

Interactive comment on “Using high-resolution phosphorus data to investigate mitigation measures in headwater river catchments” by J. M. Campbell et al.

J. M. Campbell et al.

jm.campbell@ulster.ac.uk

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Corrections and amendments to “Using high-resolution phosphorus data to investigate mitigation measures in headwater river catchments” by J.M. Campbell et al.

We thank the two reviewers for their careful reading and comprehensive comments. We have addressed these, below, and propose that the changes have improved and strengthened the manuscript.

Referee #1: 1. Abstract: In places the introduction starts to sound a bit conversational, especially with the repeated use of “wicked” and “filthy”, I think the writing here could

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be tightened up. Response: Agreed, use of “wicked” and “filthy” deleted to be less conversational. Abstract “Specifically, the work investigates the issue of agricultural soil P management and subsequent diffuse transfers at high river flows over a five year timescale. The work also investigates the phenomenon of low flow P pollution from septic tank systems (STS) and mitigation efforts – a key concern for catchment management.” Introduction “This conundrum is considered to be one of the ‘wicked problems’ of resource management (Smith and Porter, 2010). The P transferred from agricultural catchments can be from diffuse and/or point sources and in recent years the role of septic tank systems (STS), as rural point sources, has been identified in elevating low flow P concentrations (Withers et al., 2012, 2014). The flow paths taken from source to impact point are affected by the complexity of catchments at both temporal and spatial scales (Turcotte, 1997; Kirchner et al., 2004) resulting in river P that has dependencies and signals according to hydrological conditions (Jordan et al., 2007).”

2. P.10967 15-17: states that high resolution monitoring is preferred and Harris and Heathwaite (2012) are cited. Perhaps some other literature should be included here as there are many authors who have stated this and some well before. Response: Agreed, amended with an earlier reference. “However, it is recognised that in order to completely understand the full range of river chemical signals, which are influenced by catchment processes and entrained in the range of river discharges, higher resolution monitoring is preferred (Palmer-Felgate et al., 2008; Harris and Heathwaite, 2012).”

3. P.10968 7: states that rising and falling limb relationships are going to be investigated along with seasonal changes.... I think this could be explored more in the discussion, at the moment it feels like this analysis is missing. Response: Agreed, we can see where the expectation was misleading. The method integrates all the patterns rather than analyses them individually. We have amended the paragraph by clarifying and omitting some text. “In this investigation, a method is used to detect catchment change influences on P transfer which integrates all the discharge-P concentration patterns that might occur, in toto, during different stages of river discharges including low

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and storm flows.”

4. P10968 25: LU ha-1, perhaps define this unit? Response: Agreed, unit defined. “Land use is 90% agricultural with mixed livestock (beef, dairy and sheep enterprises, in order of importance) (Land cover 2000 classification) and a stocking density of 1.5 LU/ha (livestock unit per hectare).”

5. Methods: The sections need some rearrangement, currently section 2 outlines just the soil analyses and the water quality data is not introduced until section 2.2. It would be clearer to the reader if section 2 provided a brief summary of all of the data collected followed by more detailed descriptions of the soil and water quality data in subsequent sub-sections. Response: Agreed. We have included a short introduction to the three surveys and then subsequently provided individual descriptions under the sub-headings: Soil P surveys Septic tank system surveys Water quality

6. P10969 16-17: was there only one sample taken per field? How was the sampling location chosen? How did you ensure the sample was representative? Are these also classed as high resolution as the manuscript title suggests? Response: Agreed, detail added. “Between December 2004 and February 2005 composite soil samples were taken from 170 fields in the Co. Monaghan sub-catchment and 276 fields in the Co. Tyrone sub-catchment, following a reasonable period since the application of organic/inorganic fertiliser to ensure soil P equilibrium (Agbenin and Tiessen, 1995); this represented 62 % and 69 % by land area, respectively. The composites consisted of thirty sub-samples that were randomly extracted to 7.5cm depth from each field using a soil corer and across a “W” pattern in order to allow for heterogeneity of soil nutrient status at intra-field scale, but avoiding areas where animals would have sheltered or congregated close to feeding troughs. The composite samples were prepared for analysis by air drying and sieving through a 2 mm mesh”

7. P10969 18: states a “reasonable period since the application of fertiliser” – what is a reasonable period? More details needed. Response: Agreed, amended with the

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detail. “Between December 2004 and February 2005 soil samples were taken from 170 fields in the Co. Monaghan sub-catchment and 276 fields in the Co. Tyrone sub-catchment, following a reasonable period since the application of organic/inorganic fertiliser to ensure soil P equilibrium (six weeks: Agbenin and Tiessen, 1995).”

8. P10969 22-23: need rationale for the two different soil analyses in the two catchments. Response: Agreed, Additional Morgan P soil analysis in Monaghan explained. “Plant available Olsen-P concentrations were determined on 5 g samples in both catchments and, in accordance with standard soil P testing methods for the Republic of Ireland in Co. Monaghan, plant available Morgan-P concentration was also analysed (Olsen et al., 1954; Morgan, 1941).”

9. P10670 1-3: this paragraph needs some rewording, it sounds like the original samples were re-analysed rather than a new set of samples collected from the field. Perhaps reword to clarify. Response: Agreed, clarified. “Between December 2009 and February 2010 a percentage of the same fields was resampled and analysed to assess any change in soil nutrient concentration subsequent to nutrient management recommendations. Sampling fewer fields was necessary due to budget and time constraints.”

10. P10671 24-27: sentence is not clear, reword – especially last section “despite different plant available tests....” Response: Agreed, paragraph clarified “Having determined normality of the soil test P data, all changes in potential soil P test concentration were assessed using a two tailed matched pair t-test. Olsen P results were compared based on whole catchment, farm block, soil P index and individual field status. The assumption here is that, as no P fertiliser was being applied to fields where there was found to be an excess in the 2005 testing, both catchments would see a reduction in soil P concentrations and a convergence on an optimum index equivalent to Olsen16-25 mg P L⁻¹ (Morgan 5-8 mg P L⁻¹).”

11. P10975 3: “Despite this small set-back” – sentence sounds a bit conversational,

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reword Response: Agreed, sentence amended. “Despite this, the nature of the time series data of this study is of a resolution that all states of hydrological discharge, including storm flow, have been captured by the data set.”

12. P10975 22 and 25: Phosphorus concentrations used, referred to as TP elsewhere in the manuscript – should be kept consistent Response: Agreed, will change to TP concentrations. “Total P concentration, load and discharge distributions for the Q40–Q50, Q20–Q30 and Q5–Q10 discharge ranges over the five years showed that both catchments had a significant increase in TP concentration at the higher flows (> Q10) between 2006 and 2011, although there are some small decreases in TP concentrations at Q40–Q50 and Q20–Q30 in both catchments, in the interim years (Table 5).”

13. P10976 7: “although there had been a strategic replacement of four and eleven” – do these refer to septic tanks? Not clear. Response: Agreed, clarified. “Results for the low flow analysis were confounded as, although there had been a strategic replacement of four and eleven, older and potentially polluting septic tanks systems in Co. Tyrone and Co. Monaghan, respectively, there had also been an increase in household density in both catchments since 2005.”

14. P10976 14 and 19: state significant increase – these should be back up by stats in the text, or do not use the word significant without specific evidence. Response: Agreed, table 6 added to show statistics. Table 6: Pairwise comparisons between years for TP concentrations. The mean difference is significant at the 0.05 level (*), with TP as the dependent variable.

(I) Year (J) Year Mean 95% Confidence Difference (I-J) (I) Year (J) Year Mean 95% Confidence Difference (I-J) Mon. 2006 Q90-95 2007 0.099* Tyrone 2006 Q90-95 2007 0.002 2008 0.024* 2008 0.049* 2009 0.016* 2009 0.017* 2010 0.028* 2010 0.000 Mon. 2006 Q80-90 2007 0.002 Tyrone 2006 Q80-90 2007 -0.018* 2008 -0.037* 2008 0.027* 2009 -0.058* 2009 0.014* 2010 -0.028* 2010 0.010*

15. P10976 15: the changes in concentration stated are small, perhaps some comment

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needs to be made regarding the precision of the measurements and whether these subtle changes are real effects or within the noise? Response: Agreed, narrative augmented. “The pair-wise comparison analysis of yearly concentrations of the low and extreme low percentile discharges (Q80–90 and Q90–95), in Monaghan showed there was a significant increase in TP concentration between 2006 and 2010 for Q90–Q95, from 0.120 to 0.148 mg P L⁻¹ (Table 6). For Q80–Q90 there was a significant decrease in TP concentration between 2006 and 2010, from 0.183 to 0.155 mg P L⁻¹. The same analysis in Tyrone showed there was an initial significant increase between 2006 and 2008 for Q90–Q95 but no overall change between 2006 and 2010. For Q80–Q90 there was a small, significant increase from 2006 to 2010 from 0.122 to 0.133mgP L⁻¹. The changes are small and there is perhaps a risk of including instrument and sample ‘noise’ in the comparisons; however, the comparisons are also made on filtered data based on an average of three data-points per hour which should give confidence in the statistical tests used.”

16. P10976 16-18: raises an interesting question regarding the length of the dataset and our ability to detect trends, this could be an interesting point to raise in the discussion. Response: Thank you for this comment – we think that the discussion addresses this enough in this version but agree that when cited, this paper (if published) would provide a reference base to show that there is an issue with the length of the chemistry data record and the ability to detect trends. No further amendment added.

17. P10978 10: add some numbers and stats to support “significant increase in TRP” as the data is not shown in the manuscript. Response: Rather than include these data and statistics here, we have decided to omit the comment as the precise method and data re not included in this paper and will also form part of a companion manuscript to be submitted at a later time. “Arnscheidt et al. (2007) stated that there was a significant correlation in the two 5 catchments between STS condition and density, and low flow TP concentration. The increase in STS density in Tyrone from 3.4 to 4.6 km⁻² may, therefore, have had some impact on the P concentrations in the catchment during

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the post mitigation period. Despite the Monaghan tank density also increasing, from 13.8 to 17.2 km⁻², there was no significant increase in TP concentration. However, data (not shown) from a companion streamwalk survey did show a small (significant), increase in SRP concentration in both catchments between 2005 and 2010.”

18: P10978 14: annual TP load – presumably this is average annual TP load from the recorded data? Clarify Response: Correct – clarified. “Changes in the overall annual sub-catchment TP loads...”.

19. P10980 20-25: this is a particularly long sentence which would benefit from some reorganisation Response: Agreed, reorganised. “However, this study showed that at larger scales, and in these particular catchments, already wet soil has greater potency for TP transfer during storm events. This is due to sustained wetting (prolonged events maintaining saturation excess flows and an increase in effective rainfall) and, in particular, during periods which may coincide with nutrient management and incidental losses during the summer.”

20. P10981 6-10: I would rethink if the first bullet point regarding instrument performance is necessary; it feels a little out of place. Response: Agreed, this technical point is made adequately within the narrative. Deleted. “The bankside analyser method had a high recovery compared with the laboratory method (97 %) but lower recoveries (88 %) were observed at the sample preparation step, which is likely to be similar to other automated sampling techniques due to horizontal and vertical lift distances.

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