

Preliminary results of the trial of a new release regime at Kielder reservoir

Following the flooding that took place around Corbridge as a result of Storm Desmond in early December 2015, NWL were asked to provide additional flood storage capacity at Kielder Reservoir. At the same time the Environment Agency were keen to pursue the idea of variable releases to the river and the hydropower operator (innogy) wished to review operations in order to maximum generation ahead of plans to refurbish the main turbine in 2017.

Kielder reservoir has many important roles including river regulation for water supply, hydropower generation and as a tourist attraction. As such any amendments to the operation of the reservoir should not impact on Kielder's ability to support these activities. The three stakeholders (NWL, innogy and the Environment Agency) worked together to build a **new operating regime** for the hydroelectric plant at Kielder with the following key aims:

- to maintain the security of water supply to the North East;
- to better reflect natural changes in river flows which should protect the ecology of the river;
- to provide increased flood storage in Kielder reservoir;
- to increase the generation of clean, renewable energy; and
- to take into account the requirements of river and reservoir users.

The initial trial of this new regime began on 1st November 2016 and ended on 31st March 2017. This short report examines the results of the trial and assess the new regime against the following success criteria:

- The reservoir level is kept within an acceptable range of the target curve;
- There is a variation in the amount of water released;
- Fish passage at Riding Mill is not impacted and the broodstock collection is successfully completed;
- The revised release regime does not adversely impact fish populations, as indicated by, for example, electrofishing survey and angler catch data;
- Spill is limited;
- Flood releases are required infrequently; and
- The estimates made for the proposed week turn out to be correct more often than they are wrong.

Hydrological context

The release of water from Kielder reservoir is dependent on two things: the control rules which determine how much water is released at different times of the year and at different reservoir levels; and the amount of water flowing into the reservoir. This means that, before we consider the impact of the new release regime on flows, it is important to understand how the weather since 1st November has affected the amount of water available for release.

The second half of 2016 was exceptionally dry in the Tyne catchment with the **3rd driest 6 months** ending in January since 1910 totalling only 75% of the long term average. For the North East area as a whole it

was the 6th driest December/January since 1910 with just over half of the long term average (LTA) rainfall recorded. However, February and March were relatively wet, with 140% of the LTA in the Tyne catchment. Temperatures showed a similar variation with early November being very cold and frosty but February and March being milder than average. These natural variations in rainfall and temperature have to some degree masked the impact of any changes in the releases and have made it difficult to identify any direct cause and effect.

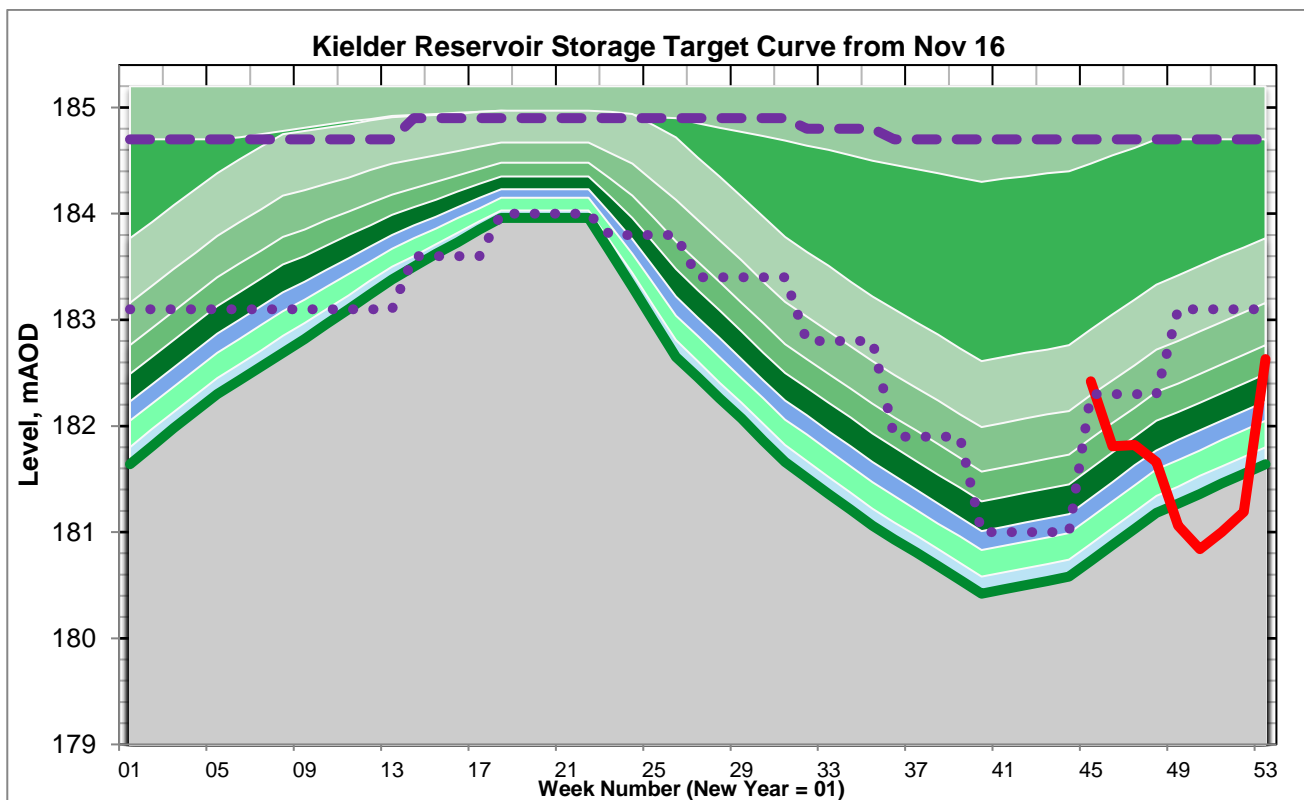
Success criteria

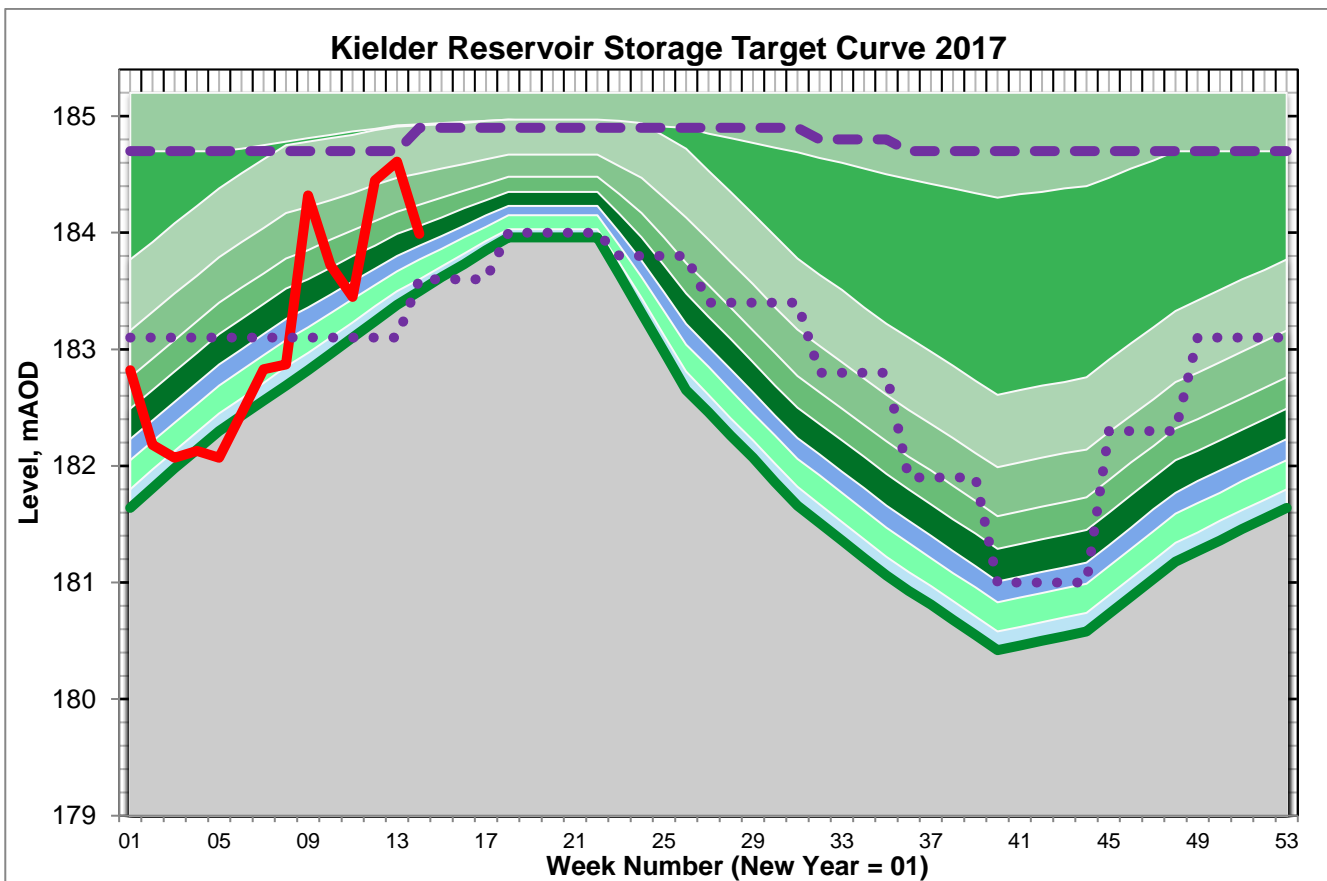
The following section will look at each of the success criteria in turn and consider whether the trial has achieved the aims of the new regime.

The reservoir level is kept within an acceptable range of the target curve

When the trial began the reservoir was over 1.5 metres above the target curve. A combination of low rainfall and large releases meant that the target curve was reached in only 4 weeks. A period of dry weather then resulted in the reservoir level falling below the target which caused access problems for the sailing and water ski clubs. NWG worked alongside the reservoirs users and have agreed to fund the extension of the slipway when water levels allow.

Kielder reservoir storage since the start of the trial, compared to the target curve





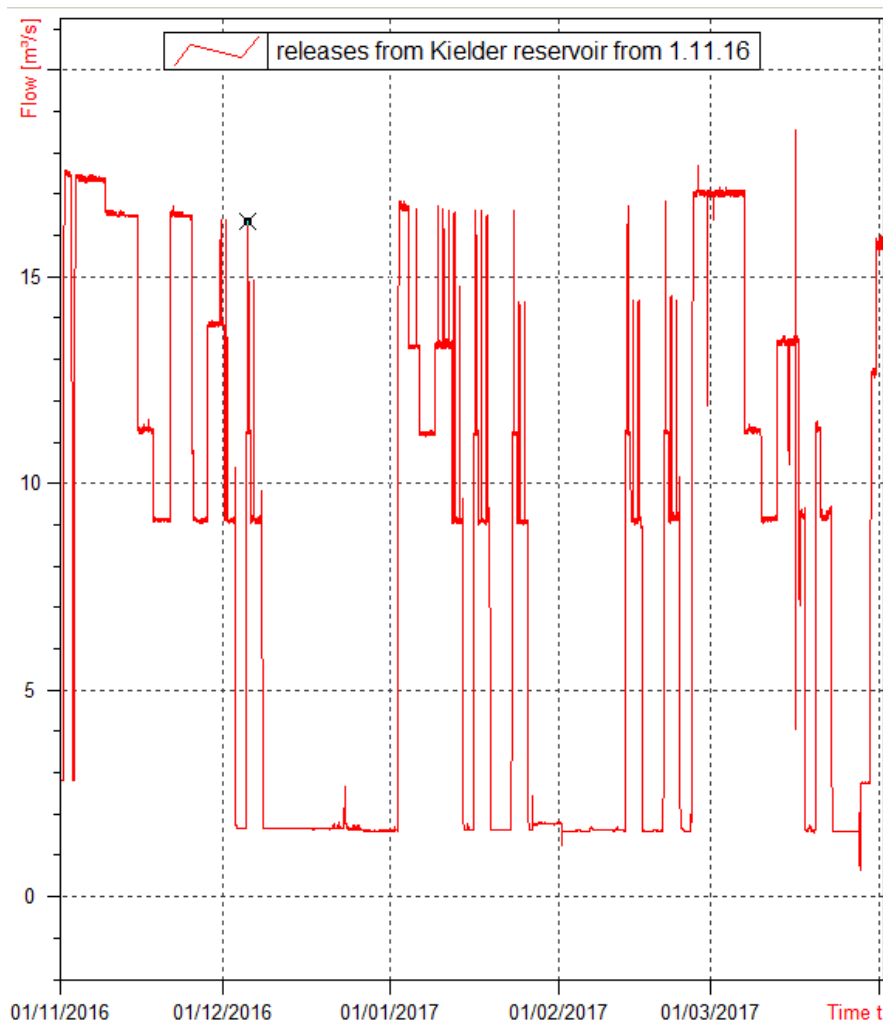
At the start of 2017 the reservoir level was kept within a planned range of the target curve, until the large inflow at the end of February caused by Storm Doris. Extra releases were made which resulted in the reservoir level falling fairly quickly back towards the target curve, before another period of wet weather on the 22nd March. No flood alleviation releases were required, despite these large inflows.

This objective has been achieved.

There is a variation in the amount of water released

The graph below shows how the releases from Kielder reservoir have varied since the beginning of November. There was an extended period in December when only compensation releases were made as there was very little water flowing into the reservoir. The new regime is designed to release a higher flow at the start of each week's release, followed by slightly lower flows to mimic a natural hydrograph.

Fig 2: releases from Kielder reservoir



In addition to compensation water releases, since the start of the trial there have been releases at 8, 10, 12 and 15 cumecs, as detailed on the table below.

Table 1: number of days at different release rates

| | |
|--------------------------|----|
| Compensation flow | 65 |
| 8 cumecs | 15 |
| 10 cumecs | 24 |
| 12 cumecs | 16 |
| 15 cumecs | 31 |

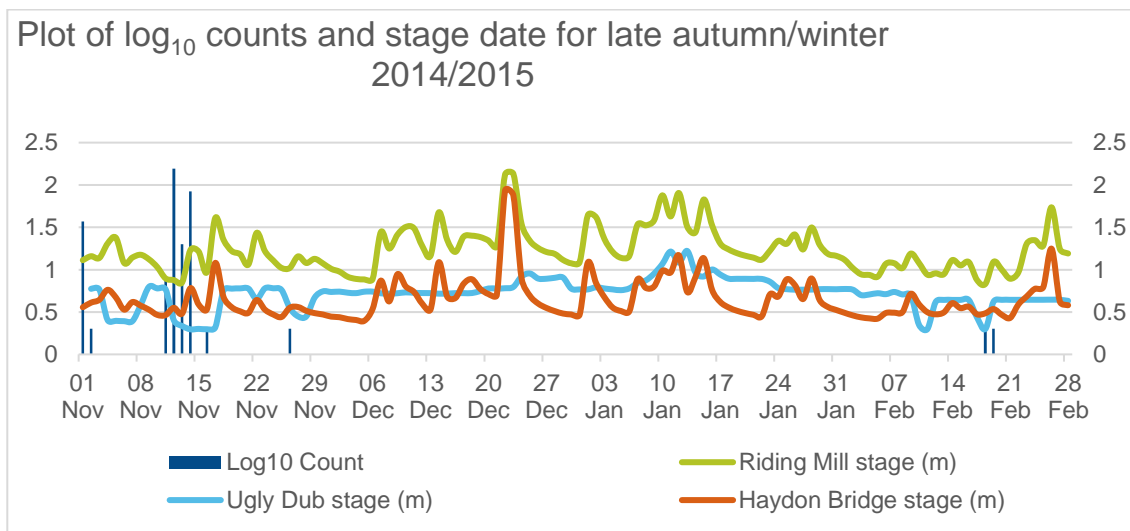
However, when compared to inflows during the same period, the current restriction on the rate at which water can be released (i.e. no releases between 1.3 and 8 cumecs) means that outflows are still very different to inflows. When the main turbine is refurbished it will be possible to make releases in the range from 3.5 to 8 cumecs which should allow outflows to more closely reflect inflows.

This objective has been achieved.

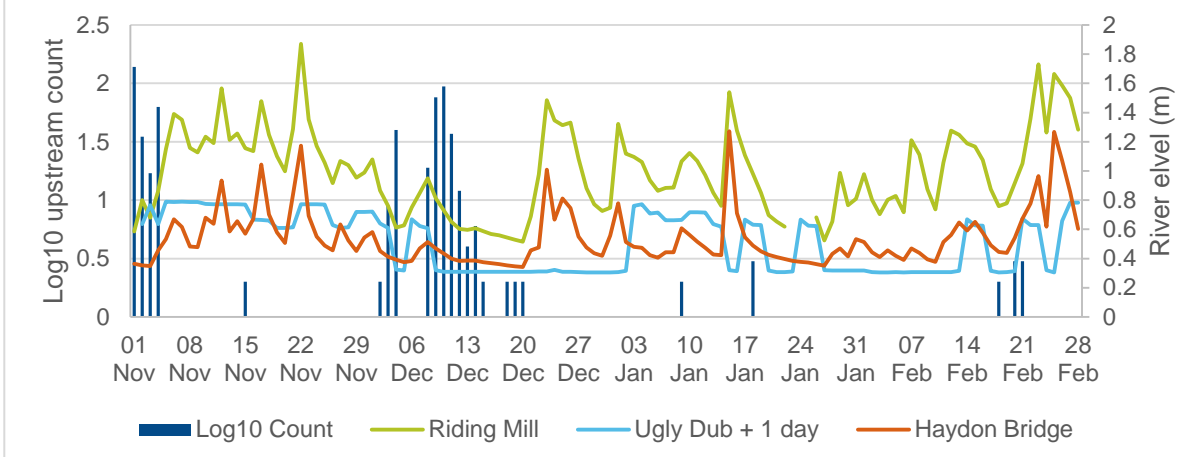
Fish passage at Riding Mill is not impacted and the broodstock collection is successfully completed

Fish passing through the weir at Riding Mill are recorded at our fish counter at the gauging station. Factors influencing the numbers counted include the depth (and therefore velocity) of the water, water temperature and the availability of fish willing to move upstream. Due to natural variation in flow and temperature it is difficult to identify if the changes to the release regime have had an impact on migration and further monitoring will be required before any firm conclusions can be drawn. During the second half of November 2016 natural river temperatures were quite low and are likely to have inhibited counts. The comparison of counts below suggests that there hasn't been a serious negative impact on fish movement.

Fig 3: river levels and numbers of fish passing through Riding Mill in 2014/15 and 2016/17



Plot of Log₁₀ counts and stage data late autumn/winter
2016/17



The brood stock collection was successfully completed in just a few days at the start of November.

The revised release regime does not adversely impact fish populations, as indicated by, for example, electrofishing survey and angler catch data

There is little evidence to determine whether or not fish populations have been affected by the changes to the releases but anecdotally, the coarse fishing has been favourable, although this may be more due to the mild winter and low natural flows.

It is not possible to conclude if this objective has been achieved or not.

Spill is limited

There were no periods of spill during the trial and the highest reservoir content was 97% on 31.3.17.

This objective has been achieved.

Flood releases are required infrequently

Flood releases (in excess of 15 cumecs) were not required at all during the trial due to the low rainfall from November to January. This is one of the main shortcomings of the trial as it has not been possible to monitor any impact on temperature or rate of rise that these large releases may have.

This objective has been achieved due mainly to low rainfall and reservoir inflows.

The estimates made for the proposed week turn out to be correct more often than they are wrong

Due to differences in the way the releases for the coming week are calculated there was some uncertainty at the start of the trial about how accurate the releases in the 'proposed' week would be. At the drop-in event in October several river users expressed a preference for keeping the 'proposed' week and so, although these releases have not been communicated via the innogy webpage, they have been calculated. Results have shown that the proposed week has only been correct 4 times during the 21 week trial (1 week

in 5) due to the wide variation in inflows. If the proposed week is going to be published then users will have to understand that it is unlikely to be correct.

This objective has not been achieved and views will be sought from external stakeholders about whether or not to publish the proposed releases, given how often the releases change.

Summary of the success criteria

| | |
|--|--|
| The reservoir level is kept within an acceptable range of the target curve | The revised regime was designed to keep the reservoir contents within the release zones B-H and avoid large releases or spill. This has been largely achieved. |
| Variation in the amount of water released | Some improvement in flow variation but still does not reflect natural inflows. |
| Fish passage at Riding Mill is not impacted and the broodstock collection is successfully completed | No evidence to suggest fish passage has been impacted; broodstock collection was completed. |
| Not adversely impact fish populations | Little evidence either way, but some suggestion of good coarse fishing. |
| Spill is limited | No spill. |
| Flood releases are required infrequently | No flood releases. |
| Estimates made for the proposed week turn out to be correct more often than they are wrong | The proposed week was only correct one week in five. |

Shortcomings of the trial and further work

It is difficult to draw too many conclusions about the impact of the winter trial of the new regime on river flows, given the very short dataset (5 months) and the unusually dry, then wet, weather conditions. The main shortcoming of the trial is that no releases in excess of the maximum hydropower generation were required. Furthermore, it was not possible to arrange monitoring of the TRIAD releases (these are short duration increases in hydropower generation to capture periods of peak energy demand during week day evenings).

Given that no adverse impact of the new regime has been detected the trial will continue into the summer months. Further monitoring is planned, some of which is aimed at trying to increase the understanding of freshwater pearl mussels and how they may react to the releases.

The additional monitoring includes:

- rate of rise, velocity, wetted area and turbidity measurements during 25 and 50 cumec releases;
- time lapse, rate of rise, velocity and turbidity readings during TRIAD releases when natural flows are low, ramping from 8 cumecs to 16.4 cumecs;
- a trial of a 3.5cumec release to assess if it would be safe for broodstock collection. This will be the new minimum flow rate through the refurbished turbine;
- continued monitoring of temperatures and flows during the summer months when there is the potential for the effects of the releases to be more noticeable.

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