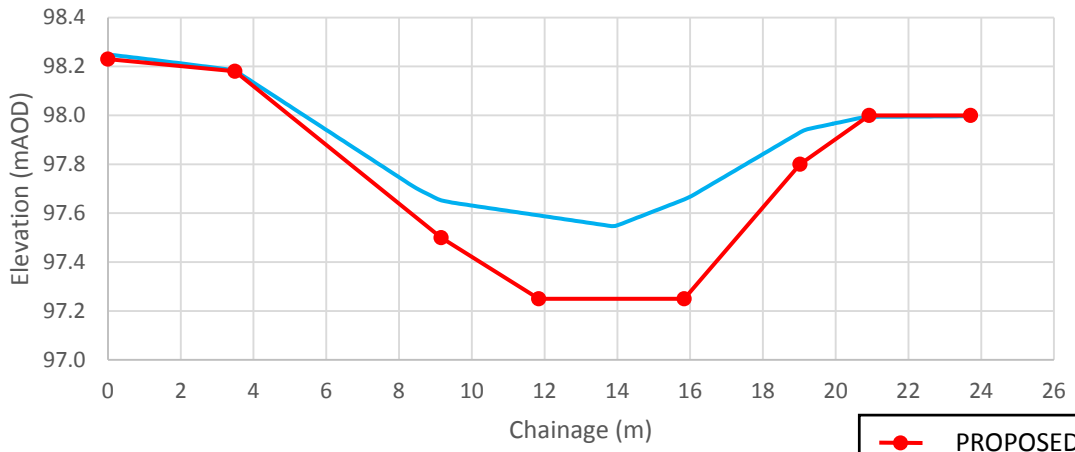
Crummock Water Weir Removal and River Cocker and Restoration Bed Level Information

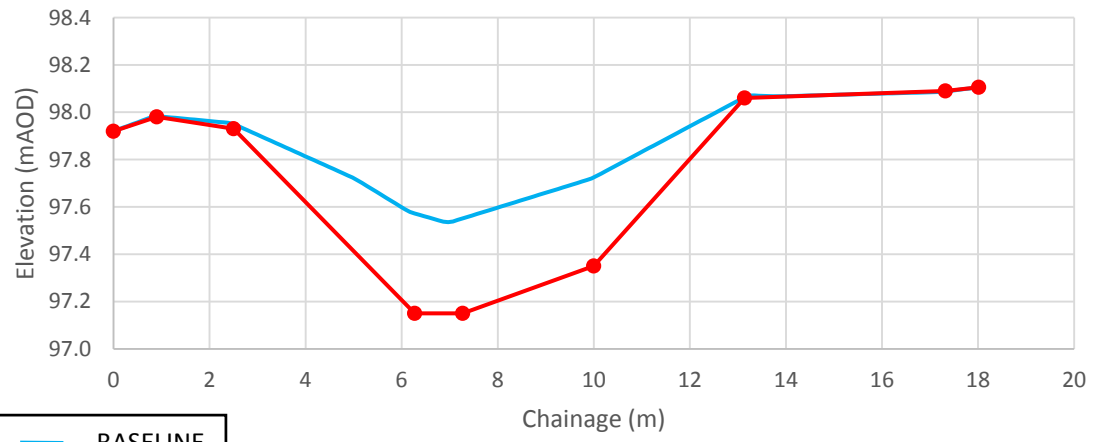
Outflow Design

- Bed levels restored to reflect natural levels at outfall. The blue line (baseline, bathymetric survey 2020) shows the sediment that has accumulated within Crummock Water behind the weir structure.
- At these cross sections there is approximately 300mm deepening (compared to the baseline). The red line is the proposed channel cross section (broadly reflecting natural, pre-weir, bed levels).
- Western channel at a higher bed elevation (+100 mm) than eastern channel. Eastern channel will act as the primary outlet channel.
- Eastern channel will also act as the low flow channel to retain flows during drier conditions
- Downstream channel remains unaltered

RC_01 (RIVER COCKER - WESTERN CHANNEL)

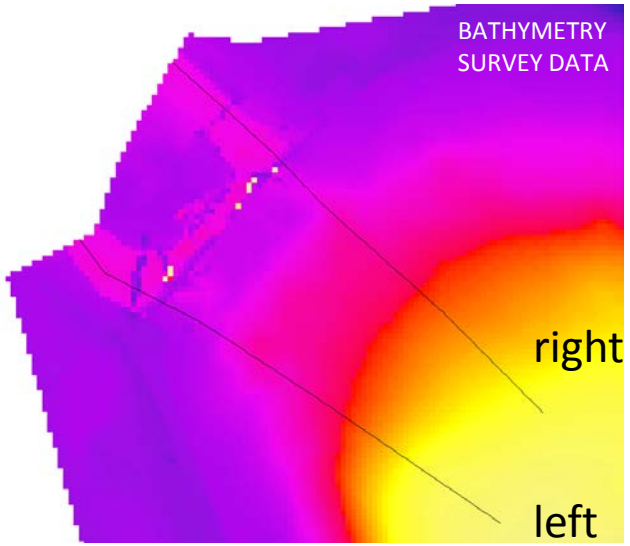


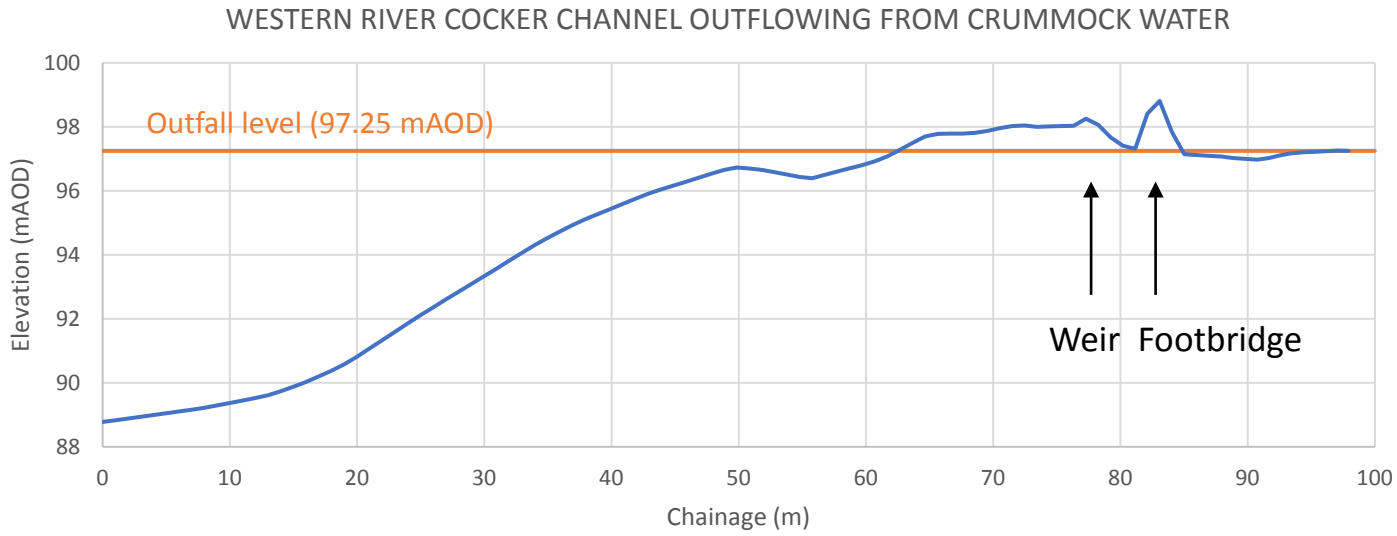
RC_06 (RIVER COCKER – EASTERN CHANNEL)

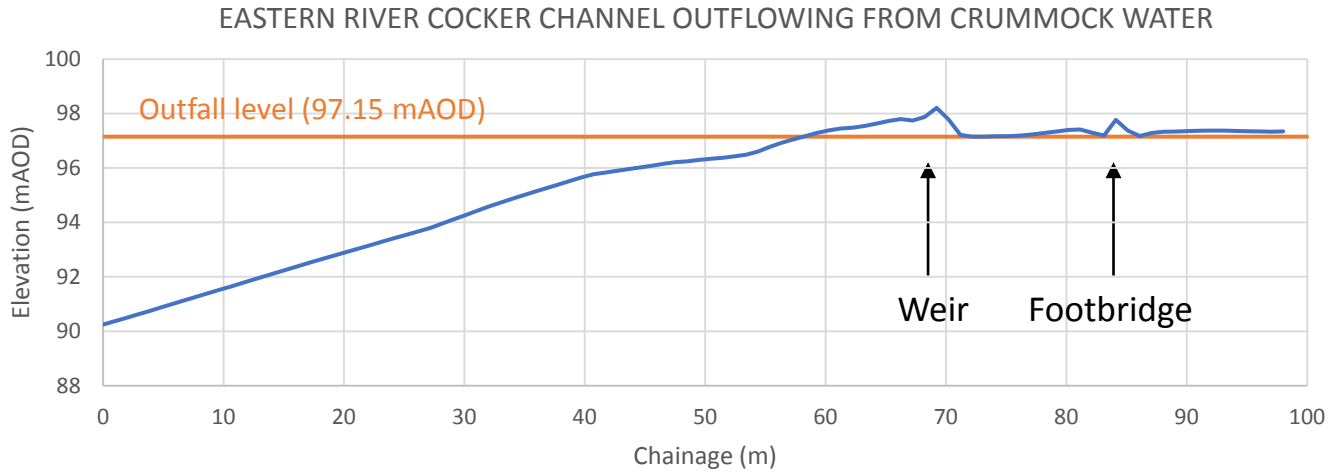


PROPOSED BASELINE

Crummock Water Bathymetry





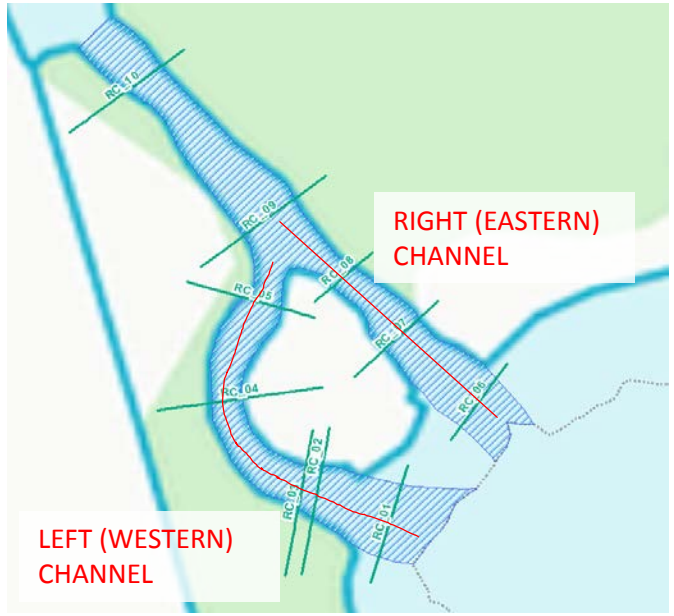


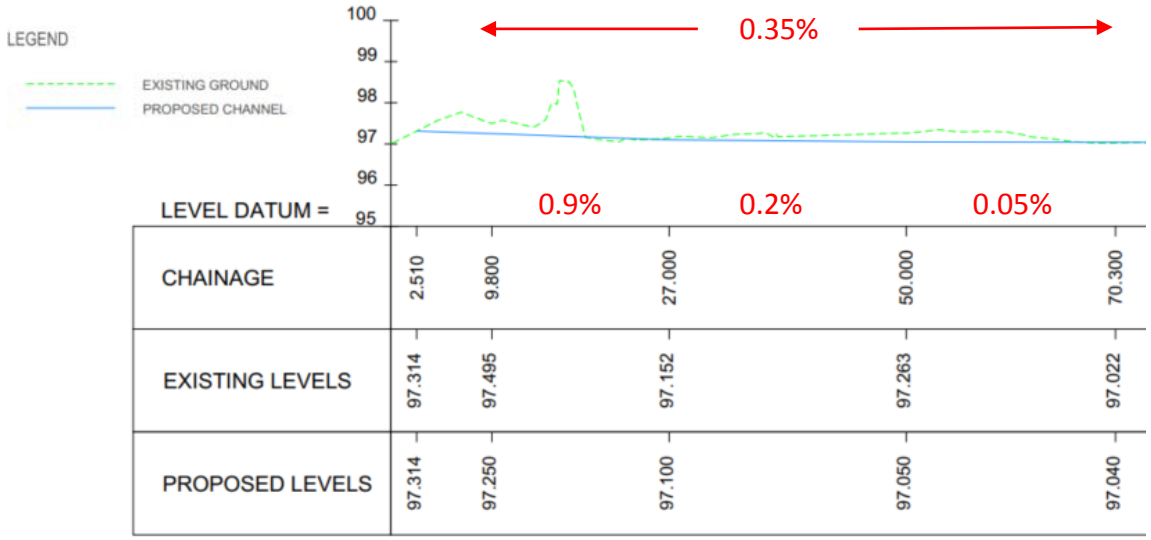
PROPOSED OUTFALL LEVEL

CRUMMOCK WATER / RIVER COCKER BED AND STRUCTURE LEVELS

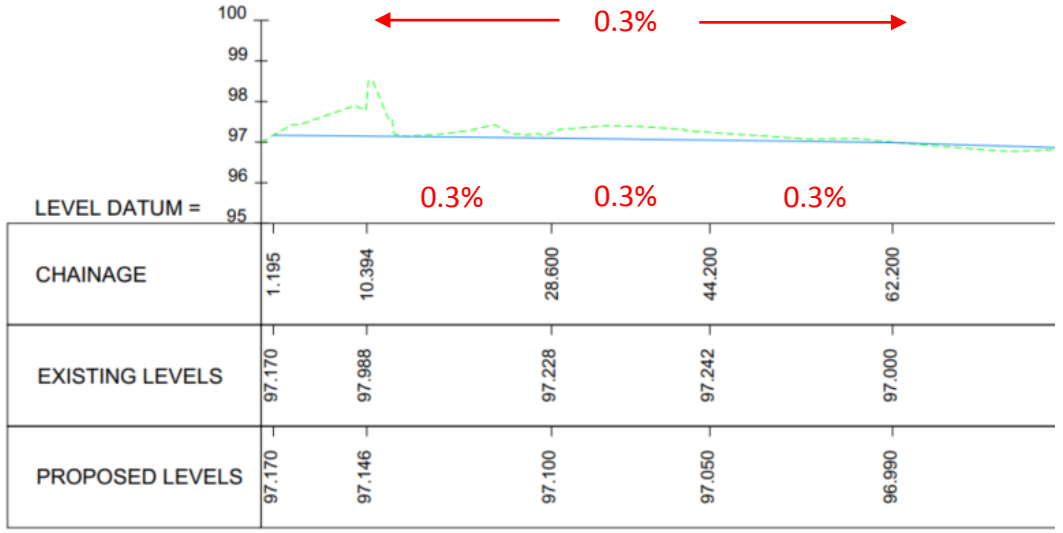
River Cocker Bed Level

- Long profile of the River Cocker downstream of the weir shows the gradient to be fairly flat.
- The average gradient of the right (eastern) channel is a consistent 0.3%. The outlet level is proposed to be 97.15 mAOD (i.e. the level of the existing lower sluice gate).
- The average bed gradient of the left (western) channel is 0.35% with the upstream proposed to be higher than average at 0.9%. The outlet of the left (western) channel will be set at 97.25 mAOD, 100 mm above the right (eastern) channel.





WESTERN CHANNEL – RIVER COCKER (LONG-SECTION)



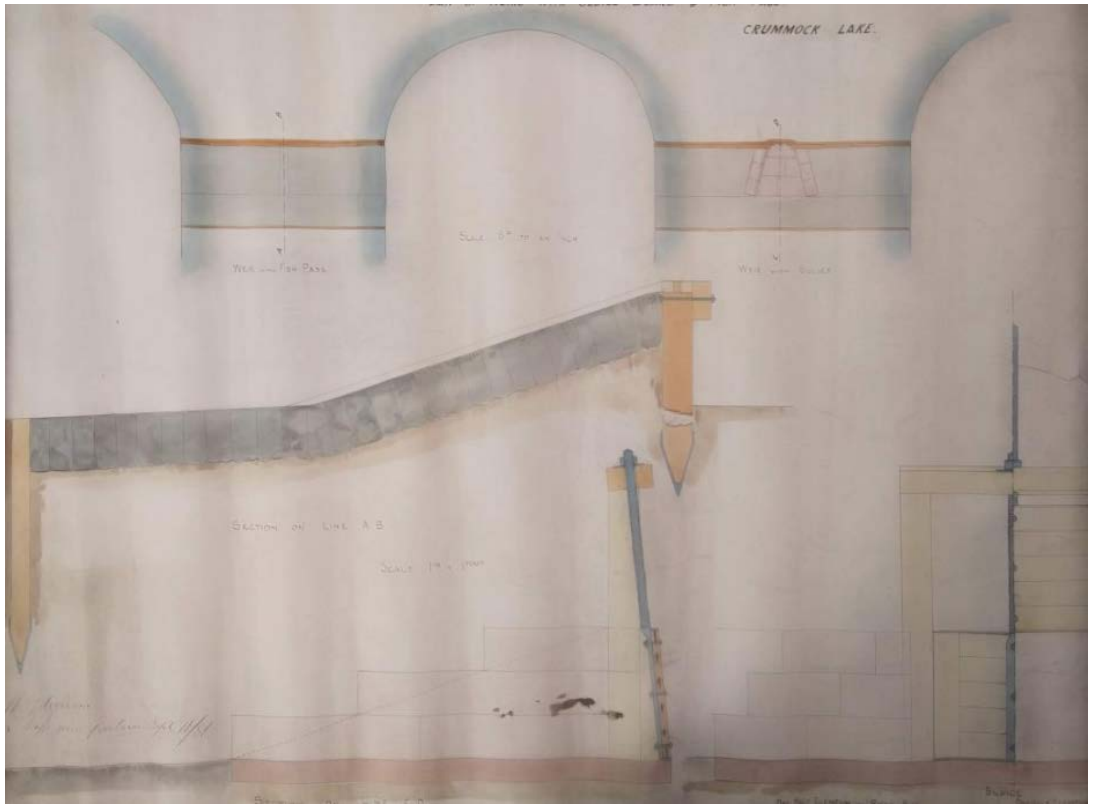
EASTERN CHANNEL – RIVER COCKER (LONG-SECTION)

Crummock Water – Weir Modifications

Scheme	Date	Weir elevation	Notes
1. Timber weir *(since removed)*	1879	97.91 mAOD (estimated)	Wooden weir with fish pass and sluice gate. Weir is holding the average winter water level throughout the whole year. Measured water level of 97.96 mAOD in June 1895.
2. Masonry weir	1899-1903	98.52 mAOD	Larger stone weir raised lake levels by further 2 ft (0.6 m)
3. Repairs to weir *(current structure)*	1967-1969	98.52 mAOD	Crest level remains the same. Level of the lower sluice gate set at 97.15 mAOD.

Information provided from Jacobs Feasibility Report, 2020.

Crummock Water – Timber Weir



Images from D Hughes, 2022, PhD Newcastle University. Simulating and Visualising the Hydrological and Landscape Impacts of Reservoir Engineering at Crummock Water. Original source: J.B. Wilson, 1899 (left image), and Pickering and Crompton, 1881 (right image).

The photograph (left) demonstrates that the crest of the weir is higher than the bed level of the River Cocker downstream. The sketch (right) depicts the fish pass on the right side of the weir and the sluice gate on the left side of the weir

Crummock Water – Timber Weir

Images from D Hughes, 2022, PhD Newcastle University. Simulating and Visualising the Hydrological and Landscape Impacts of Reservoir Engineering at Crummock Water. Original sources: J.B. Wilson, 1899 western (left) weir/channel (left image), Park Beck outlet and shoreline (right image).

At high water levels the timber weir became submerged. This also happens with the existing weir at high flows.

The shoreline of Crummock Water is gravelly; the lake level will fluctuate with rainfall / tributary inflow as it did in the 19th century and as it does currently. Removal of the existing weir and re-profiling of the River Cocker channels will reduce the outflow potential, and the range of lake levels will fluctuate more widely. Hydraulic modelling suggests the peak water level will be up to 1.5 m higher for a Q100 flood event (1% annual exceedance probability; 1:100 year flood event), compared to approximately 1 m now but the flood level is at a lower elevation compared with existing.

Interpretation of historic documents and drawings

D Hughes, PhD, 2022

- On p.247, there is a suggestion that the timber weir (1879) was constructed in combination with a lowering of the River Cocker bed (see extract below). However, this is an interpretation and is not directly quoted from the original documents.
- It is the understanding of United Utilities and the designers the timber weir held up the winter water level all year around for abstraction purposes. This would have been higher than average summer water levels.
- The timber weir was low enough not to cause wider flooding on the surrounding land in winter and instead spilled over the weir crest down the River Cocker. The photograph of the timber weir (slide 6) shows the height difference between the bed of the River Cocker and the Lake water level (during drier conditions).
- The exact bed level prior to construction of the timber weir in 1879 is unknown.

> *Crummock Lake*' in 1874 (Pickering & Crompton, 1877). The engineers noted that '*the splendid natural reservoir of Crummock had advantages the other two schemes did not possess*', despite its lower elevation. They judged that it was '*not expedient to raise the surface of the Lake*' as this would submerge valuable land. Instead, they recommended that the bed of the River Cocker be lowered, '*a weir put across so as to keep up as nearly as possible the winter level of the lake; and self-regulating apparatus inserted in the weir, so as to insure* [sic] *a proper quantity of water being run down the river*'.

Interpretation of historic documents and drawings

Jacobs Feasibility Report, 2020

- A discussion is presented in the Jacobs Feasibility Report (pp.172-173) around the level required for discontinuance of Crummock Water.
- It was concluded by an All Reservoir Panel Engineer (ARPE) that the level of the base of the sluice gate (i.e. 97.15 mAOD) should be applied to the final river bed level at the Crummock Water outlet to satisfy the Reservoirs Act.
- The concluding remarks from the Jacobs Feasibility Report (p.173) are shown below. These are written from the perspective that the natural bed level was the same as the crest level of the timber weir (i.e. 97.91 mAOD). However, this value is the water level (holding the average winter water level), not the natural bed level.

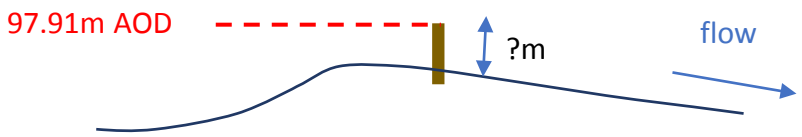
> From this it can be concluded that the level for discontinuance is the base of the trench for the outlet, which in the case of Crummock Water is the base of the sluice gate.
>
> From the information and discussions, whilst it would be possible to reinstate the original outlet level as recorded in 1879 prior to the timber weir being installed, this would not remove the Lake from the Reservoirs Act or remove United Utilities Duties as Undertaker for the lake as it would still be classed as being able to hold a body of water above the natural ground. In order to remove this obligation under the act the new natural lake outlet is required to be set at the level of the lower sluice gate (97.15m AOD) approximately 740mm lower than outlet level in 1879.

Discussions with QCE (2022)

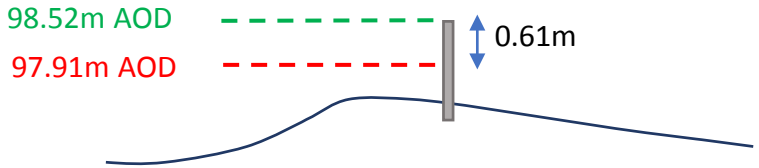
- United Utilities and the designers have been engaging with the Qualified Civil Engineer (QCE), appointed under the Reservoirs Act (1975). The QCE is a statutory role responsible for supervising and certifying the discontinuance of the reservoir.
- The Reservoirs Act contains requirements in order to allow reservoirs to be discontinued (i.e. removed from the Act). In this case, the water level in Crummock Water is required to be permanently lowered to be close to “natural ground level”.
- The QCE agrees in principle that it would be reasonable to adopt the existing bed level just downstream of the weir as “natural ground level” going forward. This level is 97.15 mAOD.
- The intention is to remove the entirety of the existing structure, including those parts that are below the bed level immediately downstream of the weir (and reinstate the bed), thus removing any doubt that an impoundment remains.
- Therefore, the level of any previous structures acting to impound water on Crummock Water is not pertinent to this decision-making process.
- This supersedes any previous advice.

Crummock Water – Weir History and Water Level Schematic

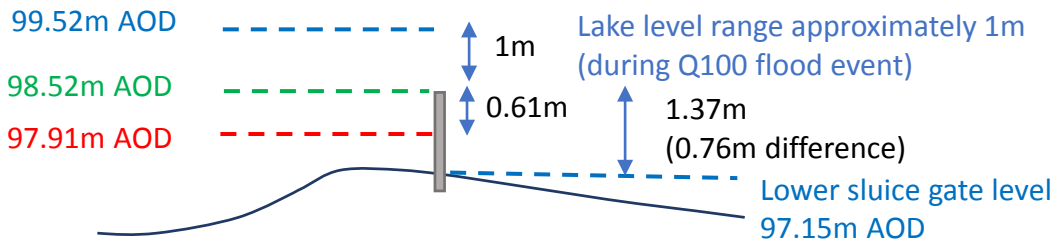
1. 1879 Timber weir to maintain average winter water level



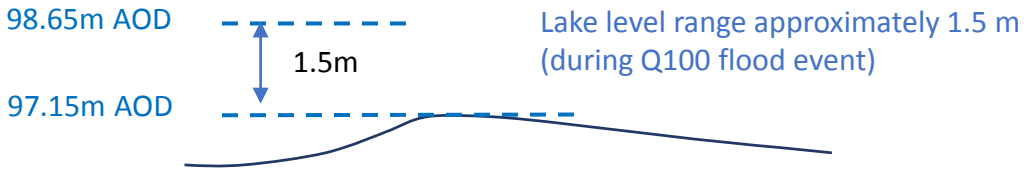
2. 1899-1903 Masonry impounding weir raising lake levels by approximately a further 2 ft (0.61 m)



3. 1967-current Repair work but crest level remains the same (98.52 mAOD)



4. 2026 restoration proposals



Summary

- Crummock Water has been impounded since 1879.
- The first (timber) weir (1879) was constructed to hold the **average winter water level** (approx. 97.91 mAOD). This held an elevated water level in the drier seasons so water could be abstracted from the lake all year around.
- A masonry weir was installed (1899-1903), raising the crest level by a further 0.61 m (2 ft) to 98.52 mAOD.
- Modifications to the masonry weir were made in the 1960s, but the weir crest remains at 98.52 mAOD today.
- Removal of the weir and associated infrastructure will **re-naturalise Crummock Water and the flow regime to the River Cocker.** The variation of flows down the River Cocker will be greater than currently exists, providing benefit to the ecology.
- The baseline average bed level for up to 70 m downstream of the River Cocker has been calculated at approx. 0.3% gradient. The proposed restored outflow level (97.15 mAOD) is compatible with the 0.3 % gradient. The western channel has a slightly higher bed level (and subsequently, bed gradient) at the upper end. This has been designed so that the eastern channel will preferentially flow during lower flow conditions.
- The removal of the weir will lead to a drop of the water level in Crummock Water by 1.37 m, but this is reflective of the natural bed level prior to the timber weir construction and meets the conditions required by the Reservoirs Act. However**, this new water level will fluctuate more widely** with rainfall and incoming tributary flow (up to 1.5m compared to 1m for Q100 today) but the **peak water level will still be lower than currently exists with the weir** all other factors being equal.
- The extent of the shoreline will vary with this water level fluctuation and more vegetation will develop on the upper shore where it is less frequently inundated (wetted). Shoreline planting will also be undertaken.