

Bath flood risk

Batheaston compensatory flood storage: review of BNES/34

Technical Note MAM6777-01



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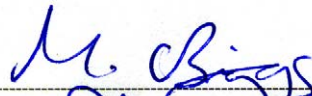
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Summary

This document presents a review of the information provided in BNES/34, regarding the possible provision of upstream compensatory storage at Batheaston. It considers issues associated with the inclusion of land at the previously proposed Bath East Park and Ride site.

Key conclusions include the following:

- The Park and Ride area is required if one is to achieve a substantial compensation storage volume at Batheaston.
- However, most of the storage would still be at low levels. This is not effective for major flood events.
- The inclusion of ponds and banks raises significant design, operation and maintenance safety issues. No comments are made on any of these matters.
- There is still no modelling to indicate the scale of any downstream benefits.
- Indeed, WYG now admits to uncertainties in the scale of the likely benefits in Bath.
- It is HR Wallingford's strongly held view that the Council's confidence in the proposed scheme is misplaced. Whilst there will be some hydraulic benefits in Bath the scale of these - and thus how much development may be implemented as a result - have yet to be established. This latter point is now accepted by WYG.
- Whilst some hydraulic benefits might be achieved there are currently too many serious major risk issues that have not been adequately investigated.
- Several key issues - such as environmental matters, costs and material disposal - have not been investigated adequately to justify the Council's confidence.

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1. *Introduction*

Following discussions on 1st February at the Bath Core Strategy Planning Inquiry a clarification note was prepared by White Young Green (WYG) on behalf of Bath and North East Somerset Council (B&NES). The note, which is referenced BNES/34, covers the issue of the possible provision of upstream flood compensation storage at Batheaston.

The main purpose of BNES/34 was to provide clarification regarding the potential additional storage that might be available if the previously proposed Bath East Park and Ride site is used for flood storage. This new possibility was outlined by B&NES and WYG at the Inquiry.

This document has been prepared by HR Wallingford following a review of BNES/34, with its associated plan and cross-sections.

2. *Overview of BNES/34*

BNES/34 refers to the original WYG report on compensatory storage (CD4/FR35), summarising some of the original proposals for Batheaston, providing some information on flood levels and possible storage volumes. It repeats the previously reported volume of 61,500m³ being available above the 2 year flood level (20.49m).

It notes that some additional volume would be available if the original site were to be excavated below this level.

It describes how a strip of land at the 1 in 2 year flood contour could be left, but the ground behind it excavated. This would in effect create new storage at the 1 in 2 year flood level.

If another strip is left, at a higher level (and consequently further from the river) this would facilitate storage that only becomes available at the higher level. If the area previously considered for the Park and Ride scheme is included then a significant amount of additional storage could be made available. Specific details for the spill level into an upper storage are not mentioned. Indeed, no details are proposed.

It is indicated that a total volume of up to approximately 300,000m³ (all levels included in this volume) might be available at the combined site.

BNES/34 concentrates on the release of compensation volume. There is still no assessment of its effect downstream. It is clear that no detailed modelling has been carried out. Information is still presented as ideas, rather than as schemes that had been properly developed.

Despite there being no modelling evidence the Council's confidence in the scheme is reiterated.

3. *HR Wallingford Review*

3.1 INTRODUCTION

HR Wallingford has carried out a review of the information presented by WYG, and their interpretations. The findings are summarised below.

More specific comments are tabulated in Appendix A. Whilst many of these are quite detailed it is important to note that although the provision of a large storage volume might seem in itself to be good, in practice it is the details of how it operates that are very important. These will help to determine whether in practice there are any substantial benefits downstream, and whether the benefits satisfy all of the requirements. A large excavated volume upstream does not simply mean that a large amount of flood storage volume can be removed in Bath as part of development work.

Only the main issues are brought forward to this main text. For a full understanding of the situation all of the points in Appendix A should be considered.

Some volume calculations have been carried out to assess whether quoted volumes appear to be reasonable. However, it should be noted that these calculations are only approximate, as they have had to be based on details scaled from the long-sections and the mapping available. Thus, there is a significant tolerance in the calculated volumes. The HR Wallingford figures should therefore be considered as approximate, and for comparison purposes only.

However, this approximation is not of concern, as it should be remembered that there is already considerable uncertainty regarding the likely volumes of lost storage in Bath. In addition, as established at the Inquiry, a simple volume balance is not adequate. The levels of lost and compensatory storage relative to flood levels are far more important. It is accepted by all parties that the suitability of any proposals will only be confirmed using detailed modelling techniques.

There is no discussion in BNES/34 of other key issues – such as environmental matters, material disposal issues or costs. This is despite the fact that the scale of all of these issues would increase substantially. Any one of these matters may be sufficient to make such a proposal very difficult or impossible to implement.

3.2 GENERAL COMMENTS ON BNES/34

- The recent information provides improved understanding of what is proposed and how the storage might work.
- The text and the cross-sections confirm that most of original site is below the 2 year flood level. This makes it clear that the original proposal would achieve very little indeed at the higher flood levels – where most of the lost volume in Bath is likely to occur.
- The site has been extended to include the previously proposed Park and Ride site. This is higher ground, with a substantial part above the 1 in 100 year plus climate change flood level.
- Consequently, there is an increase in the new storage volume available at higher levels.
- Because of the topography approximately 100,000m³ of the excavated material comes from above the 100 year plus climate change level. This needs to be disposed of but does not contribute to the compensation flood storage.

3.3 TYPICAL CROSS-SECTION

A typical cross-section through the river floodplain is depicted below. This shows the different areas that might become available for flood storage for the whole site area. Different flood levels referred to below are also depicted.

In addition, the extent of the original site is depicted by the X–Y line – see comments in Section 3.4 regarding a correction to this.

The brown areas that are shown depict possible non-excavated ground, with storage available behind them. This storage is in effect at the level of the top of the “bank”.

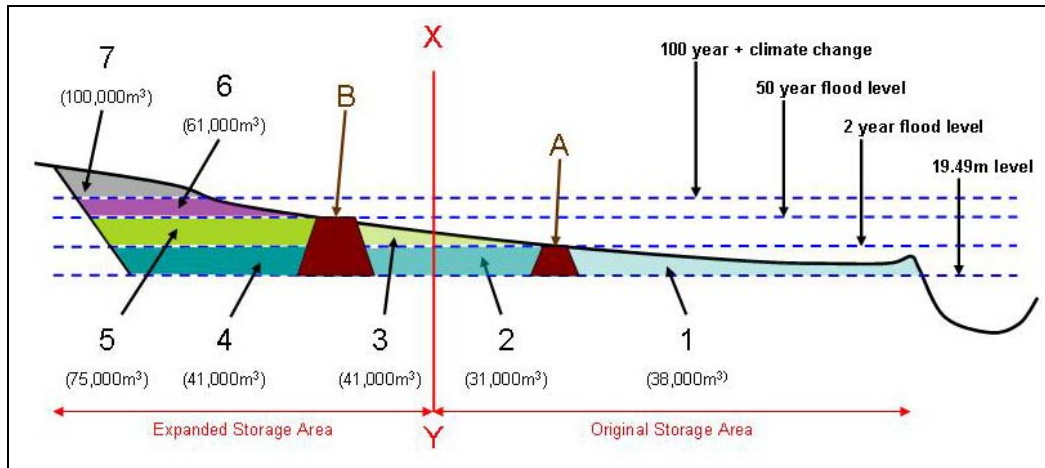


Figure 1 Typical cross-section (full site area)

3.4 ORIGINAL SITE AREA

- The edges of the original site (X–Y lines) are shown incorrectly on 3 of the 4 WYG cross-sections (errors of up to 75m). The results presented by WYG substantially over-estimate the available storage volume for the original proposal. HR Wallingford estimates about 13,000m³ using the corrected alignments (the part of area 3 to the right of the X-Y line) compared to the original WYG volume of 61,500m³. (The large difference is because of the errors in the positions of WYG’s X-Y lines. These meant that too much of the higher ground was included in the WYG volume).
- Areas of lower lying ground beyond the WYG proposed non-excavated strip nearer the river (A) mean that volumes that would fill at the 2 year storm are overestimated by WYG. Much of this volume could already be full of water, that flows across from the lower ground to the east. (This is not depicted on Figure 1).
- Whilst WYG suggests a base excavation level of 19.49m this is 1m below the 1 in 2 year peak flood level. Although the return period for 19.49m is unknown it is likely to be very low. Indeed, it is likely that during storm / flood events there will be a significant volume of water already in the very low part of the storage, from local runoff and groundwater. Water may also flow from the river, through the alluvial deposits and into the base of the storage. It is therefore unlikely that it will all be available when required.
- Because of locally low ground levels the non-excavated strip should be substantially further away from the river than shown by WYG. The storage available at the 2 year level – water flowing over “bank” A into a pond area (area 2) - will therefore be less than presented by WYG.

3.5 BENEFITS OF EXTENDED SITE AREA

- If the storage area is extended into the previously proposed Park and Ride area WYG indicates that the total storage available is 296,000m³. This assumes that the whole site is excavated down to the lowest level (19.49m near the river, with a 1 in 1,000 gradient falling towards the river). HR Wallingford confirmed the total WYG volume – HR Wallingford estimated a volume of 290,000m³ (areas 1 – 6).
- Whilst WYG promotes the idea of having different areas filling at different levels no details are given. There is no indication of how much storage might be utilised at different levels.
- HR Wallingford looked at one possible combination of 2 ponds - water spilling into a lower storage pond at the 1 in 2 year flood level and into a higher pond – assumed to be at the 1 in 50 year level. The available volumes at different levels were estimated. (The 1 in 50 year flood level was selected as a reasonable level for the “bank” of an upper pond).
- Using this arrangement the available volume at or below the 2 year level is approximately 70,000m³ (24%) – areas 1 and 2. The volume at or below the 50 year level is approximately 230,000m³ (80% of the total) – areas 1 - 5.
- A maximum of approximately 60,000m³ (area 6) is likely to be created at flood levels higher than the 1 in 50 year event.
- Figure 2 depicts the profile of the storage in 25 year return period bands (volumes between the 1 in 100 year and the 1 in 100 year plus climate change levels are not included, as the current return period for this higher level is not known). Available storage is concentrated at the lower levels.
- There is no equivalent profile available for the lost flood storage volume against flood return period for the proposed developments in Bath. However, based on predicted flood return periods at the different development sites (Section 4.6 of Atkins report CD4/FR2) it is clear that the majority of lost storage would be in the higher flood return periods – above 1 in 50 years.
- With the proposed scheme there is therefore a major imbalance in the storage provision. Even with the higher flood storage from the Park and Ride site there will be insufficient volume at higher levels to compensate for much of the lost storage in Bath, at equivalent levels.
- These estimated figures rely on a base excavation level of 19.49m. However, this may not be appropriate (see above). Having a base excavation level at the 2 year flood level results in about 110,000m³ (38%) of the storage not being available – areas 1, 2 and 4. The total volume is therefore reduced to 175,000m³ (WYG indicates 168,000m³).

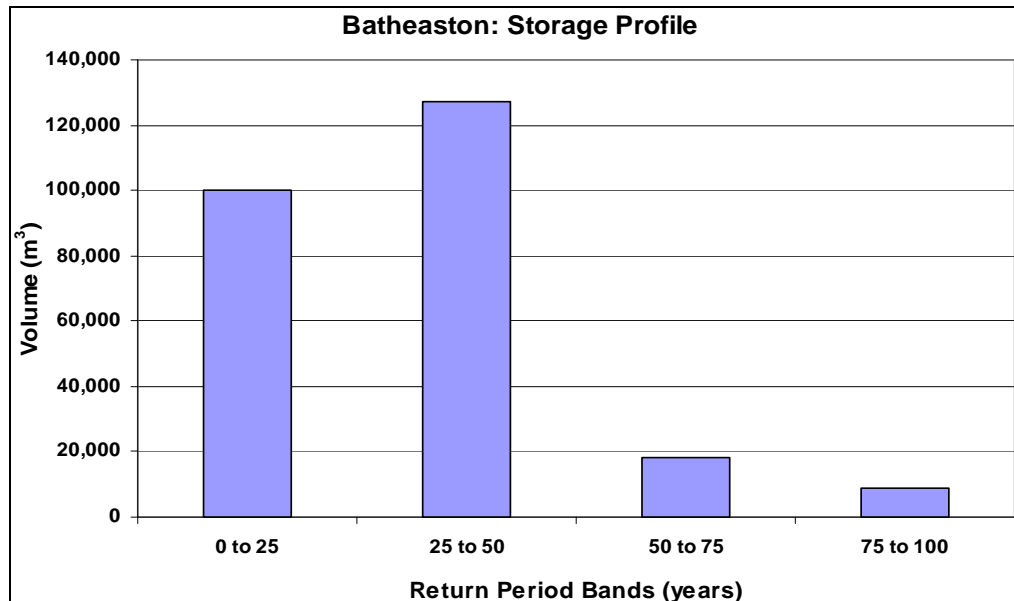


Figure 2 Batheaston Storage Profile

- In the final paragraph WYG admits to uncertainty in the storage capacity benefits of the scheme, stating “*how major will need to be worked up*”.

3.6 IMPACTS OF BANKS

- If the proposed system is implemented there will be a series of storage areas, separated by what appear to be earth banks (even though they are no higher than the existing ground). Water will flow over these, so careful consideration is required in their design, to achieve appropriate elevations and to avoid any erosion as a result of water flowing over them. “Spillway” sections may be required, with appropriate revetments, scour protection, etc.
- Bank stability is very important. The banks will act like dams and should be treated as such from a safety perspective. If there were to be a failure of an upper bank a large volume of water could be released rapidly, causing additional and very rapid local and downstream flooding. Thus, careful consideration of their stability is vital. No mention of this, and the impacts on the possible design, is made.
- The safe design and ongoing maintenance of the banks are therefore very important. They should in effect be treated as if they come under the Reservoirs Act. This has serious design, operation and maintenance implications. However, no comments are made on such issues.

3.7 MATERIAL DISPOSAL / ACCESS / TRANSPORT

- The proposals indicate that 385,000m³ of material would be excavated. As there is nowhere suitable on site all of it will have to be disposed of elsewhere.
- This is over 6 times the previously quoted volume for this site and would require approximately 38,500 lorry loads of material to be removed from the area.
- There is a note on the plan with BNES/34 that the proposed construction traffic route is via Mill Lane. However, due to restrictions at the river and canal bridges this is simply not realistic.
- Access should be provided via the A46 – as suggested at the Inquiry. However, achieving this will reduce the available compensation storage volume.

4. *Conclusions*

- Whilst there remain doubts concerning the available volume for the initial Batheaston proposals it is clearly small. The Park and Ride area is required to achieve a substantial volume.
- Even with the inclusion of “banks” at relatively high levels most of the available storage is at low levels. This is not effective for major flood events.
- The inclusion of the banks also raises significant safety issues - they should be treated as if they come under the Reservoirs Act. Whilst this raises serious design, operation and maintenance implications no comments are made on these matters.
- There is still no modelling to confirm what benefits downstream might actually be achieved.
- In its final paragraph WYG now admits to uncertainty in the scale of benefits in Bath resulting from the provision of upstream storage capacity.
- It is HR Wallingford’s strongly held view that the Council’s expressed confidence in the proposed scheme is misplaced. Whilst there will be some hydraulic benefits in Bath the scale of these - and thus how much development may be implemented as a result - have yet to be established. This is now accepted by WYG.
- Whilst some hydraulic benefits might be achieved there are currently too many serious risks to the implementation of the scheme that have not yet been adequately investigated.
- Several key issues – such as environmental matters, costs and material disposal - have not been investigated sufficiently to justify the Council’s confidence.

Appendix A Detailed comments

When assessing the note prepared by WYG some approximate volume calculations have been carried out. These have been based on the cross-sections provided by WYG. The areas are shown schematically on Figure 1, in Section 3.3. However, it is recognised that because of the nature of the available data the calculated volumes are not necessarily totally accurate. However, they do serve as an indication of the available volumes and as a comparison to the volumes presented by WYG.

Reference	Issue	Comments
Para. 1	The Phase 1 Report (CD4/FR35)	<ul style="list-style-type: none"> • This confirms that about 50% of the original Batheaston site is at or below the 2 year flood level. • The figure of 61,500m³ (WYG Phase 1 report) is repeated. It is not clear if it has been checked or is just repeated. 58,810m³ was also quoted for this by WYG in CD4/FR35. The reason for the different figures remains unclear. • Based on calculations using the cross-sections provided and corrected X-Y lines (see notes on para. 2 below) a volume of only about 13,000m³ above the 2 year level is estimated (part of area 3 to right of X-Y line). Work by the Hignett Family Trust team has also indicated that the available volume is far smaller than that quoted by WYG. • Whilst there is clearly some storage available it is only a relatively small volume and is concentrated at low levels. This is virtually useless as compensation for high return period events. • The original available volume quoted for this site seems excessive.
Para. 2	Cross - sections	<ul style="list-style-type: none"> • The X-Y line on the sections (depicting the approximate edge of the original site area) is correct for Section D-D. For Sections C-C, B-B and A-A it is incorrect – it extends well outside of the actual original site (error of up to 75m). • This results in a large excess volume seeming to be available under the original scheme. • <u>Based on the incorrect lines</u> a volume of about 54,000m³ above the 2 year level is estimated – similar to WYG volume of 61,500m³. • <u>Based on corrected X-Y lines</u> the available volume is estimated to be about 13,000m³ (part of area 3, right of X-Y line). The large difference is because the incorrect area is in higher land, which has greater storage potential. • The WYG plan is now to leave a strip of existing land (A) and to excavate behind it, to create some additional storage. The plan is NOT to construct a raised bank close to the river, even though this was indicated at the Inquiry. • The idea is that water will not spill into the lowered area until it has reached the 2 year level. Thus, the new (excavated) storage only becomes available when the flood reaches the 2 year level. • However, on sections D-D and C-C there is existing low land behind the proposed edge at A. Analysis of the level information on Figure 5.3 of the original WYG report (CD4/FR35) shows that in practice water could enter these low areas from the eastern side. Thus, the proposed additional storage will start to inundate before the 2 year event. It is therefore not as effective as WYG suggests. • Although one could raise ground to the east, to block such routes, this may have an adverse impact for lower return period events, so may not be appropriate. • Rather, the line of A needs to be moved further away from the river, beyond any local low areas.

Reference	Issue	Comments
Paras. 3 & 4	Level of excavation	<ul style="list-style-type: none"> The proposed excavation base level of 19.49m is very low – probably well below the 1 year flood event. There is a high risk that a significant proportion of the volume will regularly be taken up by local runoff, groundwater or water flowing from the river through the ground. This will result in very wet land during winter months. Such a level may simply be too low and the land become a boggy mess, which would be difficult to maintain. The impacts on storage volumes are discussed against para. 9. Based on the WYG (incorrect) X-Y lines an additional volume of 52,000m³ is estimated from the cross-sections. With corrected X-Y lines this is revised down to approximately 38,000m³ – area 1. This is a significant reduction, and is well below the 61,5000m³ advised by WYG.
Para. 5	Creation of series of “ponds”	<ul style="list-style-type: none"> At the Inquiry it was stated that recent modelling had been carried out and that it had proved that the proposals worked. When questioned about what had actually been done in the modelling no satisfactory answer was given. There is still no confirmation of any model results. Indeed, the wording of this paragraph indicates what such modelling would seek to demonstrate, not what it has already demonstrated. There is no confirmation presented that any proposals will provide adequate benefit downstream. The note indicates that WYG and B&NES are considering leaving one or more additional strips of ground, to create other contained storage areas. There is no indication at all that the model shows how well this might actually work. A non-excavated strip (B) is shown on the sections, to provide the edge for storage that comes into operation at a higher flood level. Unfortunately the levels of the top of B vary between the different sections – between approximately 21.8m and 22.5m. However, a more consistent level is required. The lack of consideration of details and the unclear comments on modelling are of concern. What is being presented is a concept, rather than a proposal that has been assessed and developed in detail. The quoted volumes therefore have to be treated with some caution. There is no evidence offered that in practice substantial benefits will be available to downstream developments. Note: Whilst technically the non-excavated strips are not dams, in practice they will retain substantial volumes of water. Should there be a failure of the higher one there could be a sudden release of water, with additional rapid flooding downstream. Thus, in practice the safe design and ongoing maintenance of these “banks” is very important. They should in effect be treated as if they come under the Reservoirs Act. This has serious design, operation and maintenance safety implications. However, no comments are made on such issues.
Para. 6	Design development	<ul style="list-style-type: none"> As in para. 5, this is initial ideas and aspirations. There is much detail yet to cover in the design development. There is nothing of substance to demonstrate that a solution has been thought through sufficiently or that it will work well.

Reference	Issue	Comments
Para. 7	Site area	<ul style="list-style-type: none"> The size of the additional proposed site appears to be about 7 hectares, rather than 9 hectares. However, it depends upon the exact extent of the original and the additional sites – not always clear.
Para. 8	Excavation depth	<ul style="list-style-type: none"> Correct – the excavation of several metres depth will be required in some places.
Para. 9	Total volume potentially available	<ul style="list-style-type: none"> WYG suggests a total volume of 296,000m³. A check by HR Wallingford based on the cross-sections gave a maximum volume of 290,000m³ (areas 1 – 6). Thus, the potentially available total volume seems about right. (The HR Wallingford volume allows for some volume reduction due to pond rims or “banks” being left). Although WYG indicates that capacity can be brought into use at different levels there is no indication of what volumes would actually be available at what levels. In order to gain some understanding of the potential volumes a pond filling at the 2 year level and a second pond assumed to be filling at the 50 year level - have been considered by HR Wallingford. The total storage volume available at or below the 2 year flood level is approximately 70,000m³ (areas 1 and 2). The total volume available between the 2 year level and the 50 year level is approximately 40,000m³ (area 3). The total volume available at or below the 50 year level is approximately 230,000m³ (areas 1 – 5). This is approximately 80% of the total. Thus, only approximately 60,000m³ is likely to be created at the higher flood levels, where most of the volume is likely to be lost in Bath (area 6). The suggested works may therefore achieve significant benefits at the lower flood levels. However, there remain concerns that there will be insufficient new storage available at the important higher flood levels to provide significant benefits in that depth band. These figures rely on using the 19.49m level for the base of the excavation, which may not be appropriate. Raising this to the 2 year flood level would result in more than 110,000m³ of the possible new storage not being available (areas 1, 2 and 4). The storage is therefore reduced to about 175,000m³ (WYG indicates 168,300m³ on their plan).
Para. 10	Blockages	<ul style="list-style-type: none"> Stability of the “banks” between the ponds is very important. Careful consideration of this is required to avoid the potential for any collapse or gradual weakening leading to failure as a result of a differential head across the “bank”. This would always occur during filling and could also occur (in the opposite direction) during emptying. It could occur if the release rate is low or if there is a blockage in the pipework. Although the soil properties (strength, permeability, etc.) are very important to this they are all currently unknown.

Reference	Issue	Comments
Para. 11	Topography and flood flows across site	<ul style="list-style-type: none"> Part of the site is open to the east – so it may not be as effective for storage as WYG suggests – see para. 2 notes. Flood flows across the site will be easier once the works are carried out, although the scale of this is not known. There is potential that under some flood conditions the proposed removal of material from the floodplain would mean that there would be less resistance to flow and consequently an increase in the flow downstream. It is important that the modelling of the proposed scheme demonstrates that in practice this is not an issue. If necessary some design details may need to be amended to achieve this. This issue is not acknowledged by WYG.
Plan	Access	<ul style="list-style-type: none"> The plan surprisingly indicates that construction traffic will use Mill Lane. As noted previously this route is totally inappropriate due to major restrictions at the river and the canal bridge either side of the site. The new WYG note indicates up to 385,000m³ of material to be excavated. As there is no disposal area suitable on site this will have to be disposed of elsewhere. This will require approximately 38,500 lorry loads. Access will be required onto the bypass immediately to the south of the site.
Para. 12	Summary	<ul style="list-style-type: none"> This clarification note has confirmed that the Park and Ride area is required if a large compensation volume is to be provided. In effect it confirms that the original Batheaston option, without the Park and Ride site, was not suitable. It has confirmed that overall a maximum volume of up to about 300,000m³ of storage may be available at Batheaston. Whether this can be achieved practically is not considered any further. The note concludes that B&NES is confident that “major capacity” can be provided at Batheaston. However, it accepts that in practice the amount of storage that might be provided is not clear. It states “how major will need to be worked up”. Thus, it is accepted by WYG that there is uncertainty regarding the amount of storage that could actually be provided. There is also uncertainty regarding the scale of the associated benefits downstream, and whether it will be possible to mitigate the effects of all of the proposed downstream developments. This is admitted by WYG in this paragraph. Whilst this approach can indeed “work in principle”, that does not mean that it will provide substantial benefit. To promote this as a hydraulic solution, without the results of modelling, is far too premature. Indeed, the concentration of the new flood storage at lower levels suggests that it will not work well for the more severe flood events. This key point is not considered in the WYG work. No comments are made on any of the potential environmental issues. Indeed, the greatly increased scale of the proposals (storage 5 times that previously reported, excavated volume over 6 times that previously reported) means that all of the impacts are likely to be substantially greater. Nothing has been presented to demonstrate that storage at the Batheaston site will actually provide a significant benefit for Bath itself. This can only be confirmed with detailed model results.