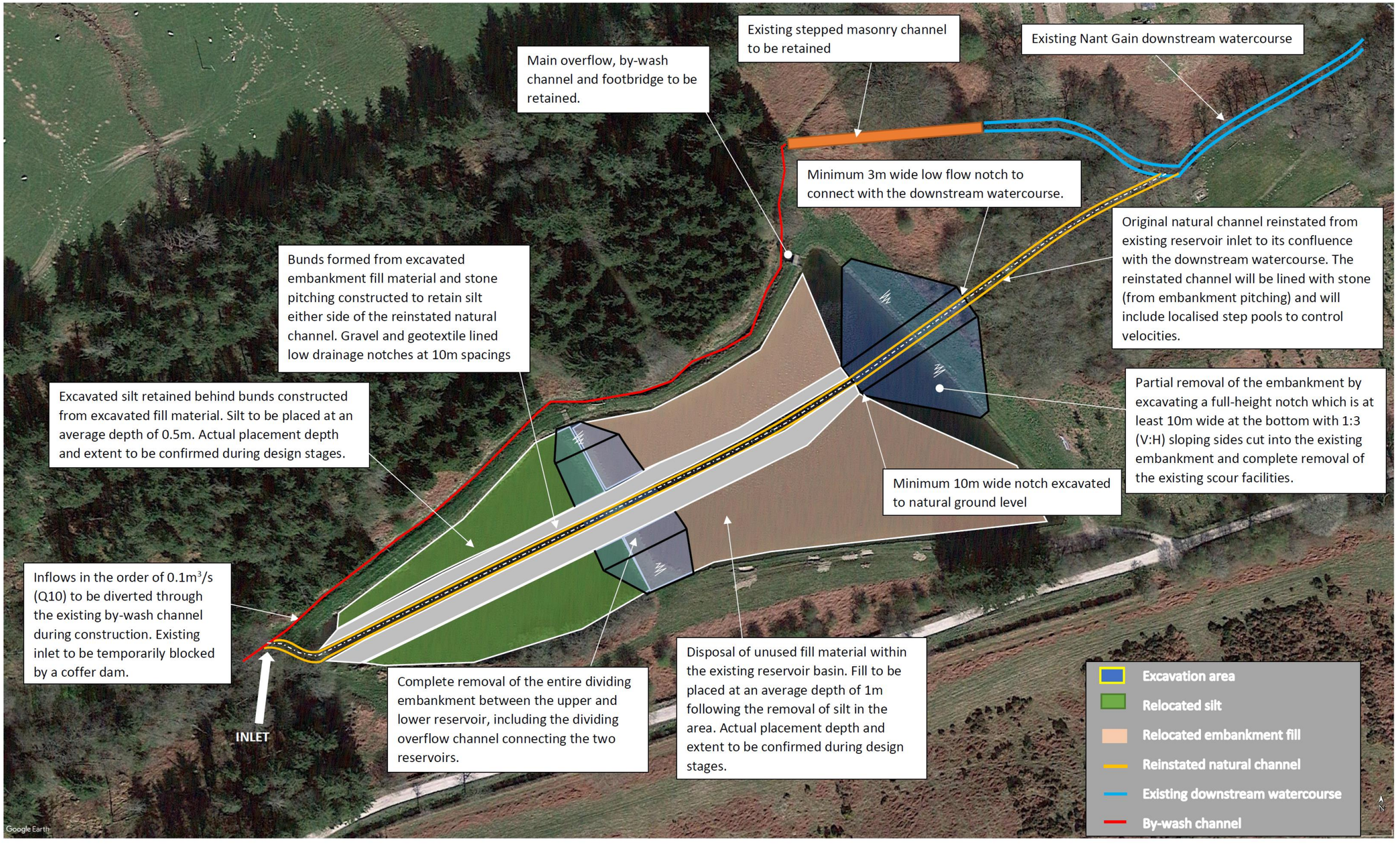
An estimated range of the overall project cost along with the estimated 40-year 'whole life' scheme cost is given in Table 7 below.

Table 7: Cost Estimate for Option 2: Discontinuance

Item	**Item Cost[1]**	**Total Cost (*DCWW Cost Range*)**
Studies & Investigations[2]	£35,000	**£1,070,000 (*£1m – £2m*)**
Design (incl. construction management)	£180,000	
Construction (incl. mitigation)[3]&[4]	£840,000	
Operational and maintenance costs over 40 years[5]	£15,000	

Notes:

1. *All values are estimated high-level costs.*
2. *Includes ecology assessment and surveys costs supplied by Ricardo Energy & Environment.*
3. *Includes ecology mitigation costs supplied by Ricardo Energy & Environment.*
4. *Includes 50% optimism bias.*
5. *Assumes ownership of the asset remains with DCWW.*



Notes:

1. *Not to scale.*
2. *The excavated embankment material can be relocated or re-used within the reservoir basin.*
3. *Extents of cut and fill to be determined following site investigations.*
4. *New safety signage to be placed at each abutment.*

Stillwater Associates
Reservoir Safety & Water Consultancy

Dŵr Cymru Welsh Water

Client:	Dŵr Cymru Welsh Water
Project:	Discontinuance Feasibility Assessment
Drawing title:	Cilcain Reservoirs 1 & 2 Discontinuance Option 2
Drawing number:	Figure 2
Date:	April 2019

Figure 2: Cilcain Reservoirs 1 & 2 discontinuance Option 2