

General response to Reviewer 2

We thank the Reviewer for the positive feedback and minor comments. It is encouraging to read that the current synthetic model setup is reviewed as a good representative for a UK water resource system. However, we do acknowledge that some aspects of the water resources system are missing (see our response to comment 4) or at least simplified (see our response to comment 5). We will review the discussion to make sure recommendations are supported by the sensitivity analysis. Overall, we have provided a first author response to the main comments (1-6) here and will address comments (7-12) directly in the point-wise rebuttal later.

Comment 1: As I mention, modelling water resources with groundwater in a joined up way is surprisingly rare - the authors may wish to include a slightly expanded review (even just a paragraph in the intro) on this subject to help justify their reasonably simplistic hydrological representation.

We thank Reviewer 2 for noting the value for joining water resources modelling and groundwater and appreciate their suggestion of a (short) paragraph in the introduction to emphasise this.

Comment 2: Can water demand be written as an equation, just to make it easier to follow

Agreed. This is a good point, as adding an equation for the total water demand is more consistent with the overall modelling approach and will improve the manuscript. The suggested demand equation might also clarify the term 'headroom' as Reviewer 1 mentioned (Comment 7).

Comment 3: L116/133 - Perhaps either move some of the text from S3.2 here, or at least reference that this is described in more detail in the Data section. On first reading it appeared that this line was essentially the only description of water demand in the model!

We agree with Reviewer 2 that there is some information missing in the Model Structure section. We will add some explanation regarding the water management plans (now in the Data section) and refer to the overview Table A1 in the supplementary material.

Comment 4: I was under the impression that ecological flows are typically met by reservoir releases, rather than groundwater pumping (though I suppose this is highly regional). No need to rerun the model, but might be interesting for UK readers.

This is an interesting point by Reviewer 2, as maintaining ecological flow requirements can refer to either reservoir release or restricting groundwater abstractions supporting surface water and wetlands, or possibly a combination of both options depending on the position of reservoir in the catchment and connectivity of the stream and aquifer (Environment Agency, 2019). Based on the thirteen drought management plans that source water from both surface water and groundwater, we found that groundwater abstractions are restricted when baseflow falls below a certain ecological minimum flow threshold. During severe droughts, drinking water companies can apply for a drought order to sustain groundwater abstractions potentially lowering ecological flows. This is why we modelled the 'hands off flow' scenario applying this restricted use of groundwater. We will clarify this groundwater-related focus on maintaining the ecological flow in the scenario description in section 3.2.

When simulating a specific catchment setting or alternative modelling approach, the 'hands off flow' also could include a fixed reservoir release or a combination of restricted groundwater use and reservoir release depending on the relevant catchment setting. We will mention this alternative approach when suggesting alternative modelling assumptions in section 5.3 (model limitations in L431-437).

Comment 5: The groundwater and reservoir levels in this model are often 0 (Fig 2). This is no problem since the case study is synthetic, but the authors should note in the text that UK groundwater/reservoir systems are not this stressed (even if effort has been taken to parameterise the model in a sensible and nationally reflective manner) - perhaps expand a little in Section 5.3 (water companies might be alarmed if you give the impression that this is portrayed as a 'nationally average' model)

We agree with the Reviewer that particularly the low groundwater storage system is quite stressed *in the baseline scenario*

50 given the synthetic model settings. This is likely a combination of a fast responding aquifer modelled in a lumped model and
considerable pressure on the water system *without any management interventions* in place. In the lumped model, the avail-
able groundwater storage excludes deeper groundwater sections or lateral groundwater flow (L170-171 in old manuscript) that
results in zero storage when the storage capacity of an aquifer is low and fast responding and groundwater demand is high.
Even though the pressure on water resources is based on actual water resource management plans, the use of water resources is
55 static in the baseline scenarios based on the average of thirteen drinking water companies and fixed for the 37-year modelling
period. Scenarios including conditional/flexible use of surface water and groundwater might be a better representation of water
management practises in England considering the low flow alleviation scheme in place (Environment Agency, 2016; Howarth,
2018) and the relatively flexible combination of both surface water and groundwater in larger water management regions (She-
pley et al., 2009; Fowler et al., 2007; Thorne et al., 2003). Therefore, modelled groundwater and reservoir levels in scenarios
60 that include either conjunctive use or ‘hands off flow’ are likely to be a closer representation of the status of water resources in
England. As suggested, we will expand on these aspects in section 5.3 and remove statements suggesting that the unmanaged
(baseline) condition reflect the status of water resources in England.

**Comment 6: Can the model/modelling setup be made publicly available so that results can be reproduced - it seems
that the models/data are all openly available so I don’t see why not?**

65 We agree with the Reviewer that this possible given the open data and use of published models. However, more work is
still required to meet open science and coding standards, which are difficult to meet withing the time frame of the current
employment contract.

References

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