Appendix:	8.2 – Engineering Options **Option 2: Full Reservoir Discontinuance**
Reservoir name:	Brithdir Mawr Reservoir

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 - the partial removal of the 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.

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

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

- It was found that the benefit that complete removal of the embankment and appurtenant structures would give by reducing the visual impact to what it was before the presence of the reservoir would require a substantially larger amount of work and costs to achieve.
- It is considered that the benefits of **Sub-Option 2B** would be disproportionate to the resulting cost of the works.

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 embankment. It is proposed that the notch width at ground level is no less than 10m wide to allow for fallen 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. To allow the natural stream to follow its original path towards the downstream watercourse, the centreline of the excavated notch would need to align with the original stream alignment. This may require excavation into the existing right abutment and complete removal of the existing masonry overflow, although the ground conditions at the site may show that the notch excavation can follow the existing ground level at a steeper slope and potentially avoid the removal of the masonry overflow structure. Placing the notch location in line with the original stream would mean that the removal of the existing culvert through the embankment could be avoided. The existing auxiliary overflow structure will be retained for this option.

In addition to the main notch opening a low flow notch channel would be created within the main notch 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.

See Figure 1 for a sketch of the proposed Option 2.

3. Residual Dam Structure: Stability

During detailed design, proper material tests should be carried out in order to determine the properties of the embankment fill and to ascertain the founding conditions. The notch side slopes should then be properly designed to ensure that they will be stable.

The foreseeable loading scenarios, with greatly reduced upstream water depths, would be expected to be less onerous on the retained sections of embankment compared to the existing loadings on the embankment when fully impounding. Furthermore, the existing leakage problem at the dam is expected to disappear as water will not be impounded and it is not anticipated that leakage would continue and pose a risk to the retained sections of the wall.

No further investigations or stability checks are proposed for this option.

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 indicates that there is a risk of flooding to the road crossing and adjacent properties (postcode: CH7 5SE) some 1.1km downstream of the dam during extreme flood events.

The existing reservoir provides negligible flood attenuation for all floods considered (see flood routing details in **Appendix 4)**. 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 all valves and pipework, including those associated with the existing scour outlet and the draw-off works, be removed as part of the discontinuance works.

7. Managing Reservoir Water Levels During Construction

Use of Existing Facilities

The existing 250mm diameter scour pipe running through a tunnel in the embankment could be used to lower the reservoir initially. A high-level drawdown capacity estimate of the existing scour facility in relation to reservoir inflows indicates that this approach will be achievable and if that is the case, initial drawdown could be achieved without the use of mobile equipment such as pumps and siphons.

Use of Mobile Equipment

The existing scour facility is operated regularly and therefore it is unlikely that it will be inoperable during the works. However, as a fail-safe, if the scour main proves to be inoperable 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 at the upstream end (pass through flows);
- The amount the reservoir is required to be lowered by (lowering rate).

It may be necessary to supplement the drawdown with temporary equipment to achieve the required drawdown depth, depending on the exact level of the scour pipe inlet.

a) Pumps

Pumps will provide a good solution for drawing down the reservoir 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 i.e. 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 reservoir and to draw down the reservoir.

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 are 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 below is a high-level indication of the order of capacity that might be required to initially draw down the reservoir by using mobile equipment, in the event that the existing scour pipe was not operational. 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 agree with the QCE for the discontinuance 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
Q_{50} inflow[1]	l/s	22	Assessment of inflows carried out for this study
	m^3 / day	1,900	
Area of reservoir, a	ha	0.7	Flood Assessment (**Appendix 4**)
Suggested target rate, D_i	mm /day	300	This can be changed depending on the requirements of the scheme
Volume to be evacuated based on target rate, V	m^3 / day	4,000	Q_{50} (m^3/day) + 10 x a x D_i
Pumps			

Item	Units	Value	Source / Comment
Recommended number of 80mm diesel pumps (Assuming 27 l/sec delivery per pump at 8m head).	nr	2 [4,665 m^3/day]	GP80 from Sykes Pumps
Recommended number of 50mm diesel pumps (Assuming 15 l/sec delivery per pump at 8m head).	nr	4 [5,184m^3/day]	GP50 from Sykes Pumps
Siphon Pipes			
Estimated nr. of 150mm dia. siphon pipes, assuming 40m pipe length.	nr	2 [4,916m^3/day]	High-level hand calculation for siphon discharge
Notes: *1. Appropriate inflow pass-through allowance – refer to Section 5.2 of the "Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning" (Environment Agency, 2017).*			

Once the reservoir level has been sufficiently drawn down to safely carry out discontinuance works, the incoming flows would have to be diverted, most likely by gravity pipes. An indicative capacity calculation has been provided below in Table 3 to demonstrate the typical arrangement of pipes or pumps that would be required to pass the Q_{10} inflow with the reservoir already draw down to the desired level. It should be noted that there are two separate inlets to the reservoir and any pipes or pumps should be located at each of these inlets to divert incoming flows.

Table 3: Indicative flow diversion (over-pumping) requirements during discontinuance works

Item	Units	Value	Source / Comment
Q_{10} inflow	l/s	80	Assessment of the combined inflows from the two inlet streams carried out for this study
	m^3 / day	6,912	
Volume to be evacuated based oninflows, V	m^3 / day	6,912	As above
Recommended number of 100mm PVC pipes to divert inflows by gravity (Assuming 0.026 m^3/s per pipe at 7m head and total length of 80m)	nr	4 [9,216m^3/day]	Hazen-Williams formula for a full pipe
Recommended number of 150mm diesel pumps (Assuming 64 l/sec delivery per pump at 8m head).	nr	2 [11,060m^3/day]	GP150M from Sykes Pumps
Recommended number of 100mm diesel pumps (Assuming 37 l/sec delivery per pump at 8m head).	nr	3 [9,590 m^3/day]	GP100 from Sykes Pumps

8. Managing Silt

Stillwater Associates Limited commissioned NHTB 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 824m^3 of silt within the reservoir (approximately 4% 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 reservoir. Berms consisting of compacted 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 the discontinuance works. The arrangements for such an access track should be determined by the proposed contractor to suit their choice of accessing the site with materials and equipment, but as a minimum, the following works are envisaged:

- Vegetation and topsoil layer to be stripped and set aside for future re-use.
- Installation of suitable temporary track surface (geotextile / granular fill, bogmats or proprietary trackway system).
- The access tracks will need to be completely removed on completion of the works and the area returned to its pre-scheme condition.

It is envisaged that vehicle access to the location of the site will only be required for major construction interventions. No permanent vehicle access other than by 4 x 4 vehicle is envisaged and no additional works are proposed in this respect.

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 (Aber Eilun) is allowed to return to its original course and it is proposed that the reservoir basin area is rehabilitated and seeded in order to allow the natural flora of the surrounding area to establish here. 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 12 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 section of the dam will leave approximately 30m length of the embankment dam to the left of the notch looking downstream. The maximum height of the retained sections of the embankment would be approximately 10m, reducing to zero height where the structure meets ground level at the bottom of the notch, and would be visible from both upstream and downstream. Overall the most notable landscape change will be the disappearance of the reservoir footprint and the old masonry overflow on the right side of the embankment, 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 reservoir 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 and National designated site, and notable and protected species, such as bats, breeding and wintering birds, reptiles, great crested newt, water vole, otter, dormouse and fish.'*

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 4 and the anticipated further assessments or surveys and possible mitigations are summarised in Table 5.

Table 4: 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

Table 5: 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
Notable habitats	None stated as being required	• Measures to minimise impacts to the broad-leaved woodland, standing open water and semi-improved grassland habitats. • Habitat restoration may be required following works.
Notable invertebrates / assemblages	None stated as being required	• Tracking plant on the drained down area, rather than the bankside habitat, minimise access routes, storage of materials/plant/compounds in non-sensitive areas. • Any impacts should be off-set with enhancements such as re-planting with species of local provenance and suitable food plants.
Bats	Development Licence (European Protected Species Mitigation Licence) from NRW	• Soft demolition of buildings [or retain buildings] with licensed bat worker present; • 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).
Badger	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.
Reptiles	None stated as being required	• Implementation of RAMs during construction. • The area will need to be hand-searched by an ecologist for any remaining reptiles hidden in low-lying vegetation and soil crevices.

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
		• 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. • 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
Otters	Development Licence (NRW)	• Avoid night-time working. • Best practice biosecurity procedures should be implemented as standard when undertaking the works.
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 (during late autumn).
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.

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 trees.
- Localised riparian scrub planting to provide resting opportunities for otter.
- Landscaping of the reservoir banks and planting of native marginal and aquatic vegetation of local provenance.
- Improvements to fish passage.

11. Archaeology and Heritage

A detailed archaeological assessment was commissioned for Brithdir Mawr reservoir and the proposed construction access route. The full assessment is given in **Appendix 6**.

The assessment states: *'Whilst the potential for the identification of further archaeological remains in the wider area remains high, neither these or any of the sites listed in the gazetteer should be affected by the reservoir discontinuance works as the works only affect the footprint of the reservoir itself where the ground is likely to have been heavily disturbed.'*

Therefore, for the discontinuance option there would be no 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) and Site of Special Scientific Interest (SSSI) suggest that other third party consents may also be required.

14. Monitoring and Maintenance Requirements

Once discontinued Brithdir Mawr Reservoir 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 and other concrete structures such as the auxiliary overflow 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 6 and Table 7 respectively.

Table 6: Summary of suggested monitoring/ surveillance for Brithdir Mawr dam under discontinuance Option 2

Element	Observations	Frequency
Reservoir Level	Not required.	
Drainage and leakage flows	Not required.	
Dam wall	Walk-over consisting of a visual check of the all areas of the retained embankment (movement, cracks, settlement), including the abutment and toe areas.	Annually
Overflow	Check the condition of the concrete overflow (cracks, movement, deterioration). Check that the outlet notch and channel (10m wide opening and low flow notch) are free of debris and operating as designed.	Annually
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 7: Summary of routine maintenance for Brithdir Mawr 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.	
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.

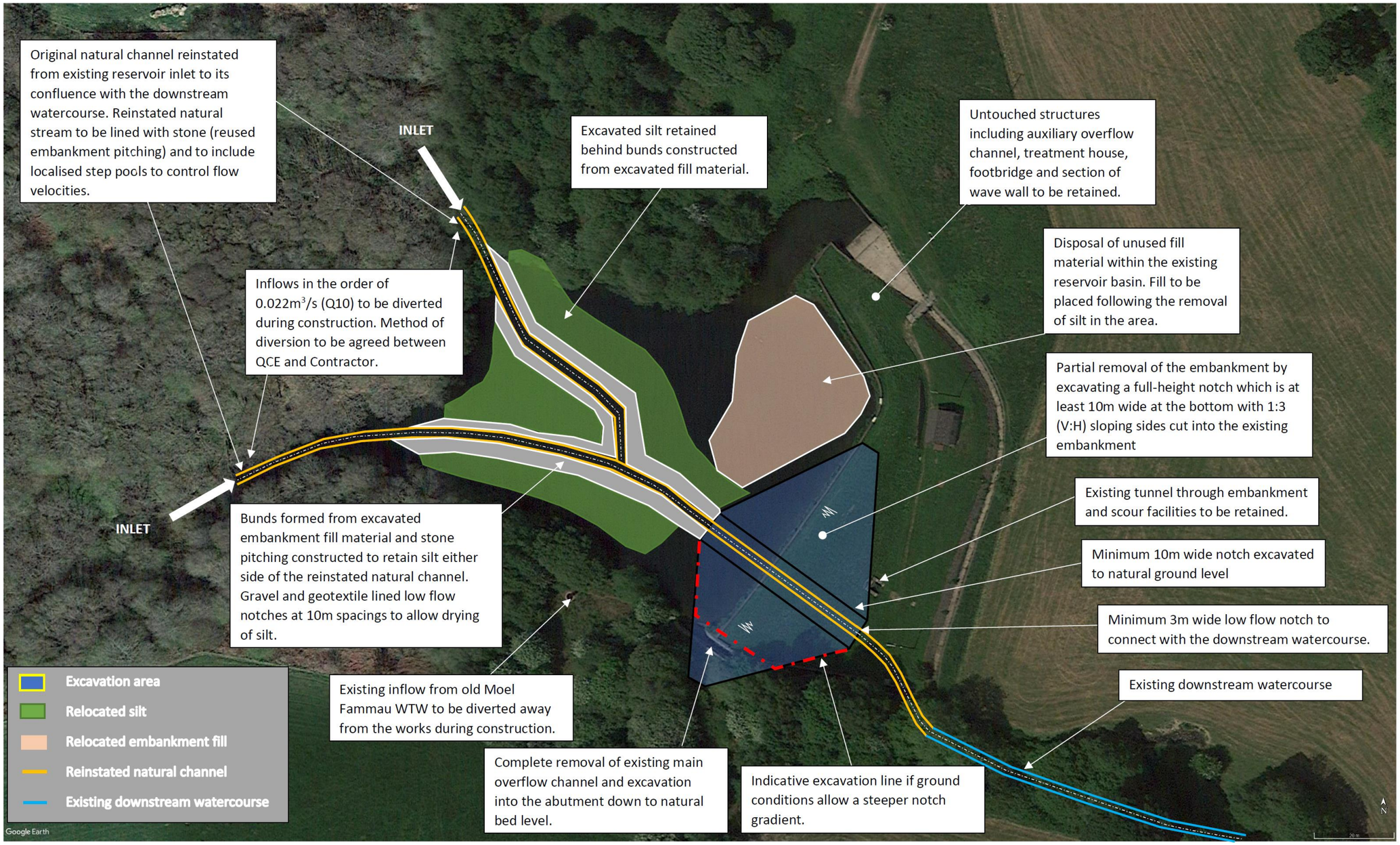
An estimated range of the overall project cost along with the estimated 40-year 'whole life' scheme cost is given in Table 8 below.

Table 8: Cost Estimate for Option 2: Discontinuance

Item	**Item Cost[1]**	**Total Cost (*DCWW Cost Range*)**
Studies & Investigations[2]	£50,000	**£1,045,000 (*£1m - £2m*)**
Design (incl. construction management)	£170,000	
Construction (incl. mitigation)[3]&[4]	£810,000	
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. *Concrete arisings to be broken up on site and carted away for off-site disposal.*
5. *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:	Brithdir Mawr Reservoir Discontinuance Option 2
Drawing number:	Figure 1
Date:	April 2019

Figure 1: Brithdir Mawr Reservoir discontinuance Option 2