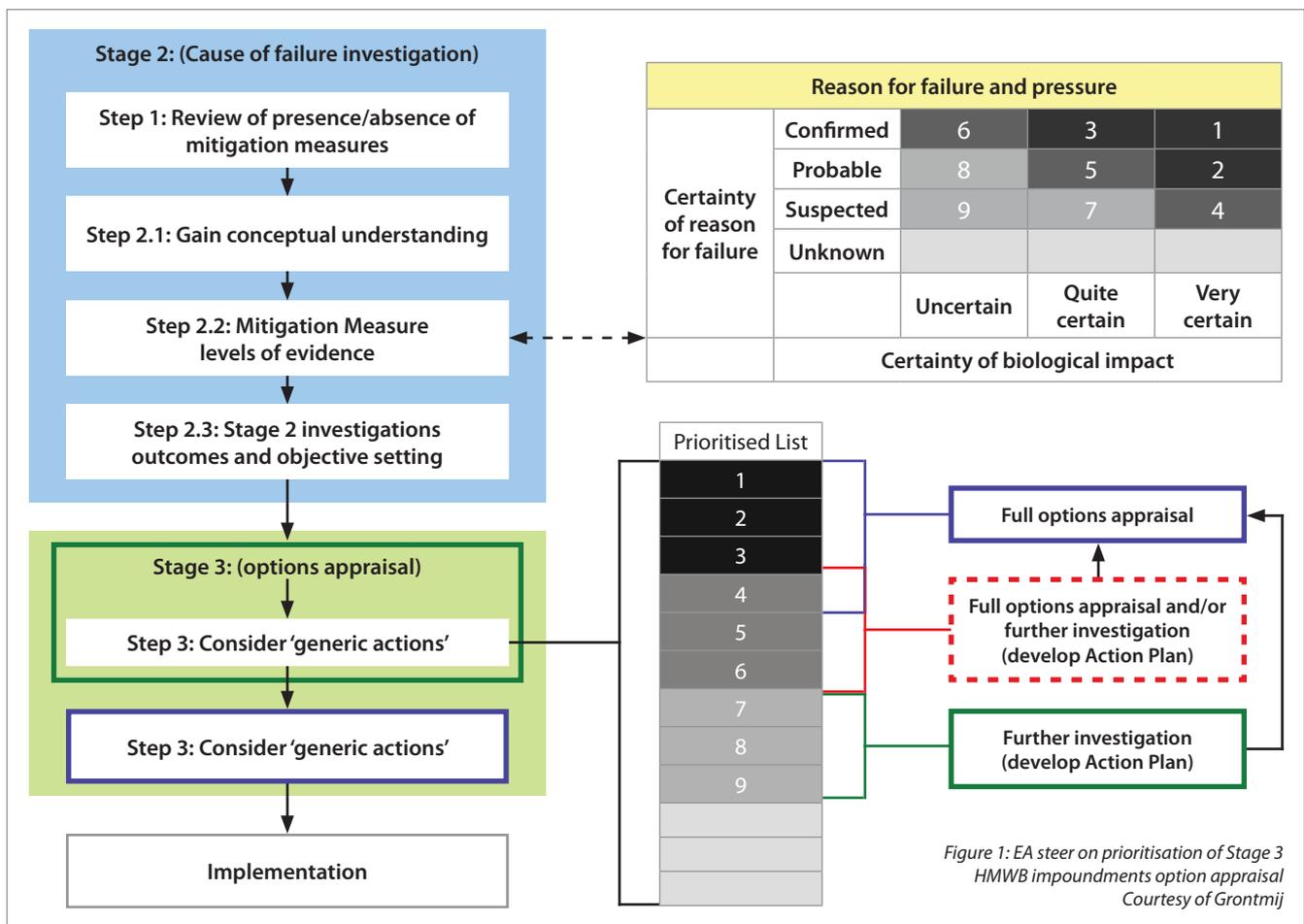


Heavily Modified Water Body Directive Assessments

mitigation measure option appraisals to achieve good ecological potential for United Utilities water resource assets

by Dr Doug Lewis BSc PhD & Emma Mooney BSc

Option appraisal reports for Heavily Modified Water Bodies (HMWBs) affected by water abstraction activities are required under the Water Framework Directive (WFD) to ensure Good Ecological Status (GES) is attained or retained for all possible water bodies. In some cases this may conflict with the specified use of a water body which provides social and economic benefits. Where a water body is designated as a HMWB, the environmental objective under the WFD is therefore to achieve Good Ecological Potential (GEP), rather than GES. All HMWBs should meet GEP by 2027. A multidisciplinary team from Grontmij was engaged by United Utilities (UU), as one of their Professional Engineering Service Framework Consultants, to provide option appraisal reports in the North West.



Project background & scope

In May 2012, the Environment Agency (EA) provided Stage 2 assessment reports for all HMWB, indicating potential 'Cause of Failure'. The initial phase of the project collated and reviewed input data from these reports, included confirming the list of water bodies and associated reservoirs requiring options appraisal (Stage 3 assessment). In total, 64 units containing 194 reservoirs and water bodies required assessment in the North West

Five environmentally relevant drivers were considered:

- Driver 1: Fish Migration.
- Driver 2: Downstream Flow.
- Driver 3: Sediment.
- Driver 4: Water Quality.
- Driver 5: Lake Level.

The key objectives of the HMWB project were to:

- Review (challenge/confirm) Stage 2 outcomes for all drivers.
- Hold Value Management (VM) meetings to agree prioritisation, in terms of high, medium and low priority sites.
- Perform Mitigation Measure (MM) optioneering for high/medium priority sites.
- Hold further VM meetings, agree cost-benefit analysis outcomes, and the way forward to tie into UUs business case for AMP6.

Design process

As part of this study, challenges were made to either the certainty of failure, or the level of impact of such failure presented by the

EA as part of their Stage 2 assessment (see Figure 1 on page 1). The outputs of the study were presented in a series of unit specific reports. These provided an overview of the water resource zone, unit schematic arrangements, and detailed reviews of the EA findings for each driver.

Any issues identified as part of the assessment were also listed, as was any supplementary information relevant to the investigation (i.e. the presence of environmentally sensitive areas). Depending on the outcomes of the Stage 2 review, a scope of assessment was then proposed for each driver, as shown in the following table.

Driver	Action
1	High Priority (full options appraisal)
2	Medium Priority (full options appraisal)
3	Scope further investigation into the level of biological impact, and develop an action plan (Low priority)
4	None at present, further work required at Stage 2
5	None

Table 1: Typical scope of assessments

For high and medium priority drivers, MM were proposed. These were selected from a list of generic actions provided as part of the UK Water Industry Research guidance documentation for the project. If any of the actions proposed had a potential impact on the yield of the water body, then a flow analysis was undertaken to determine the level of this impact.

A working group was established (comprising representatives from UU, the EA, Grontmij, and a specialist aquatic sub-consultancy APEM. This working group participated in an initial round of VM meetings to agree prioritisation and scope of assessment. The group then participate in a second round of more detailed VM meetings, to agree the outcomes of MM optioneering and in particular the way forward for UU (and the EA) in AMP6 for each unit, as indicated in Figure 2 below.

Hydrological assessment

Prior to the first working group meetings a compensation flow analysis from all of the reservoirs covered by the HMWB study was undertaken. This was carried out to assess how many reservoirs may be impacted by driver 2 mitigation measures. A compensation flow

release ensures that the watercourse downstream of the reservoir does not drop below a minimum flow and maintains ecology, with commonly defined seasonal flows (summer and winter).

Typical compensation flows require a Q95 release, equal to the natural flow which is exceeded 95% of the time. An assessment of Q95 values for each reservoir was completed based on three distinct methods (flow factors, low flow estimates and National River Flow Archives scaling). This was compared against existing compensation flows set in place by UU, to assess if these were sufficient.

Where a gap between existing compensation flow and calculated Q95 values was identified, a corresponding impact on the effective yield of the water body was assessed. A loss in reservoir yield can have a significant cost impact to UU (estimated at £1m per 1MI/d), and this data was used to inform budget and planning for the next investment period, PR14.

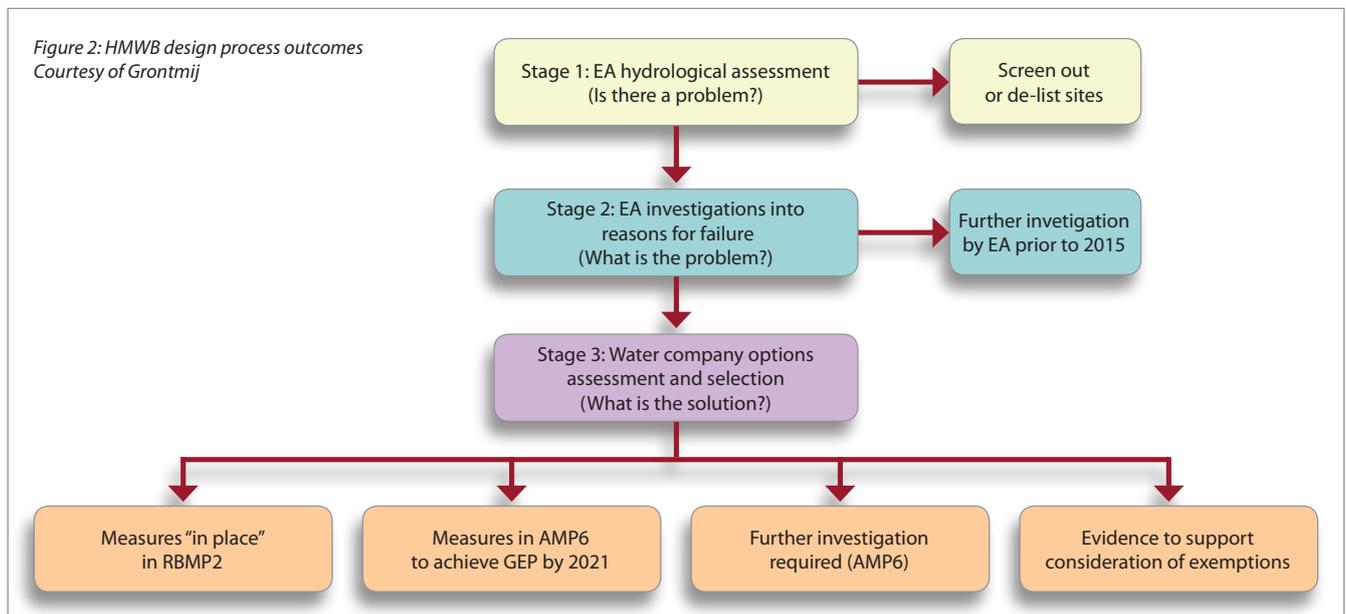
An assessment of reservoir spill frequency was also carried out using gauged water levels provided by UU. This provides further information on the variability of the flows released from reservoirs, during rainfall events, and which are essential in ensuring GEP is achieved.

For those sites where a fish pass (driver 1) has been identified as a generic action required, an allowance was made for allowing an 'attractive' flow to discharge down this pass. As defined in the *EA Fish Pass Manual*, a minimum target discharge of 5% of annual daily mean flow (ADF) is recommended, and if possible considerably more (≥10%), in order to provide a sensible size of fish-way with good attraction. Where 5% of ADF exceeds compensation flow at a given site, a corresponding loss in yield was also assumed.

Further data gathering and ecological assessments

The current EA steer on prioritising units into high, medium or low priority was applied for each of the five drivers. At the first VM meeting specific units and water bodies were identified and any high or medium priority sites for drivers 1, 2 or 3 were shortlisted for further detailed analysis. No driver 4 or 5, high or medium priority sites were identified, and further investigation into these was required by the EA.

Grontmij and APEM undertook site visits for driver 1, 2 and 3 sites in August to October 2012. The work undertaken during the site visits included topographic surveying of river channels at ecologically sensitive stretches, structural assessments of reservoirs, discharge



arrangements and associated channels, flow surveying, sediment availability assessment, and quantification of channel habitat suitability for migratory fish. The attainment of such crucial data allowed a more informed discussion on each driver and the following conclusions to be drawn:

- **Driver 1:** The lack of fish habitat upstream of a reservoir resulted automatically in no requirement for fish passes at these sites, as they were deemed at GEP. Otherwise a length of benefitted river upstream was assessed.
- **Driver 2:** An ecological flow assessment for fish requirements, examining hydraulic, depth and velocity characteristics at transects resulted in river stretches with low compensation flows being deemed at GEP and so no mitigation measure was required.
- **Driver 3:** The reduction in channel sediment below reservoirs was assessed qualitatively and Sediment Management Plans (SMP) progressed to transport sediment from feeder stream traps to identified places downstream of the reservoir.

Mitigation measures and cost benefit ratio (CBR)

Following the further data gathering and assessment, a proposed programme of MM was developed for each unit (where required). Engineering drawings were produced by Grontmij and subsequent costs produced by UU's engineering costing team.

The main MM for driver 1 was fish passes (Pool & Traverse, Alaskan or Larinier baffle), fish locks, fish transport or bypass channels. Due to the significant number of sites being looked at, high level generic designs based on a typical reservoir detail was produced for outline cost estimation purposes. For instance, the fish pass designs were all based on the *EA Fish Pass Manual* with parameters such as maximum gradient, maximum rise length, minimum width.

The length of each fish pass type was dependent on embankment height, maximum fish pass gradient, maximum length of rise sections and number of intermediate resting pools required. As embankment height was the only variable between reservoirs, this allowed the generic design to be transferable.

For driver 2, the main MM considered to provide compensation flows was through modifying existing bypass channels, water abstraction arrangements, scour pipes, or through new compensation towers or over-pumping. SMP were accepted as suitable for all high and medium priority driver 3 sites. The benefitting length of channel downstream from these MM's was assessed as extending to where the catchment was 2.5 times the area of the upstream impounded catchment.

An outline economic assessment (CAPEX/OPEX/CBR) was undertaken for the programme of MM, considering indicative costs of feasibility studies, survey, design, construction and operation for the preferred MM and the environmental economic benefits associated with them.

The economic assessment is based on guidance produced by the EA National, with a change in status value of £25,100 per year per km for moderate to good status for the North West adopted.

This is a benefit value across six components (fish, invertebrates, macrophytes, clarity of water, safety and flow/morphology), which is divided by six for the fish component only, with the flow and sediment MM requiring the full value per km.

Assuming a 43 year assessment period, the CBR ratio of the present value of the costs to the benefits was calculated. EA National indicated that a ratio of ≥ 3 is required for a disproportionate cost to be considered.

Conclusions

The second round of VM meetings were held in November 2012, where the MM were discussed with the key objective of ensuring the EA and UU agreed to the proposed actions (or in many cases no actions) for the units. Agreement of a programme of MM in AMP6 was achieved for all units assessed:

- **Driver 1:** No units were deemed to require progression to MM due to disproportionate costs.
- **Driver 2:** Due to required changes in compensation flows, seven units progressing to MM.
- **Driver 3:** Due to requiring specific SMP, eight units progressing to MM.

Grontmij are currently providing further design details for the driver 2 units and MM's.

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Driver 2: Typical scour pipe compensation flows arrangements - Courtesy of Grontmij