

Severn Trent Water AMP6 Low Flows Programme: Adaptive Management Plan - Quorn Brook

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Severn Trent Water AMP6 Low Flows Programme: Adaptive Management Plan - Quorn Brook

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Severn Trent Water Ltd

2 St John's Street

Coventry

CV1 2LZ

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New Zealand House, 160-162 Abbey Foregate,
Shrewsbury, Shropshire
SY2 6FD

Telephone: +44 (0)1743 276 100
Facsimile: +44 (0)1743 248 600

Registered Office:
Stantec UK Ltd
Buckingham Court
Kingsmead Business Park
Frederick Place, London Road
High Wycombe HP11 1JU
Registered in England No. 1188070

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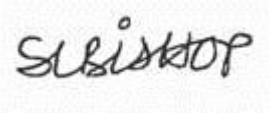
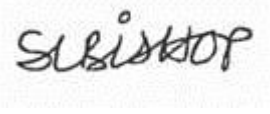

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	Name	Signature
Author	Rick Hayes (APEM) Sam Bishop (Stantec)	
Checked by	Dan Cadman (APEM) Sam Bishop (Stantec)	
Reviewed by	David Bradley/ Dan Cadman (APEM) Cecilia Young/Paul Daily (Stantec)	

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*Severn Trent Water Limited **Environment Agency

Executive Summary

This report defines an Adaptive Management (AM) approach for the introduction of minimum compensation releases from Cropston and Swithland reservoirs within the catchment of the Quorn Brook. Currently there is no requirement upon Severn Trent Water Limited to make compensation releases at either reservoir. The introduction of compensation releases at Cropston and Swithland Reservoirs was the AMP6 notional solution, as defined following investigations and Options Appraisal.

The aim of making these releases was to make localised improvements to river habitat and ecology in the reaches downstream of the reservoirs. Improvements in Water Framework Directive Status at the waterbody scale are not envisaged, but modest benefits at the reach scale are considered achievable as a no regrets measure that can readily be implemented. However, unintended consequences from the release of this water cannot be entirely discounted; the reservoir water contains elevated nutrient concentrations, and both reservoirs are also designated as Special Sites of Scientific Interest, the designated features of which are dependent upon appropriate water levels. Should unintended consequences arise, the drawdown requirements of the Sites of Special Scientific Interest associated with each reservoir, and the WFD status of the waterbody are considered to be a priority over the introduction of compensation releases.

The notional solution was for provision of minimum flows to the reaches downstream of both Cropston and Swithland Reservoirs of up to 2 Ml/d and 4 Ml/d respectively. Managed releases to mimic the effect of some natural spates were also recommended. Operational arrangements to maintain reservoir levels are being progressed independently and are not part of the notional solution.

To reduce the risk of negative impacts, and given the potential for unintended consequences, the compensation releases are to be implemented in two-phases in an adaptive management (AM) approach. AM works on the basis of an iterative approach, designed to provide a structured, flexible approach to managing systems in the face of uncertainty. The success criteria are:

- meeting the proposed compensation flows, and;
- avoiding unacceptable negative impacts attributable to the implementation of compensation flows.

The target flows for Phase 1 are 1 Ml/d downstream of Cropston Reservoir and 2 Ml/d downstream of Swithland Reservoir. At the end of Phase 1 (a minimum three-year period, but which should include a dry year), assessment of monitoring data collected throughout this period will inform Phase 2 specifications as appropriate. These will be made in close consultation with the Environment Agency (EA). Releases to mimic spates may also be trialled once an annual minimum flow is established.

The report specifies the monitoring requirements that will check for unintended impacts during implementation of the compensation flows, enable assessment of the success criteria, and ensure that any unintended negative consequences do not cause deterioration in Water Framework Directive (WFD) status of any quality element at the waterbody scale. Justification for the proposed monitoring is given for each element, as well as details of how the data collected will be assessed to determine success.

An idealised timeline is also outlined. However, annual assessment of the data collected will feed back into the programme; determining whether changes are made to compensation flow specifications and/ or monitoring requirements at a given time. All annual assessments will be made in consultation with the EA. The report also sets out how different types of failure are dealt with. The process that will be taken to adapt and adjust in response to 'failure' to meet the success criteria is outlined. Under the scenario where the requirements of reservoir level management are in conflict with compensation release, a reduction of compensation flows will not constitute a failure.

Contents

1	INTRODUCTION	1
1.1	This report	1
1.2	Principles of adaptive management	1
1.3	Aims and objectives	2
1.4	Monitoring strategy for adaptive management	2
2	SITE BACKGROUND	4
2.1	Cropston and Swithland Reservoirs	4
2.1.1	Impacts on downstream river flows	4
2.2	Options appraisal	5
2.3	Reservoir drawdown and SSSI condition	5
3	PROPOSED CHANGES	8
3.1	Compensation flows	8
3.2	Phasing of implementation	8
3.3	Prioritisation of drawdown requirements and compensation releases	9
3.4	Summary of Adaptive Management actions	10
4	MONITORING THE EFFECTS OF MEASURES	11
4.1	Monitoring during implementation (turning-on) of compensation flow releases	11
4.1.1	Water quality	14
4.1.2	Habitat walkover	15
4.2	Monitoring during Adaptive Management	15
4.2.1	Reservoir storage	17
4.2.2	River flows	17
4.2.3	Morphology	17
4.2.4	Water quality	18
4.2.5	Macrophytes and phytobenthos	20
4.2.6	Macroinvertebrates	20
4.2.7	Fish	20

4.2.8	Invasive Non-Native Species	21
4.2.9	Severe Pressure Surveys	21
5	EVALUATING SUCCESS	22
5.1	Success criteria	22
5.2	River flows	22
5.3	Avoidance of unacceptable negative consequences (short-term)	22
5.4	Avoidance of unacceptable negative consequences (long-term)	22
5.4.1	Water quality	22
5.4.2	Macrophytes and phytobenthos	23
5.4.3	Macroinvertebrates	24
5.4.4	Fish	25
6	ADAPTATION AND ADJUSTMENT	26
6.1	Compliance failure	26
6.2	Failure due to external causes	26
6.3	Failure due to measurement uncertainty	27
6.4	Failure to meet stated success criteria	27
6.5	Timeline	29

ILLUSTRATIONS

Illustration 1.1	Adaptive Management (from Macleod et al., 2016)	1
Illustration 2.1	Storage zones and conservation drawdown (Charnwood Level Management Agreement)	6
Illustration 3.1	Drawdown recorded in 2018 against target.	10
Illustration 6.1	Flow diagram for the proposed process of adaptation and adjustment of AM	28

TABLES

Table 2.1	SSSI details for Cropston and Swithland reservoirs	4
Table 2.2	Proposed Operational rules under the Charnwood Level Management Agreement	7
Table 3.1	Recommended releases at Cropston and Swithland Reservoirs (from ESI & APEM, 2018a)	8
Table 4.1	Indicative programme of short-term monitoring to be carried out at implementation (turning-on) of compensation release at Cropston Reservoir	12
Table 4.2	Indicative programme of short-term monitoring to be carried out at implementation (turning-on) of compensation release at Swithland Reservoir	13
Table 4.3	List of water quality parameters to be measured during implementation monitoring	14
Table 4.4	Quorn Site Investigation Plan monitoring locations.	16
Table 6.1	Indicative timeline of progression of Phase 1 of AM for the Quorn Brook	30

APPENDICES

Appendix A Compensation release trial reports

Appendix B Environment Agency guidance on adaptive management

1 Introduction

1.1 This report

This report defines an Adaptive Management (AM) approach for the introduction of compensation releases from Cropston and Swithland reservoirs within the catchment of the Quorn Brook. It sets out:

- the rationale for AM in the catchment;
- the compensation flows to be released during the AM period;
- conditions under which the compensation may be amended and not to compromise the conservation objective drawdown curve targets;
- criteria over which success of the scheme will be assessed, and;
- monitoring to assess achievement of the success criteria and avoidance of unintended consequences.

1.2 Principles of adaptive management

AM of an environmental system is an iterative approach whereby objectives are set, management decisions made, and the effects monitored; the observed effects improve understanding of the system and are used to inform future management decisions (e.g. Williams *et al.*, 2009; Macleod *et al.*, 2016). AM is designed to provide a structured, flexible approach to managing systems in the face of uncertainty. Macleod *et al.* (2016) provide the following useful summary graphic (Illustration 1.1).

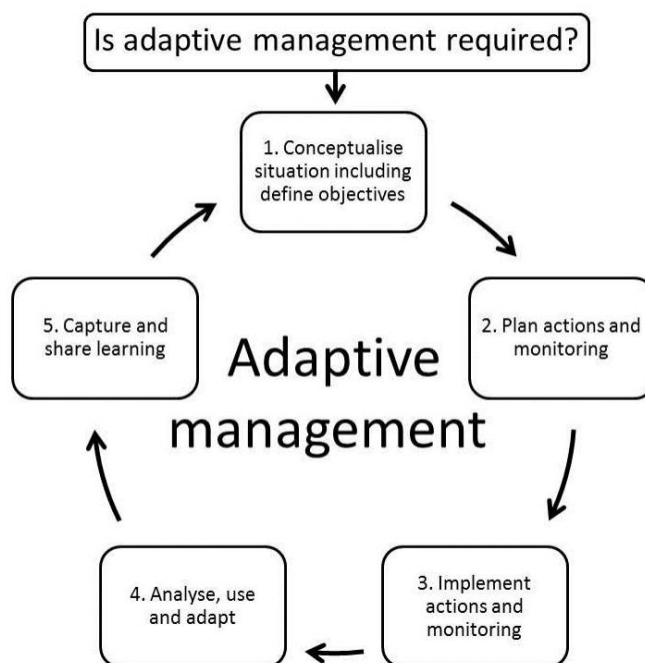


Illustration 1.1 Adaptive Management (from Macleod *et al.*, 2016)

In the context of the Quorn Brook, the observed effects of compensation releases on physical habitat, water quality and ecological receptors will be used to manage the system in the future and to inform avoidance of

possible negative consequences. Objectives for the environmental gain achieved by the introduction of the compensation flows will be set and tested through monitoring and comparison to an established baseline condition and will be subject to regular reviews through the abstraction licensing process.

- Sections 1,2.1 and 2.2 of this report constitute Step 1 of Illustration 1.1.
- Sections 2.2 and 3 detail the actions to be made; Step 2 of Illustration 1.1.
- Section 4 outlines the monitoring required; Step 2 of Illustration 1.1.
- Sections 5 and 6 define the success criteria and proposed evaluation and adjustment for the AM process; Step 4 of Illustration 1.1.

1.3 Aims and objectives

Compensation releases at Cropston and Swithland Reservoirs should provide the benefits expected during selection of the preferred mitigation measures (ESI & APEM, 2018c). The aims of introducing compensation releases at Cropston and Swithland Reservoirs are therefore to:

- Make the flow regime immediately downstream of the reservoirs consistent with that agreed through the AMP6 notional solution (ESI & APEM, 2018c), implemented through a phased adaptive management approach, and, as a result;
- Make localised improvements to river habitat and ecology in the reaches downstream of the reservoirs as set out in the Options Appraisal report (ESI & APEM, 2018c).

Monitoring must also ensure that any unintended negative consequences do not cause deterioration in Water Framework Directive (WFD) status of any quality element at the waterbody scale. Monitoring of effects on reservoir levels is considered separate.

Implementation of a minimum compensation flow from both reservoirs (QB09) is not expected to result in improvement in status of any WFD element categories of the Quorn Brook waterbody, because the status of all biological and supporting elements in the 2015 Cycle 2 classification was Good at the waterbody level (ESI & APEM, 2018b). However, it should be noted that the 2016 interim classification reduced the overall waterbody status to Moderate as a consequence of phosphate (measured in Quorn) and macrophytes.

The objectives for AM, to achieve the above stated aims are to:

- Phase 1; implement compensation releases of 1 MI/d and 2 MI/d from Cropston and Swithland Reservoirs respectively;
- Review monitoring data on an annual basis to measure success or failure and adjust/ stop compensation if unacceptable risk is identified, and;
- Depending on the outcome of a minimum of three years of compensation (Phase 1 should also include a dry year), review and agree with the Environment Agency whether 1 MI/d / 2 MI/d achieves the required environmental outcomes (i.e. providing benefit to habitat quantity and quality while not having negative consequences, such as effects from poorer water quality), or, if an increase to compensation flows of 2 MI/d and 4 MI/d from Cropston and Swithland Reservoirs, respectively, is required.

1.4 Monitoring strategy for adaptive management

The objectives of introducing compensation flows, and the risk of unintended consequences, are measurable. The monitoring programme will enable assessment of the scheme against defined success criteria, and for adjustments to be made, as appropriate.

Monitoring for AM is intended to address any uncertainties that remained subsequent to the compensation review (CR) (ESI & APEM, 2018a), which recommended the mitigation measures. The CR acknowledged uncertainties in the recommended compensation flows; in particular, the geomorphological and ecological effects of reintroducing minimum flows could not be predicted with precision, and therefore it could not be guaranteed that the desired benefits would be achieved. Possible unintended consequences identified include downstream effects of increased nutrient input from Swithland Reservoir (ESI & APEM, 2017a) and effects of reservoir drawdown on marginal plant communities. The first of these is of particular relevance given the interim 2016 WFD status classification failing to achieve Good, principally as a result of high phosphate downstream of Swithland Reservoir. Uncertainties are common to quantifying compensation releases downstream of many waterbodies downstream of impoundments and, in line with recommendations for dealing with such uncertainties, the recommended mitigation measures were treated as an initial estimate to be refined, as necessary, via an AM approach.

Monitoring is designed to complement Environment Agency (EA) and Natural England (NE) surveillance and condition monitoring. It is also designed to be proportionate to the benefits of introducing the compensation flows as assessed during OA, and to Severn Trent Water Limited's (STWL's) 'fair share' of action required to address pressures acting within the Quorn Brook catchment. Expected benefits are likely to be modest given that Good Ecological Status (GES) was supported for flow dependent receptors in the 2015 River Basin Management Plan. It is acknowledged that under the 2016 interim classification the waterbody fails to achieve Good status. As this is principally driven by phosphate, the introduction of water from Swithland Reservoir, which is recognised as being nutrient rich, will need to be monitored to ensure this does not cause deterioration. This is accounted for in the monitoring and review process (see Sections 4 and 5 respectively).

Benefits, and unintended consequences, will be assessed by Before-After Control-Impact (BACI) comparisons against pre-implementation inter- and intra-year data (Appendix B). These comparisons will be made using standard tools in a Weight of Evidence approach as proportionate to the benefits likely to be achieved. Baseline data are already present from STWL, who have monitored the Quorn Brook since 2015 under RSA, and from the EA's and NE's routine monitoring programmes, which precede this. The monitoring data also include a number of locations upstream of the reservoirs, which will act as proxy 'control' locations in AM, allowing some assessment against background natural and third-party anthropogenic variation.

2 Site Background

2.1 Cropston and Swithland Reservoirs

STWL's Cropston and Swithland Reservoirs are located in the catchment of the Quorn Brook in the Borough of Charnwood in Leicestershire, immediately north of the city of Leicester. They impound the Quorn Brook (known as the River Lin upstream of Cropston Reservoir) in the middle (Cropston) and lower (Swithland) parts of its catchment, providing an important source of water to the city since the 19th Century. Under the WFD, three surface waterbodies are recognised within the Quorn Brook catchment:

- Quorn Brook (tributary of River Soar) (GB104028047060) – a river waterbody of 45.6 km² that includes both reservoirs and their individual sub-catchments.
- Cropston Reservoir (GB30436331) – an artificial lake waterbody covering 0.53 km².
- Swithland Reservoir (GB30436108) – an artificial lake waterbody covering 0.69 km².

Historically there has been no requirement for compensation flow from either reservoir. This has not prevented the Quorn Brook waterbody from being classified as supporting GES because the effects of the reservoir are relatively modest at the waterbody assessment points downstream of the reservoirs, and a number of assessment points are sited upstream of the reservoirs and therefore are not directly affected by them.

The reservoirs primary purpose (and the reason why they were constructed) is to supply water to Leicester. However, Cropston and Swithland reservoirs are designated as SSSIs; Cropston Reservoir is designated for its unusual marginal plant communities and diverse breeding bird communities, and Swithland Reservoir for its tall-fen and inundation plant communities and its wintering waterfowl. Both SSSIs are currently considered by NE to be in Unfavourable Condition (Table 2.1).

Table 2.1 SSSI details for Cropston and Swithland reservoirs

Reservoir	SSSI	Interest features (reservoir)	Condition (reservoir)	Comments
Cropston	Bradgate Park and Cropston Reservoir	Unusual marginal plant communities. Diverse breeding bird communities.	Unfavourable declining (Cropston reservoir open water)	Drawdown needs to be implemented over a longer period. Habitat management required to address scrub encroachment and invasive non-native species.
Swithland	Buddon Wood and Swithland Reservoir	Tall-fen and inundation plant communities of reservoir margins. Wintering waterfowl.	Unfavourable, no change (Swithland Reservoir, North and South)	Drawdown needs to be implemented over a longer period. Habitat management required to address scrub encroachment.

Source: <https://designatedsites.naturalengland.org.uk/>

2.1.1 Impacts on downstream river flows

The Quorn Brook was included in the National Environment Programme (NEP) for AMP6, initially as a Heavily Modified Waterbody (HMWB), although this classification was removed in 2014. The effects of impoundment, and lack of compensation release, on the Quorn Brook were assessed during an AMP6 NEP investigation, producing a Desk Study (ESI & APEM, 2016a) and subsequent Impact Assessment (IA) and a Compensation Review (CR), although the compensation review for Cropston Reservoir was limited in scope by access issues. These investigations were supported by ongoing hydrological/ ecological monitoring (ESI & APEM, 2016b and 2018b) and the benefit of potential mitigation measures was subsequently considered during Options Appraisal (OA) (ESI & APEM, 2018c).

The CR and IA (ESI & APEM, 2018a) concluded that, based on ecological data, the Quorn Brook waterbody met GES under the WFD. The assessment also confirmed that the flow regime downstream of both reservoirs did not conform to recommended flows sufficient to sustain the geomorphological and ecological functions in downstream watercourses designated as HMWBs due to changes in their flow regime (UKTAG, 2013). Meeting these guidelines would require both the introduction of a continuous annual minimum flow and artificial spate flows. The IA also found clear evidence that the ecology downstream of Cropston Reservoir was limited by low flows and reduced flow variability as a result of upstream impoundment. However, it considered that the most affected reaches, immediately downstream of the reservoirs, comprised a small proportion of the Quorn Brook WFD waterbody and that effects were not sufficiently extensive to prevent achievement of Good status in the waterbody as a whole. Impacts of low flows on ecology were not so evident downstream of Swithland Reservoir, as the Quorn Brook benefits from tributary inflows immediately downstream. Cropston and Swithland Reservoirs therefore caused only localised impacts downstream that were not found to translate to impacts at a waterbody scale. Lack of conformity with UKTAG recommendations is not sufficient on its own to prevent achievement of GES.

2.2 Options appraisal

OA (ESI & APEM, 2018c) found remediation options not to be cost beneficial under the Water Appraisal Guidelines (WAG), partly because the current absence of compensation flows did not impact on WFD status. Localised/ non-WFD improvements were expected, as outlined in Appendix F of the OA (ESI & APEM, 2018c). STWL's Portfolio Optimiser, however, recognised environmental benefits not considered by WAG and indicated that the options considered were cost beneficial. The OA report therefore concluded that provision of a compensation release (option QB09) would fulfil STWL's 'fair share'. The compensation would comprise a continuous annual minimum flow. Lower seasonal spate releases (as described by option QB09_LS/EA (ESI & APEM, 2018c)) were to be investigated/ trialled as part of AM. However, the higher elevation of the late summer/ early autumn spate flow releases would be constrained by the release mechanism and flood flows were also discounted – in part for the same reason and in part due to risks of downstream flooding.

This recommendation was made subject to technical feasibility, noting that, in the event that mitigation measures could not be put in place without significant adverse effects on the use of the reservoirs or on the wider environment, the absence of these mitigation measures would not prevent the waterbodies from achieving GES. Implementation was therefore subject to further feasibility studies by STWL. These were to include consideration of the effect of compensation flows upon the yield of STWL's reservoirs or have unintended consequences on the ecology of the reservoirs or of the downstream watercourse.

2.3 Reservoir drawdown and SSSI condition

An AMP5 investigation into the Charnwood Reservoirs Group, including Cropston and Swithland reservoirs, assessed the effect of the reservoir operation on associated SSSIs designated for their communities of marginal plant communities. These plant communities rely on a seasonal cycle of exposure and inundation and the SSSIs were considered to be in unfavourable condition. The outcome from the AMP5 assessment was to review the objectives set by Natural England (NE) (and expressed as desired drawdown curves to be met three years in five) and to determine an operational regime that best meets the needs of reservoir operation and environmental objectives. In response STWL proposed the Charnwood Level Management Agreement, which has been agreed in principle with the EA and NE and will be formalised by the licence. The Agreement sets a framework to modify reservoir operation based on storage state, essentially dividing storage into a series of zones, termed A to C. The figure below shows the zones for both reservoirs, along with the drawdown curve (yellow dashed line). The objective to meet the desired drawdown profile three years in five remains.

This proposed protocol is not part of the notional AMP6 solution for the Quorn Brook, but has been pursued in tandem with it subsequent to AMP5 investigations. Nevertheless, implementation of the notional compensation solution needs to account for these changes (Section 3.3).

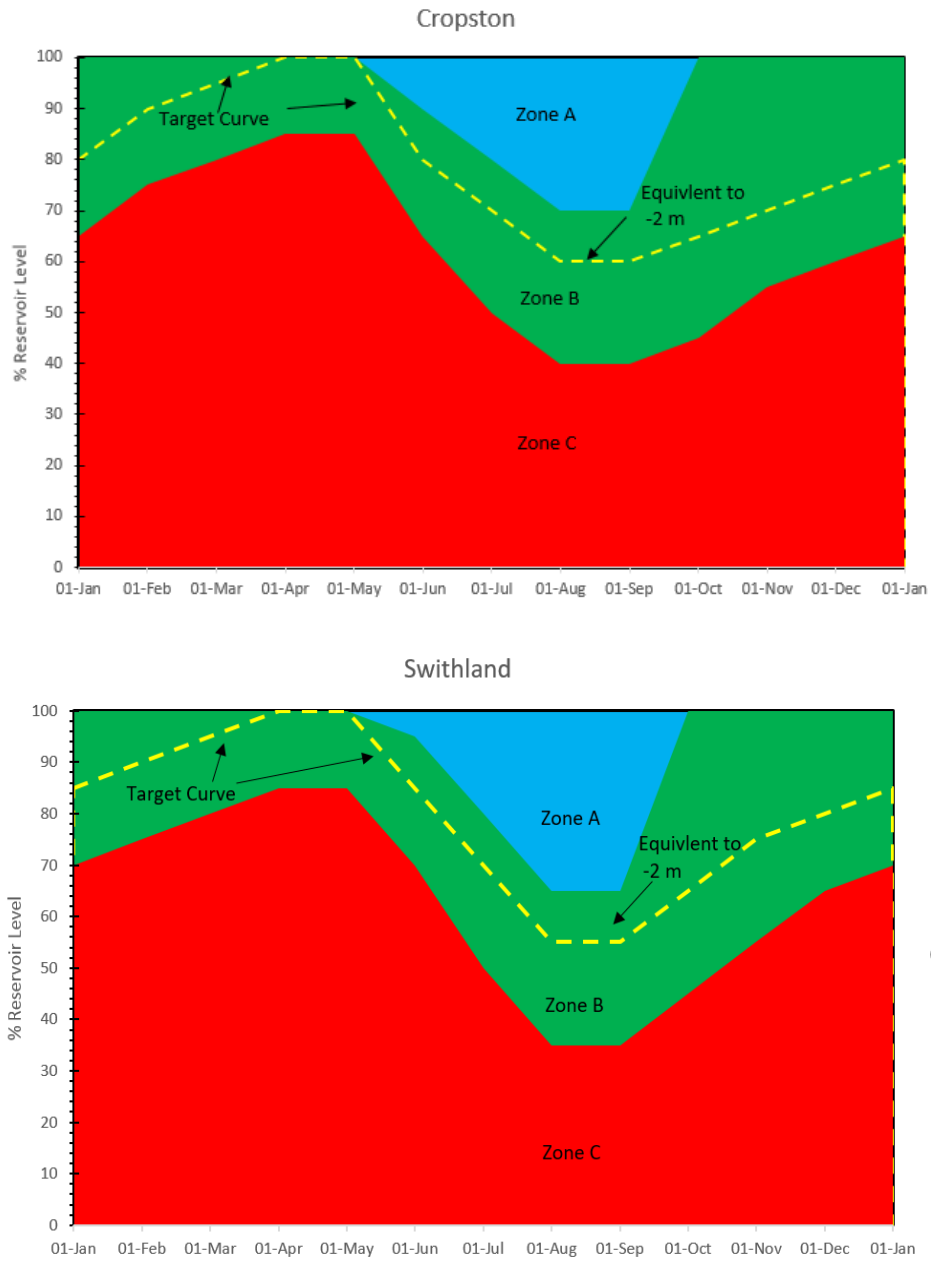


Illustration 2.1 Storage zones and conservation drawdown (Charnwood Level Management Agreement)

A summary of the operational rules presented by the agreement are provided in the following table.

Table 2.2 Proposed Operational rules under the Charnwood Level Management Agreement

Storage zone	Operational regime
A	Equal to or greater than 24Ml/d on an average weekly basis
B	Any level within licence constraints
C	Equal to or less than 14 Ml/d on an average weekly basis

Modelling has demonstrated that drawdown requirements are likely to be more frequently met under the revised management scheme. However, by maintaining summer drawdown, the proposed operation of abstraction of the reservoirs is also predicted to result in reduced spilling. This is true for both reservoirs, but particularly so for Swithland Reservoir. Recent practice has seen preferential use of Cropston Reservoir for abstraction in order to minimise operational costs. As a result, Swithland Reservoir has reached full capacity in most years (ESI & APEM, 2018a). The revised management scheme is expected to result in a reduction in the preferential use of Cropston Reservoir over Swithland Reservoir and therefore spilling of Swithland Reservoir is expected to be reduced compared with that observed in the recent historic record. Whilst separate to the AM programme itself, the implication of reduced spills for downstream ecology will require assessment and this need is included in monitoring requirements stated in this report (discussed further in Section 4).

3 Proposed Changes

3.1 Compensation flows

The selected notional solution for the Quorn Brook was (ESI & APEM, 2018c):

- Provide minimum compensation flow from both reservoirs (QB09).

Provision of compensation flows will introduce minimum flows to the reaches downstream of both Cropston and Swithland Reservoirs of up to 2 MI/d and 4 MI/d respectively, should infrastructure constraints allow and if AM indicates that this volume is required and does not have unacceptable adverse effects. This solution adopts UKTAG guidelines as a means of defining a desirable regime downstream of the impoundments, acknowledging in this instance that the Quorn Brook waterbody is not designated as an HMWB. Full details of the guideline UKTAG flows are given in ESI & APEM (2018a) and are summarised here in Table 3.1. As described in Section 3.2, Phase 1 of AM will not match UKTAG guideline flows; rather, compensation flows of 1 MI/d (Cropston) and 2 MI/d (Swithland) will be made in Phase 1 with a review for the need for additional flow beyond the initial releases undertaken as part of the AM process. Reasons for why a progression to higher compensation flows may not be recommended include unacceptable negative consequences, increased benefit relative to that expected from the initial compensation releases, or a lack of evidence that further increase would result in any additional noticeable benefit.

Lower seasonal spate releases (as described by option QB09_LS/EA (ESI & APEM, 2018c)) were also to be investigated/ trialled as part of AM. The duration and rate of rise/fall of the spate flows requires more precise definition than is given in the IA or CR, which were based on analysis of daily data. Substantiation of these refinements is required before any trialling of spate flows can proceed¹.

Table 3.1 Recommended releases at Cropston and Swithland Reservoirs (from ESI & APEM, 2018a)

Reservoir	Flow component ("building block")	Default flows as calculated (MI/d)	Duration	Frequency
Cropston	Annual minimum flow	1.8*	Constant	Constant
	Late summer/early autumn flow elevations	9.5	< 1 day**	Twice per year
Swithland	Annual minimum flow	3.6*	Constant	Constant
	Late summer/early autumn flow elevations	21	< 1 day**	Twice per year

*Including leakage from the reservoir. **Based on qualitative assessment of daily data

3.2 Phasing of implementation

To minimise the risk of unforeseen consequences, Phase 1 compensation releases will be made of 1 MI/d (Cropston) and 2 MI/d (Swithland). Review of monitoring data and assessment of success against the criteria defined in Section 5.1 will be made as per the timescales outlined in Section 6. Unforeseen consequences will also be assessed annually (incorporated within Annual Reporting) and adjustment or cessation of the

¹ A technical note on this analysis of 15-minute data will be produced prior to the implementation of the adaptive management process.

compensation flows will be made if unacceptable risk is identified (this is detailed in Section 6). Review of the success of Phase 1 will be conducted in close consultation with the EA.

If the success criteria are met following the first three years of compensation (and assuming that this incorporates a dry year), assessment of whether or not compensation flows should further be increased will be made. Agreement with the EA will be sought regarding proposed specifications for Phase 2; which will be informed by the data collected during Phase 1.

Trialling of late summer/early autumn flow elevations will follow establishment of the compensation releases (the primary aim of the notional solution being to introduce compensation releases). Assuming no unintended consequences are evident following review of data post compensation implementation, it is recommended that trialling of spate flows proceed.

Ideally, implementation (i.e. turning-on) of compensation flows might be made at a time of year when flows would naturally increase (autumn/winter), but this is not considered a necessity, given the small volumes concerned.

3.3 Prioritisation of drawdown requirements and compensation releases

While the compensation rates are modest, notably for the initial phase in AM, operation of the release should not hinder meeting of the recommended drawdown regimes of the reservoirs, either by accelerating drawdown during spring and summer or inhibiting recovery in the autumn and winter. As the absence of compensation does not prevent the achievement of GES² in the Quorn Brook waterbody (ESI & APEM, 2018a), the approach in AM prioritises the maintenance of the SSSIs as Protected Areas under the Water Framework Directive. Inflow data at Newtown Linford also shows periods in the record where flows would naturally fall below the minimum compensation volumes specified, and in these cases compensation flows might be reduced below the specified volumes whilst still being consistent with UKTAG guidance.

Another consideration is where compensation water is sourced within the reservoirs. There are three offtakes at different levels (an upper, lower and scour) and compensation water from both reservoirs is sourced from the water abstracted for supply. Under larger drawdowns, water will be required from the lower offtake. The lower offtake was used in both compensation trials and is not the same as the scour offtake; it is the offtake normally used by STWL for abstraction to treatment. However, during use of the lower offtake there is increased potential of drawing water of lower quality, which could have unintended consequences for the receiving watercourse (discussed further in Sections 4 and 5).

An example of where the above described conditions would have arisen occurred in the summer and autumn of 2018, as shown in the below figure, where drawdown continued during the stabilisation and recovery period, and levels neared dead storage. As can be seen, the low levels of drawdown during the autumn of 2018 have hampered recovery into 2019, such that the storage levels are in Zone C in March. This is despite no abstraction since autumn 2018.

Therefore, during high drawdown (Zone C), such as in 2018, reducing compensation flows would benefit water resource availability and attainment of desired water levels in the SSSI, and may also have benefits to water quality released from the reservoir. Consequently, it is recommended that should STWL identify a set of conditions such that, where there is a risk of failure to meet the level management objective, and the compensation release is a factor, STWL will consult with the Environment Agency and Natural England over potential temporary reductions in compensation. Any such temporary reductions will require the approval of the Environment Agency.

² As discussed above, even though the interim 2016 classification is Moderate, this is unrelated to the absence of compensation (related to Phosphate).

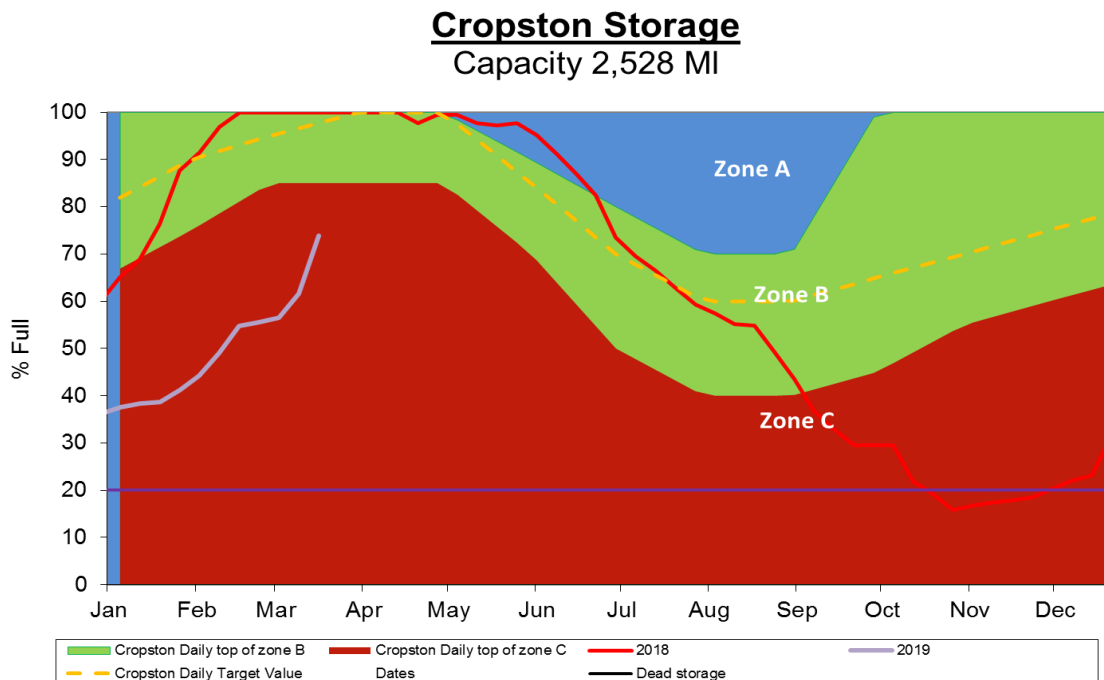


Illustration 3.1 Drawdown recorded in 2018 against target.

3.4 Summary of Adaptive Management actions

Following consultation with the EA and the finalisation of this report, AM actions can be summarised as follows (listed in sequential order):

- Implementation (i.e. turning-on) of compensation flows of 1 and 2 MI/d from Cropston and Swithland Reservoirs, respectively (Phase 1).
 - In parallel with implementation, short-term monitoring associated with the turning-on of the compensation flows will be undertaken to prevent unforeseen acute impacts.
- Assuming no acute impacts, the compensation flows of 1 and 2 MI/d will continue, with annual assessment and reporting for unforeseen negative consequences. Negative consequences could result in adjustment or cessation of the compensation flows.
- Following a minimum of three years of compensation evaluation of the success of Phase 1 of AM will be made:
 - If the releases of 1 and 2 MI/d are shown to be insufficient (and unacceptable unforeseen negative consequences have been avoided), recommendations will be made, in consultation with the EA, for a further increase in compensation flows. This assessment, and resulting specifications, will be made on the basis of data collected during the first cycle of AM. Should ecological data collected in Phase 1 demonstrate benefits beyond those currently foreseen, a Phase 2 of AM may not be considered necessary.
 - The duration of Phase 1 compensation flows may be extended as necessary, to ensure that a low flow year is represented within the AM cycle or if there are substantial periods during which compensation flows were not met because of the prioritisation of reservoir drawdown requirements,
- A second cycle of AM will be initiated as required.

4 Monitoring the Effects of Measures

Monitoring is considered over two timescales; short-term monitoring during initial implementation of the compensation flows, and longer-term monitoring over the AM cycle.

4.1 Monitoring during implementation (turning-on) of compensation flow releases

Implementation of releases has been trialled at both Cropston and Swithland Reservoirs without unacceptable impacts, although trial monitoring downstream of Cropston Reservoir was limited by a failure to gain access to observe effects along much of the downstream reach.

Monitoring during implementation will follow similar specifications to those detailed in the Cropston and Swithland Reservoirs compensation trial scoping report ESI & APEM (2016c) (Appendix A) and is intended as a precaution to ensure that any acute negative impacts are identified early (such effects are not anticipated). If unacceptable impacts are identified, implementation would be halted or adjusted as necessary. Access downstream of Cropston Reservoir will be sought but given the success of the more limited Cropston trial, is not considered a pre-requisite for implementation of the compensation flows.

Additional to the specifications of ESI & APEM (2016c), more regular water quality spot sampling will be carried out, as per concerns raised by the EA in response to the Swithland Reservoir flow trial (Paul Carrier, pers. comm.). The EA also requested a site visit during further trials or implementation, to observe first-hand the nature of on-the-ground changes when the discharge is taking place (Dan Widdowson, pers. comm.).

Summaries of the data to be collected are given in Table 4.1 and Table 4.2. It is recommended that the EA make a site visit on both Day 1 and Day 2, to afford a direct comparison between pre and post compensation release conditions.

Table 4.1 Indicative programme of short-term monitoring to be carried out at implementation (turning-on) of compensation release at Cropston Reservoir

Monitoring elements	Day 1 - pre compensation release	Day 1 - post compensation release	Day 2
Flow*	Spot gauge three times in the thirty minutes prior to compensation release at E15-03 (to establish reliable pre-implementation baseline)	Commence spot gauging at E15-03 one hour after compensation release has been confirmed to have attained target flow. Visual inspection of flow increasing prior to this point (with photographic/video record). Spot flows measurements should be undertaken a minimum of five times over the subsequent hour to confirm the release is observed at the compliance point.	Spot gauging of flows at E15-03 five times in a one-hour period to again confirm compensation flows are at the required amounts
Water quality - field and laboratory measurements	Once at E15-01 (control) E15-03 and E15-05.	n.a.	Once at E15-01 (control), CT-01 (the compensation flow itself), E15-03 and E15-05
Water quality - field measurements only	One hour and 30 minutes prior to release, at the compensation flow (CT-01) and at E15-03.	Every 30 minutes at the compensation flow (CT-01) and at E15-03. From half an hour pre-release, until a minimum of five post-release spot checks have been taken (dependent on no acute adverse effects being identified).	At 30 minute intervals at the compensation flow (CT-01) and E15-03. A minimum of three measurements to be taken as a check that parameters are stable.
Habitat walkover*	A habitat walkover survey focusing primarily upon surface flow types and substrate.	n.a.	A visual assessment of changes in habitat quantity and character to be made in comparison to the baseline phase.

*Implementation should be undertaken under dry conditions when climatic influences on flow (and associated dilution effects) are low. This will allow a more representative assessment of acute impacts.

** Note that walkovers downstream of Cropston Reservoir could not previously take place because of a lack of access permission. This may again be the case at the time of implementation, but, given the success of the more limited Cropston trial, is not considered a pre-requisite for implementation of the compensation flows.

Table 4.2 Indicative programme of short-term monitoring to be carried out at implementation (turning-on) of compensation release at Swithland Reservoir

Monitoring elements	Day 1 - pre compensation release	Day 1 - post compensation release	Day 2
Flow*	Spot gauge three times in the thirty minutes prior to compensation release at E15-07 (to establish reliable pre-implementation baseline)	Commence spot gauging at E15-07 30 minutes after compensation release has been confirmed to have attained target flow. Visual inspection of flow increasing prior to this point (with photographic/video record). Spot flows measurements should be undertaken a minimum of five times over the subsequent hour to confirm post implementation flow.	Spot gauging of flows at E15-07 five times in a one-hour period to again confirm compensation flows are at the required amounts
Water quality - field and laboratory measurements	Once at E15-06 (control), 'Location 4' of the previous trial (immediately downstream of the Woodhouse Eaves tributary), E15-08 and E15-09	n.a.	Once at E15-06 (control), 'Location 1' of the previous trial (the compensation flow itself), 'Location 4' of the previous trial (immediately downstream of the Woodhouse Eaves tributary), E15-08 and E15-09.
Water quality - field measurements only	One hour and half an hour prior to release, at E15-06 (control) and 'Location 4' of the previous trial (immediately downstream of the Woodhouse Eaves tributary),	Every 30 minutes at the compensation flow, at E15-06 (control), and 'Location 4' of the previous trial (immediately downstream of the Woodhouse Eaves tributary), from an hour pre-release, until a minimum of five post-release spot checks have been taken (dependent on no acute adverse effects being identified).	At 30 minute intervals at the compensation flow, at E15-06 (control), and 'Location 4' of the previous trial (immediately downstream of the Woodhouse Eaves tributary). A minimum of three measurements to be taken as a check that parameters are stable.
Habitat walkover	Habitat walkovers are only recommended if implementation occurs during a period of naturally occurring low flows in the catchment. Otherwise, the data collected as part of the 2016 trial is considered to be sufficient as a check against short-term effects on habitat.		
*Implementation should be undertaken under dry conditions when climatic influences on flow (and associated dilution effects) are low. This will allow a more representative assessment of acute impacts.			

4.1.1 Water quality

Water temperature, pH, dissolved oxygen (DO) saturation and electrical conductivity should be measured using a handheld probe at the compensation release on Day 1 (see Table 4.1 and Table 4.2). A measurement will be taken one hour prior to, and half an hour prior to switching-on of the compensation release and then once every 30 minutes following this. A minimum of five spot samples will be taken following implementation on Day 1. If unacceptable impacts are identified, implementation would be halted or adjusted as necessary. Although the risk for DO saturation to decrease as a result of compensation implementation is considered to be low, under the following circumstances the compensation discharge will be reduced:

- Two consecutive DO measurements show a deterioration in WFD indicative status by one class, compared to the DO saturation measured prior to the commencement of the trial, at locations E15-03 (in relation to the Cropston release) and 'Location 4' of the previous trial (in relation to the Swithland release).
- A single DO measurement shows a deterioration in WFD indicative status by 2 classes, compared to the DO saturation measured prior to the commencement of the trial, at locations E15-03 (in relation to the Cropston release) and 'Location 4' of the previous trial (in relation to the Swithland release).

Turbidity will be assessed visually throughout Day 1 and Day 2 and the respective APEM and Stantec managers will be notified immediately should any risk be observed.

In addition, water quality samples for laboratory analysis will be taken at the locations detailed in Table 4.1 and Table 4.2 for the laboratory parameters set out in Table 4.3. These data will not allow for real-time adjustment or halting of the compensation release; however, they will inform the need for any additional requirement for short-term monitoring beyond Day 2 of implementation (which is not anticipated). Assuming no acute negative effects are identified, the water quality monitoring programme will revert to that outlined in Section 4.2.4.

Table 4.3 List of water quality parameters to be measured during implementation monitoring

Determinand	Measurement
pH	Field
Dissolved Oxygen (both mg/l and % saturation)	
Temperature	
Electrical Conductivity	
Total Ammonia	Laboratory
Unionised Ammonia	
Ammoniacal Nitrogen as N	
Nitrogen: Total Oxidised as N	
Nitrite as N	
Nitrate as N	
Orthophosphate, Filtered as P	
Phosphorus: Total as P	
Suspended solids	
BOD (analysis should be started within 48 hrs of sample collection according to UKAS)	
Alkalinity to pH 4.5 as CaCO ₃	

4.1.2 Habitat walkover

Walkovers downstream of Cropston Reservoir could not previously take place because of a lack of access permission and cannot be guaranteed for the implementation of the compensation release. However, given the success of the more limited Cropston trial this is not considered a pre-requisite for implementation.

Habitat walkovers are recommended between Cropston and Swithland Reservoir. Habitat walkovers will be conducted on Day 1 and Day 2 of implementation, as described in Table 4.1. A visual assessment of changes in habitat quantity and character will be made, comparing baseline conditions to post implementation conditions the day following the turning-on of the compensation release. Walkover will focus primarily upon surface flow types and substratum, and in particular turbidity and deposition of fine sediments. Habitat transects may also be taken at suitable habitat, to model the effect of potential changes during Phase 2.

Habitat walkovers downstream of Swithland Reservoir are only recommended if implementation occurs during a period of naturally occurring low flows in the catchment. Otherwise, the results of the 2016 trial are considered to be a sufficient check of short-term effects on habitat; it has already been demonstrated that no short-term acute negative impacts to morphology will result from implementation of the compensation release. Habitat transects are not considered necessary.

4.2 Monitoring during Adaptive Management

Monitoring over the AM cycle will determine whether benefits predicted for the notional solution are delivered and that unintended consequences of the notional solution or of the proposed changes to reservoir drawdown are avoided. The proposed monitoring plan is summarised in Table 4.1. Justification and details of the recommended monitoring are given in subsequent subsections.

It should be noted that the monitoring programme is subject to change during the AM process depending on the outcomes of the annual reviews.

Table 4.4 Quorn Site Investigation Plan monitoring locations.

	Cons tant	Spot flow gaug	Bed sediment and	Water quality	Water quality	Macroinverte-	Fish	Macrophytes and Habitat at walk over,	Water quality	Water quality	Macroinverte-	Fish	Macrophytes and
River Lin at Newtown Linford	E15-01	SK 52140 09800	•										
Cropston Reservoir release	E15-01a	SK 52255 09802				•	•	•					
Quorn Brook d/s of Cropston	E15-03	SK 55552 11546	•	•	•	•	•	•					
Swithland Brook at Swithland village	E15-04	SK 55310 12910				•							
Quorn Brook at Swithland Reservoir inlet	E15-05	SK 56545 12740				•							
Woburn House Leazes tributary	E15-06	SK 55338 14798		•		•	•	•					
Quorn Brook d/s of Swithland Reservoir release	E15-07	SK 55620 14950		•		•	•	•					
Quorn Brook at Mill Farm	E15-08	SK 55841 15826		•		•	•	•					
Quorn Brook at Quorn	E15-09	SK 56374 16499				•							

Pre-implementation one-off sampling Post-implementation one-off sampling.

*Additional water quality monitoring of the reservoirs beyond that routinely undertaken by STWL will be reviewed during AM. Monitoring will be carried out each year of adaptive management, unless indicated otherwise.

4.2.1 Reservoir storage

Reservoir levels and drawdown patterns will be monitored as part of STWL's ongoing operational management as part of the Charnwood Level Management Agreement.

4.2.2 River flows

Flows downstream of Cropston upstream of Swithland (E15-03) and Mill Farm (E15-08) are continuously gauged by STWL using temporary installations put in place for investigation and adaptive management. These are sufficient for the assessment for AM; however, it is understood that STWL plan to install a permanent flow gauge at an appropriate location downstream of Swithland Reservoir in AMP7. Spot flow gauging will continue at River Lin at Newtown Linford (E15-01), Cropston upstream of Swithland (E15-03), Trib d/s Swithland (Woodhouse Eaves) (E15-06) and Mill Farm (E15-08), assuming the requirement remains for extension/enhancement of the ratings.

4.2.3 Morphology

Options appraisal (ESI & APEM (2018c) predicted the following hydromorphological benefits of the notional solution.

1. The annual minimum flow downstream of Cropston Reservoir will ensure a continuously wetted area of habitat capable of maintaining reasonable sized and healthy populations of water plants and animals throughout the year. The quality of this habitat has not been established, as access restrictions prevented walkover monitoring in association with the trial release³.
2. The annual minimum flow downstream of Swithland Reservoir will ensure an increase in habitat availability for the majority of target fish species in the Quorn Brook downstream between the Woodhouse Eaves tributary and Quorn village.
3. Late summer/ early autumn flow elevations downstream of Cropston Reservoir will flush away superficial deposits of fine sediment and/ or plant debris lying on the channel bed or at the river margins. It was acknowledged that, in the absence of the larger magnitude releases, movement of sediment accumulations may be limited, as would the maintenance of bedforms, e.g. riffles, pools and bars. This might be exacerbated by reduced spilling expected to result from implementation of measures to maintain reservoir storage.

Hydromorphological benefits will be assessed through comparison of habitat walkovers undertaken before and after implementation³.

A habitat walkover was undertaken downstream of Swithland Reservoir as part of the flow trial (ESI & APEM, 2017a). This is considered sufficiently recent not to need repeat survey, although it should be acknowledged that changes may occur prior to implementation. Provision was not made to monitor the success of spates in flushing fine sediment accumulations during the Swithland trial as the compensation review focussed on the annual minimum flow. Baseline sediment sampling and piezometry is therefore recommended in advance of the implementation of compensation releases at the downstream of Cropston upstream of Swithland (E15-03) and Mill Farm (E15-08). It is envisaged that the volume of samples taken would be sufficient to provide an indication of changes within a Weight of Evidence approach, not to provide a robust statistical baseline (which requires a large sampling programme). Repeat sampling (habitat walkover, sediment sampling and

³ Lack of access permissions precluded habitat walkovers in the reach between Cropston and Swithland reservoirs and therefore no baseline is currently available. This did not prevent the trialling of the release or monitoring of flows at E15-03, just the assessment of downstream effect on habitat. It is assumed that access permission will be obtained prior to implementation and a survey(s) will be undertaken prior to implementation to establish baseline conditions.

piezometry) is envisaged only after three years post-implementation of spates (if implemented), or if the reduction in spills over the three year period is evidently outside the current range. Undertaking repeat sampling after three years allows a degree of adaptation of the channel, acknowledging that adaptation may not be complete.

4.2.4 Water quality

Trials undertaken at both Cropston and Swithland reservoirs (ESI & APEM, 2017a and 2017b) suggested that compensation releases may cause downstream increases in the following physico-chemical quality elements and priority substances; water temperature, DO, orthophosphate, metals and suspended sediment. The WFD requires that action be taken to prevent deterioration of status of groundwater and surface waterbodies. For each parameter monthly monitoring is considered necessary for WFD classification and should be carried out for at least the first-year post implementation.

It is assumed that on-going monitoring of water quality in the reservoirs will be undertaken by Severn Trent Water and the results provided for the evaluation reviews. The adequacy of this data will be reviewed, and supplementary monitoring may be recommended during the AM process.

Water temperature

Seasonally varying effects on water temperature may result from the release of reservoir water from storage. This may be mitigated by the location of the draw-off, but during times of high drawdown lower draw-off may have to be used and effects were observed during trials, most notably at Swithland Reservoir. DO saturation can also be affected by water temperature.

Water temperature is an important influence on instream biota. For the Quorn Brook waterbody WFD water temperature is classified with a 98th percentile of 25°C being the boundary between High and Good status. It is therefore considered unlikely that deterioration of WFD status, even at the local reach scale, could occur as a result of implementation of the compensation releases. However, temperature is easily measured when sampling for other parameters.

Dissolved oxygen

DO is an important control on aquatic biota. An annual minimum flow at Cropston Reservoir may improve DO concentrations in underdrainage from the base of Cropston reservoir. During flow trial releases, high DO concentrations were also recorded immediately downstream of the discharge locations (ESI & APEM, 2017a/b), which was attributed to the discharge mechanism. The effects of any anoxia on compensation water may be therefore be mitigated by entrainment of oxygen into the flow during compensation release, and by selectively drawing water from the uppermost offtake in the reservoir. Spate flow releases may also help maintain exchange of oxygen within gravels, which is important for macroinvertebrates and for survival of fish eggs.

DO in the river is easily measured when sampling for other parameters. Measurement within gravels is not proposed. Ecological receptor data are preferred as a means of detecting impact, and piezometry data are preferred as a means of indicating if this is a mechanism for any impacts observed.

Orthophosphate

Both reservoirs, and Swithland reservoir in particular, are considered to be stores of phosphorus, and both fail under the WFD for total phosphorus and related phytoplankton blooms. Mass balance calculations for Cropston Reservoir demonstrated that a release of 2 Ml/d would be unlikely to result in deterioration in the status of the Quorn Brook with respect to phosphate, although concentrations did move closer to the High/Good boundary (ESI & APEM, 2018a). Data collected as part of the Swithland Reservoir flow trial also demonstrated that a compensation release would represent a source of phosphate to the downstream

watercourse, although downstream catchment land-use was also important and dilution calculations suggested with that the introduction of a 4.0 Ml/d compensation flow downstream water quality status would remain at Moderate status. However, one-off flow trials cannot capture seasonal variations in phosphate concentrations, and therefore some uncertainty remains regarding the potential effect of a continuous compensation release on water quality status.

Metals

The risk of stratification cannot be discounted for either reservoir when at full storage capacity (ESI & APEM, 2018a).

The Cropston Reservoir flow trial suggested that increases in metal concentrations were largely associated with downstream mobilisation of in-channel sediments, rather than the reservoir discharge itself; the exception being copper, which in its dissolved form, was indicative of being above the EQS value (bioavailable) immediately downstream of the discharge (ESI & APEM, 2017b).

The detection of manganese in the water released from the middle offtake at Swithland suggested that the reservoir may be prone to stratification, potentially with a risk that anoxia could develop in the lower part of the water column (hypolimnion), mobilising metals (APEM, 2015). During the Swithland Reservoir flow trial an apparent short-term increase in manganese concentrations was recorded; however, this effect diminished as the trial progressed, despite the greater magnitude of compensation flow in the final phase of the trial (ESI & APEM, 2017a). Manganese in its dissolved form remained well below the EQS threshold (bioavailable). However, uncertainty remains regarding possible seasonal variation in some metal concentrations that might be expected within the release water.

Short-term monitoring during implementation of the compensation releases should include a heavy metals analysis suite and would seek to demonstrate that, once concentrations stabilise following compensation flow introduction, dissolved concentrations do not remain above EQS thresholds at 'downstream of Cropston, upstream of Swithland (E15-03)' in relation to the Cropston release and at Mill Farm (E15-08) in relation to the Swithland release.

Collection of a seasonal baseline of metals concentrations is recommended, for one full year, as follows:

- Pre-compensation release implementation monthly samples should be collected from locations downstream of Cropston upstream of Swithland (E15-03) and Mill Farm (E15-08) (as well as control locations River Lin at Newtown Linford (E15-01a) and Woodhouse Eaves tributary (E15-06)).

Assuming that the pre-implementation data do not demonstrate dissolved metal concentrations above EQS thresholds, post compensation implementation criteria to ensure against priority substance (metals) failure are:

- In the first year of the AM programme, repeat monthly samples will be collected at both the Cropston and Swithland discharges themselves, and from locations downstream of Cropston, upstream of Swithland (E15-03) and Mill Farm (E15-08) (as well as control locations River Lin at Newtown Linford (E15-01a) and Woodhouse Eaves tributary (E15-06)) to allow for risk associated with possible seasonal variation to be adequately assessed.

Sediment mobilisation

Owing to the absence of compensation, exposed substratum is prevalent in the channel downstream of Swithland Reservoir. The existence of similar exposure is unconfirmed downstream of Cropston Reservoir as no habitat walkover survey has been carried out. There is also evidence of poaching/erosion downstream of Swithland Reservoir due to vehicle access. The Swithland flow trial resulted in mobilisation of fine sediment (ESI & APEM, 2017b) and was mostly due to the mechanism of release for the trial. This is less likely for an

ongoing small release. Any effects are likely to be localised and temporary and the reservoir already spills down this channel.

Monitoring of suspended solids at 'downstream of Cropston upstream of Swithland (E15-03)' and at Mill Farm (E15-08) (as well as control locations River Lin at Newtown Linford (E15-01a) and Woodhouse Eaves tributary (E15-06)) is recommended to continue as part of the AM sampling programme.

4.2.5 Macrophytes and phytobenthos

Littoral macrophytes

Monitoring of the littoral macrophyte communities is necessary at both reservoirs to determine whether changes to reservoir levels affect the condition of the Cropston and Swithland Reservoir SSSIs. However, it is assumed that this will be undertaken by NE as part of their normal surveillance monitoring and is not proposed as part of STWL's AM process.

Quorn Brook

OA considered that macrophyte and phytobenthos abundance and/ or diversity may increase in response to increased flow conditions downstream of the reservoirs, but did not assign benefits to WFD status, as WFD classification of this element is driven by nutrient status.

Continued monitoring of macrophytes and phytobenthos is therefore not recommended unless water quality data indicate that compensation flow releases have substantially increased nutrient concentrations downstream of the reservoirs. Should this be the case, survey of macrophytes and phytobenthos is recommended three years post compensation implementation to allow assessment of unintended negative effects of increased eutrophication. Macrophytes would be surveyed at locations E15-01a (River Lin at Newton Linford), E15-03 (Quorn Brook d/s Cropston), E15-04 (Swithland Brook at Swithland), E15-05 (Woodhouse Eaves tributary) and E15-08 (Quorn Brook at Mill Farm); allowing for comparison with baseline data. Diatom data would be collected from the same locations.

4.2.6 Macroinvertebrates

OA considered there to be potential benefits to macroinvertebrates from increased DO concentrations, increased flow and from improved physical habitat and periodic flushing of fine sediment associated with spate releases, although expected benefits were modest and were not anticipated to result in an increase of WFD status. However, impacts cannot be discounted due to fine sediment mobilisation, changes in water quality and reductions in spills at Swithland Reservoir (although this is outside of the AM programme).

Annual monitoring of downstream of Cropston, upstream of Swithland (E15-03) and Mill Farm (E15-08) is considered sufficient to assess any unintended consequences of measure implementation on macroinvertebrates. Spring and autumn sampling only is recommended, except in, or after, notably dry years. Continued annual monitoring of control locations River Lin at Newtown Linford (E15-01a) and Woodhouse Eaves tributary (E15-06) (EA locations and therefore infill only) is also recommended to screen for other pressures. Discontinuation of Quorn Brook at Quorn (E15-09) is advised, as this location is not representative of the wider waterbody and effects of compensation releases are not anticipated at this locale.

4.2.7 Fish

OA considered any benefits of the notional solution on the fish community in the reach downstream of Cropston Reservoir to be limited by the impassable barriers presented by the reservoirs (ESI & APEM, 2018c). Surveys have recorded only three-spined sticklebacks, a minor and ubiquitous species, unlikely to be negatively affected by the compensation implementation. Therefore, it is proposed that monitoring of downstream of Cropston upstream of Swithland (E15-03) is discontinued.

Downstream of Swithland reservoir the fish community already supports Good status (ESI & APEM, 2018a). Subtle beneficial changes to the fish community resulting from implementation of compensation releases are likely to be difficult to demonstrate without disproportionate survey effort. Therefore, it is considered that fish surveys for AM be discontinued unless water quality and/ or morphological data indicate a need for a check of any possible effect on the status of the fish biological element.

4.2.8 Invasive Non-Native Species

An absence of water in the channel downstream of Cropston Reservoir may constitute a barrier to the spread of INNS that would be removed were compensation flows to be introduced. However, the dams themselves constitute a greater barrier. The Rothley Brook transfer constitutes another potential pathway and is currently not used because of high nutrient levels in the source water and a risk of the spread of signal crayfish (*Pasifastacus leniusculus*) into the upper Quorn Brook catchment, which may still provide a refuge for white-clawed crayfish (*Austropotamobius pallipes*).

In the absence of the use of the Rothley Brook transfer, the risk from the introduction of compensation flows is considered minimal.

4.2.9 Severe Pressure Surveys

Severe Flow Pressure Surveying (SFPS) (SNIFFER, 2013) were requested by the EA during trialling of the Swithland compensation release. SFPS was developed as a rapid method for gathering a weight of evidence to identify river water bodies that might be ecologically impacted from major and severe flow alterations. This was considered more appropriate for the AM phase, when any longer-term changes were more likely to be apparent, particularly with respect to possible sedimentation impacts. This provision is not currently specified in the SIP and, given that the SFPS were intended as a rapid appraisal method, are considered more comprehensively met by the recommended monitoring described above.

5 Evaluating Success

5.1 Success criteria

The predicted benefits to ecology as a result of introducing compensation releases are relatively small because the Quorn Brook waterbody achieves GES in the absence of compensation release (ESI & APEM, 2018c). Consequently, success criteria for AM will not be determined by a direct ecological outcome as might otherwise be expected. Two criteria are proposed:

- Meeting the proposed compensation flows; Phase 1 – 1 MI/d downstream of Cropston Reservoir and 2 MI/d downstream of Swithland Reservoir. If this is successfully met and no unacceptable negative impacts have resulted from compensation implementation (the second success criteria) then the requirement for further success criteria relating to target flows for Phase 2 will be reviewed.
 - Under the scenario where the requirements of reservoir level management are in conflict with compensation release, as described in Section 3.3, a reduction of compensation flows will not constitute a failure.
- Avoiding unacceptable negative impacts attributable to the implementation of measures;
 - short-term - avoidance of acute impacts that could occur as a result of implementation (turning-on) of compensation flows or trialling of spate flows;
 - long-term - defined as indicative, waterbody-level, WFD deterioration of any classification element that can reasonably be ascribed to compensation release implementation.

Further details for the assessment of these criteria are given in Sections 5.2 to 5.4.

5.2 River flows

Continuously gauged flows monitored downstream of Cropston upstream of Swithland (E15-03) and Mill Farm (E15-08) will be assessed annually to determine compliance with the recommended flow releases of 1 MI/d downstream of Cropston Reservoir and 2 MI/d downstream of Swithland Reservoir (Phase 1) and assuming progression to Phase 2, 2 MI/d downstream of Cropston Reservoir and 4 MI/d downstream of Swithland Reservoir.

Reservoir spills will be driven by climate and the demand on Cropston/ Swithland Reservoirs for water supply. The effect of the compensation flows on reservoir spills will therefore be differentiated from climatic factors and the effect of reservoir drawdown provision using AQUATOR simulations.

It should also be noted that the IA found errors in the EA gauged flow record at Newtown Linford. A review into the reliability of low flow estimates of the gauge was advised, but this is considered outside the scope of STWL's investigations.

5.3 Avoidance of unacceptable negative consequences (short-term)

As described in Section 4.1, if unacceptable impacts are identified immediately following the turning-on of compensation flows, implementation would be halted or adjusted as necessary.

5.4 Avoidance of unacceptable negative consequences (long-term)

5.4.1 Water quality

Indicative classification will be used as the comparator to assess WFD deterioration.

EA classification of water quality in the Quorn Brook waterbody has previously been informed by three monitoring locations: River Lin at Newton Linford (E15-01a), Swithland Brook at Swithland (E15-04) and Quorn Brook at Quorn (E15-09). It is understood that future classifications will be based on locations River Lin at Newton Linford (E15-01a) and Quorn Brook at Quorn (E15-09) alone, although this could be subject to change⁴.

These locations, alongside the other locations detailed in Table 4.4, will continue to be monitored monthly for water quality by STWL. As part of the annual reporting process, an indicative classification based on these locations will be made, comparing pre-implementation data to post-implementation data to assess the risk of waterbody-level deterioration in status. Comparison of locations affected by the releases to those upstream of the reservoirs, and therefore unaffected by the releases, will also be made to control for any catchment-wide changes not attributable to the compensation releases.

Deterioration under the WFD is defined as:

“a change in the class of any one of the quality elements used to determine the status in a water body from its existing class to the class below, or any deterioration within the lowest class. It is not a change within a class unless already in the lowest class” (EA, 2018).

No quality elements of the Quorn waterbody are classified within the lowest class, and therefore within class deterioration will not be considered as deterioration. Any localised deterioration in indicative status of phosphate would be considered in the context of benefits resulting from improved flows and net effects on ecology. Modest increases in phosphate concentrations at specific sampling locations may be considered acceptable (and indeed are predicted), as long as the waterbody-level status does not show deterioration. Deterioration from the recent indicative statuses of High and Moderate, at monitoring locations Cropston upstream of Swithland (E15-03) and Mill Farm (E15-08) respectively, would therefore not be prohibitive of continuation of the compensation releases (the Cropston flow trial water quality data suggested a deterioration from High to Good may occur), provided that waterbody-level deterioration does not occur.

If dissolved metal concentrations for all locations on all sampling occasions remain below pre-implementation EQS thresholds, it is then recommended that metals analysis be discontinued from the AM programme after the first year. It is proposed that monthly physico-chemical water quality samples are collected throughout the AM programme. Following AM, STWL monitoring of water quality will be discontinued and routine EA water quality monitoring alone will be sufficient for longer-term monitoring of the catchment.

Suspended solids are not classified under the WFD and assessment will instead be based on (the now repealed) freshwater fish directive guideline limits.

5.4.2 Macrophytes and phytobenthos

Littoral macrophytes

The SSSI status of Cropston and Swithland Reservoirs will be assessed as part of condition monitoring by NE.

Quorn Brook

Potential impacts on macrophyte and phytobenthos communities will be assessed against WFD requirements, should water quality data collected as part of AM indicate that a substantial increase in nutrient status occurs. Should this be the case, data will be collected three years post implementation and used to generate indicative WFD classifications, which will be compared against the baseline data (the condition of macrophyte

⁴ It should be noted that the EA change in locations used to inform WFD status might result in a change in classification that would be unrelated to any ‘real world’ changes, including the effect of compensation releases. This will be considered in future reporting.

communities as described in Appendix I of the IA report (ESI & APEM, 2018a), as well as the subsequent indicative classifications that were reported on as part of the annual reporting process (ESI & APEM, 2018b, Stantec & APEM, 2019)). Should these data indicate no deterioration in WFD status, as anticipated, STWL monitoring of macrophytes and phytobenthos would then be discontinued.

5.4.3 Macroinvertebrates

The baseline condition is defined as “The condition of macroinvertebrate communities as described in Appendix G of the IA report (ESI & APEM, 2018a), as well as subsequent indicative classifications reported on as part of the annual reporting process until the time of compensation implementation”.

A pathway for deterioration of the macroinvertebrate element, as a result of implementation of the compensation releases, does exist. The element is classified by the EA on the basis of two locations; Newton Linford (E15-01a), sited upstream of the reservoirs, and Mill Farm (E15-08), sited downstream of Swithland Reservoir. The EA have confirmed that these are the locations currently used to inform classification.

Pending this, three years post compensation annual data will be used to assess whether compensation releases (with due consideration of any effect on habitat as a result of reduced reservoir spilling attributable to the licence change) resulted in change to the indicative WFD status of the macroinvertebrate communities of downstream of Cropston, upstream of Swithland (E15-03) and Mill Farm (E15-08).

Whilst a reduction in indicative status at E15-03 and E15-08 may not affect waterbody status, if impacts can reasonably be ascribed to an effect of the compensation releases a recommendation to reduce/ cease the releases may be made. Assessment will also be made of impacts arising as a result of reduced reservoir spilling attributable to the proposed licence change; however, this would not affect evaluation of the success criteria as the proposed licence change is not part of the notional solution being implemented.

Although not a requisite for success assessment of whether macroinvertebrates can be considered to have benefited from the compensation releases will be made. Under the WFD macroinvertebrate communities that more closely resemble those expected of the Quorn Brook in the absence of effects of impoundment would constitute a benefit to macroinvertebrates (acknowledging that other pressures, including diffuse pollution and morphological changes, will continue to have an effect). Reduced frequency of indications of possible low flow stress and excessive fine sediment deposition effects downstream of Cropston, upstream of Swithland (E15-03) and at Mill Farm (E15-08) would constitute recognisable benefits. This is most likely to be improved downstream of Cropston Reservoir. In the less modified reaches downstream of Swithland Reservoir (c. 0.8 km), episodic low flow stress is also suspected, but is infrequently evident under current conditions and improvements may therefore be less clear. Taxa associated with high flow velocities are also already observed. However, these may become more numerous and diverse.

Three years post compensation implementation a Weight of Evidence approach will be used to assess whether compensation releases resulted in changes to the macroinvertebrate communities of downstream of Cropston, upstream of Swithland (E15-03) and Mill Farm (E15-08). This will be achieved through comparison of macroinvertebrate data (species lists as well as index outputs) before and after implementation of compensation releases, as well as between locations within the catchment

It is anticipated that a three-year period of AM will be sufficient to demonstrate no unforeseen consequences upon macroinvertebrate communities resulting from compensation implementation. Following Phase 1 of AM, monitoring of macroinvertebrates will continue, assuming implementation of the higher rates of compensation. Following Phase 2, if assessment concludes that unacceptable impacts have not resulted, then monitoring for ongoing issues in the catchment will be addressed thereon from routine EA sampling.

5.4.4 Fish

Qualitative comparison of fish data pre- and post-implementation of compensation releases will be made as part of annual reporting, should EA surveillance data be available (Section 4.2.7). The baseline condition is defined as the condition of fish communities as described in Appendix H of the IA report (ESI & APEM, 2018a), and subsequent data reported on as part of the annual reporting process until the time of compensation implementation.

The EA previously classified fish under WFD on the basis of data for two locations; Newtown Linford (E15-01a) and Mill Farm (E15-08). However, it is understood that future classification will be made on the basis of Newtown Linford (E15-01a) alone. Assessment of deterioration in WFD status in relation to implementation of the (Swithland) compensation will only be made if water quality and/ or morphological data indicate a need for a check of any possible net effect of unintended negative consequences. Assessment of any changes due to revised operation of the reservoirs to maintain the desired drawdown profile would also be made, but this would not affect evaluation of the success criteria as the proposed licence change is not part of the notional solution being implemented.

6 Adaptation and Adjustment

This section sets out how failure is recognised during the evaluation of success (Step 4 in Illustration 1.1), and how different types of failure are dealt with. It is not attempted here to review any given scenario of failing to meet the success criteria. However, the process that will be taken to adapt and adjust in response to 'failure' to meet the success criteria is outlined in Illustration 6.1.

'Failure' to achieve success as defined by the success criteria is not necessarily a failure of AM because AM does not pre-suppose success in one cycle. Rather, success is recognised as uncertain and AM acknowledges at least the potential for cycles of further adjustment. Failure must therefore be defined in terms of an inability to achieve a progressive iteration to a solution. Note also that success will not necessarily achieve an optimal solution. It is sufficient to arrive at a solution that realises the success criteria (Section 5) within a timescale that is compatible with legislative or operational goals (i.e. by the end of AMP8).

'Failure' to achieve the stated success criteria must be classified as one of the below:

- Compliance failure
- Failure due to external causes
- Failure due to measurement uncertainty
- Failure to meet stated success criteria

This assessment must be made separately for each intervention (in this case for compensation flows and trialling of spates downstream of the two reservoirs). The AM monitoring scheme, supported by regulatory surveillance monitoring, must allow differentiation between these types of failure.

6.1 Compliance failure

Compliance failure for the Quorn Brook is a failure by STWL to release the target flow regime. In the event that unintended consequences are not avoided, then an adjustment to the compensation regime, or alternative measures, might be instigated. Otherwise, continued monitoring of the intended flow regime would be needed, until a compliant regime can be assessed. The result is a deferred solution.

6.2 Failure due to external causes

If flow releases are compliant, but unintended consequences have not been avoided, monitoring data should be evaluated to establish whether this is due to either:

- Other pressures
- Unusually wet or dry conditions.

If it is considered that deterioration is likely to have occurred as a result of either of the above reasons, it cannot necessarily be inferred that measure implementation would have avoided unintended consequences. Expert judgement may be required to draw reasonable inference. Continued monitoring of the intended flow regime may also be needed in the absence of other pressures or unusual weather conditions. The result is a deferred solution.

If other pressures appear likely to continue to affect AM, mitigation measures directed at addressing these may also be needed for AM to be successful. If these cannot be economically addressed, AM to the defined success measures may not be a viable solution. In this scenario it is recommended that the target flow

releases are made as specified, with revised success criteria, or monitoring continuing for compliance purposes only (and in the short-term as a continued check of unintended consequences, as necessary).

6.3 Failure due to measurement uncertainty

If flow releases are compliant and it is uncertain whether unintended consequences have been avoided, expert judgement should be used to consider whether this may be fairly ascribed to the uncertainty in measurements. Expert judgement may be needed because post-intervention sampling is recommended for a short period and that a Weight of Evidence approach has been adopted, measurement uncertainty may not be specified in numerical terms.

Measurement uncertainty may be classed as either temporary, or systemic. Temporary measurement uncertainty might include unusual or one-off failures in sampling or survey protocols. In this event, failure to discriminate between success and “failure” because of temporary measurement uncertainty would require continued monitoring to the correct protocol until success (or “failure”) could be demonstrated more conclusively. Further monitoring has been specified for some circumstances in Section 4. The result is again a deferred AM solution.

Systemic uncertainty is considered to be a failure of the specified sampling regime itself; i.e that the specified monitoring is unable to demonstrate success with the requisite degree of certainty, regardless of how well the sampling/ survey is carried out. This would require a re-specification of the sampling/ survey regime, and if a suitable sampling/ survey regime could not be specified for a reasonable cost, AM would not be an appropriate solution. In this case, an assessment of the risk of unacceptable negative consequences/ net effects would be required to determine whether or not the target flow release would continue to be made. Clearly this is not a desirable outcome.

6.4 Failure to meet stated success criteria

If a flow release is compliant, but it is considered that the release has caused unacceptable unintended consequences, then agreement would be required for the permanent cessation of compensation. In this scenario the notional solution cannot be considered an improvement over the baseline and, if further mitigation measures are not planned to be implemented by third parties, no compensation flows would have been demonstrated to be preferable to releases. Likewise, other mitigation measures might be discontinued, if these have been specified during AM cycles.

For example, if release of a compensation flow is found to increase phosphate concentrations, and this is further found to cause deterioration in status for macrophytes/ phytobenthos, the compensation flow release has not improved the overall condition of the waterbody.

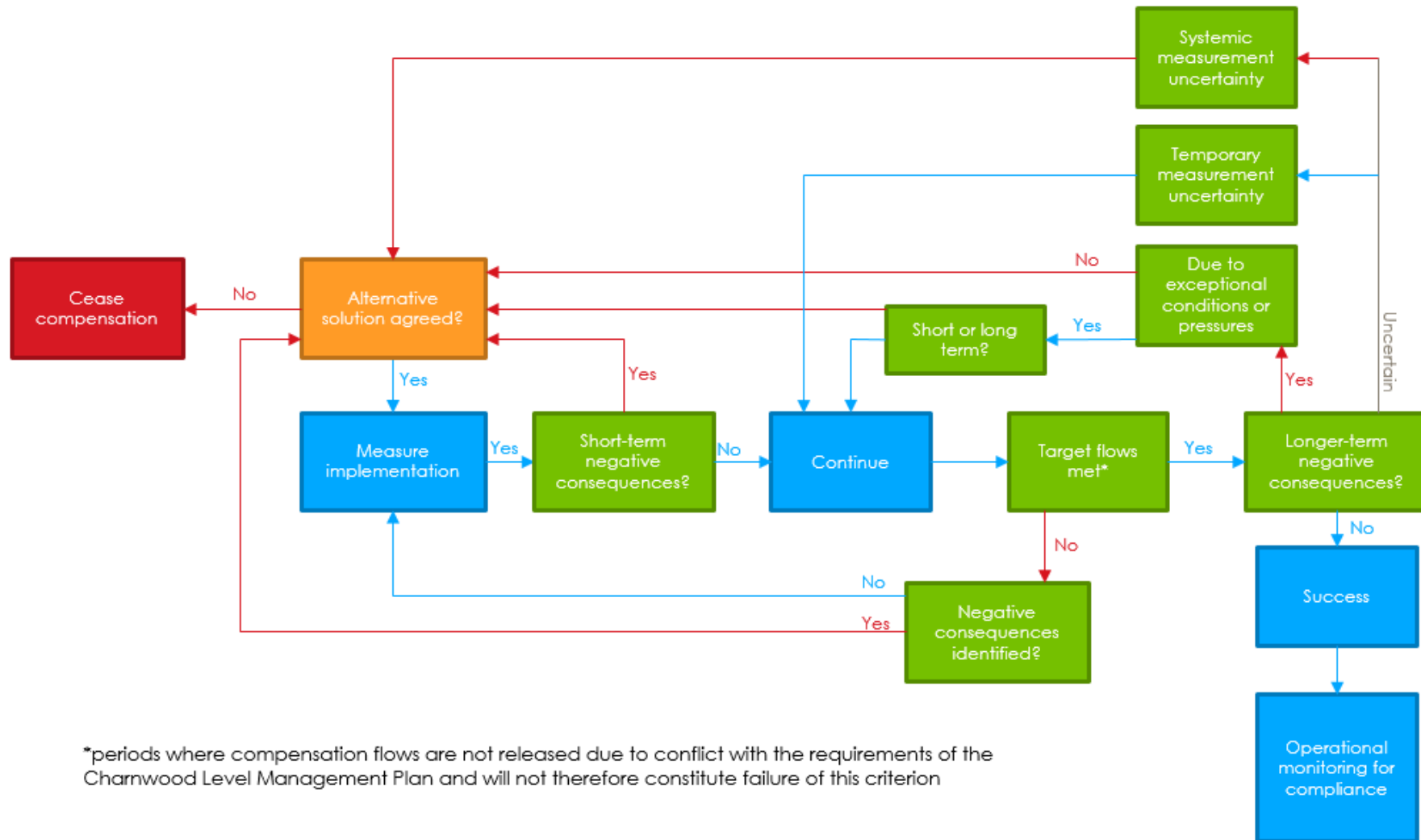


Illustration 6.1 Flow diagram for the proposed process of adaptation and adjustment of AM

6.5 Timeline

An idealised timeline for the progress of the AM cycle is presented in

Table 6.1. It should be noted that the timeline will be subject to change as AM progresses and it makes the assumption that at no point does failure to meet success criteria occur. This could happen at any stage and could result in change to the timescale of AM. Furthermore, timing of the trialling of late summer/ early autumn flow elevations will be determined by success of implementation of compensation releases and therefore is uncertain.

Before AM can begin, the success criteria must be agreed with the Environment Agency. Monitoring data will be reviewed annually to ensure that any potential issues are quickly recognised. The expectation is that Phase 1 will take at least three years (this is dependent on there being a dry year in this period) for the success criteria to be met with confidence, although it is acknowledged that geomorphological and ecological changes may take longer to fully manifest.

Review of the success of Phase 1 will be made in close consultation with the EA. The formal criteria described in Section 5 will determine the assessment of success of Phase 1. The need for/ requirements of a Phase 2 of AM will be informed by these criteria and other environmental data collected in Phase 1, as per the AM process (Illustration 1.1). Should ecological data collected in Phase 1 demonstrate benefits beyond those currently foreseen, a Phase 2 of AM may not be considered necessary. This will be reviewed in close consultation with the Environment Agency.

It is envisaged that, assuming success criteria are met following Phase 2 (assuming Phase 2 progresses), monitoring will revert to ongoing EA surveillance and condition monitoring and ongoing compliance monitoring by STWL to demonstrate adherence to the terms of their abstraction licence.

Table 6.1 Indicative timeline of progression of Phase 1 of AM for the Quorn Brook

Phase 1	Pre-implementation	Year 1 Cropston – 1 M/d Swithland – 2 M/d	Year 1/ 2	Year 3	Year 4*
Summary AM status/activities	Ensure baseline requirements fulfilled	Monitoring for risk of immediate acute impacts	Annual assessment of flows and unintended consequences	Annual assessment of flows and unintended consequences	Weight of evidence assessment to inform second phase
Monitoring elements					
Flow	On-going	Monitoring of water quality and habitat alongside switching-on of compensation flows for assessment of risk of acute impact	Yes	Yes	Yes
Habitat/sediment sampling/piezometry	Required		Only if unintended consequences determine a need	Only if unintended consequences determine a need	Yes
Water quality	On-going		Yes	Yes	Yes
Macroinvertebrates	On-going		Yes	Yes	Yes
Fish	Complete		Only if unintended consequences determine a need	Only if unintended consequences determine a need	Only if unintended consequences determine a need
Macrophytes/phytobenthos	Complete		No	No	Only if unintended consequences determine a need
Assumption					
In the above timeline at no point do failure to meet success criteria occur. This could happen at any stage and would result in a change to the timescale of AM. Timing of the trialling of late summer/early autumn flow elevations will be determined by success of implementation of compensation releases and therefore is uncertain.					

*Note that three years post implementation is the earliest that evaluation of a complete AM cycle could be made. A dry year must be encompassed within an AM cycle and, therefore, the timescale for evaluation of success may extend beyond three years.

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APPENDICES

Appendix A

Compensation release trial reports

Appendix B

Environment Agency guidance on adaptive management