

## **Observations and suggestions on Wainfleet's flood protection**

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Note that the following remarks are observations and suggestions based on my visit to Wainfleet's flood action group (W-FLAG) augmented with some information found online and based on my expertise in fluid dynamics. Stewart Peltell from W-FLAG kindly guided me past the rivers and canals around Wainfleet on August 19<sup>th</sup> 2019.

It may be useful to determine the flood-excess volume (FEV) involved for the June floods, as well as the percentage and cost that each flood-mitigation measure can have as fraction of this overall flood-excess volume. To date the flood-excess volume of the June 2019 floods in Wainfleet does not (yet) seem available. The use of FEV in a cost-effectiveness analysis is explained in Bokhove et al. (2018) and Bokhove et al. (2019ab – article and presentation); these are evidence-synthesis documents written for a larger audience (e.g. for decision-makers and a general public with interests in flood mitigation). For all flood-mitigation measures suggested, one needs to determine whether the (protection) volumes gained and water levels reduced are worth their investments.

An overview of some observations is given in the annotated map in Fig. 1 and the local flood-risk map in Fig. 2. I have the following suggestions, also indicated on the corresponding map in Fig. 1:

- 1.. There is a weak point where the dike along the alleviation canal joins to the venturi railway passage. It concerns the dike on the south side of the canal about 400m NW from the (repaired) June 2019 breach. The dike eroded to a 0.5m top width, while the main dike width on top is circa 3m, with a steep cliff edging into the alleviation/relief canal due to long-time erosion. See Fig. 3. The weak point in the dike has been reported on 21/22-08-2019 to the Environment Agency (EA) by Stewart Peltell from W-FLAG, whose spokesperson stated that they already knew about it; hence, there exists a dated report at the EA, presumably with images of the weak point, either from before the floods in June 2019 or afterwards. Hence, one can request to receive that report.
- 2.. Two new weirs could be constructed directly after or at the split of the River Steeping into the River Steeping (southern branch) and the alleviation canal (northern branch). Currently there are no weirs to control inflow into the River Steeping (denoted as a new weir no-2) and the inflow (denoted as a new weir no. 3) into the alleviation canal. Such weirs can be operated to direct more or all of the main flow into the River Steeping, such as to enhance flow and erosion, thus leading to less siltation and deeper water levels, while little to no flow is maintained in the alleviation canal under normal conditions. Alternatively, one can alternate the main flow between the two channels to reduce siltation in both river and canal. See Fig. 4.
- 3.. The existing weir (denoted as no-1) downstream of Wainfleet (at the SE corner of map) can be used to further explore the control of the upstream water levels in the River Steeping and the alleviation canal. Modern dynamic and “automatic” control of the downstream no-1 weir in conjunction with the (tentative) two new upstream weirs no-2 and no-3 can assist in enhanced flood mitigation (cf. Breckpot 2013 and Breckpot et al.

2013 –some of the best work on optimal control to date)? Also making weir no-0 further downstream at the outflow in the The Wash automatic may be useful in order to operate these four weirs optimally, such as to minimize or prevent flooding, under the assumption that the dikes do not fail. Constraints in this control problem are: a) reduction of the water-level heights for flood protection, b) maintenance of the water levels for fishing and c) maintenance of the water supply, for farmers. See Fig. 5.

4.. The riverbed of the River Steeping riverbed is very narrow, confined tightly between its dikes without significant flood plains or wider berms, which gives little room to rising flood waters; there may, however, be bends where the dikes can be moved outward (away for the river) to create “Dutch” giving room-to-the river (GRR) flood-plain storage, some potential locations have been indicated on the map? In each case, it needs to be determined whether the volumes gained and water levels reduced are worth such an investment.

5.. The old River Lymn, once branching off and flowing southward from the River Steeping to Boston, is blocked off. It could be used as (minor) controlled outflow and alleviation channel provided that the old River Lymn riverbed is cleared. It will be required to calculate volume, flow and cost estimates to assess whether this is worthwhile. The same remark holds for the bypass canal in the NW corner of this map.

6.. There is an approximately one-foot high cement wall between the dike road and the River Steeping before entering the town of Wainfleet. The wall seems to be old and crumbling.

7.. In general the dike heights seem very uneven all along both the River Steeping and the alleviation canal? Is that on purpose?



Fig. 1. Overview map of the area, River Steeping and alleviation/relief canal around Wainfleet All Saints. North is upward. A distance scale is found bottom-right.

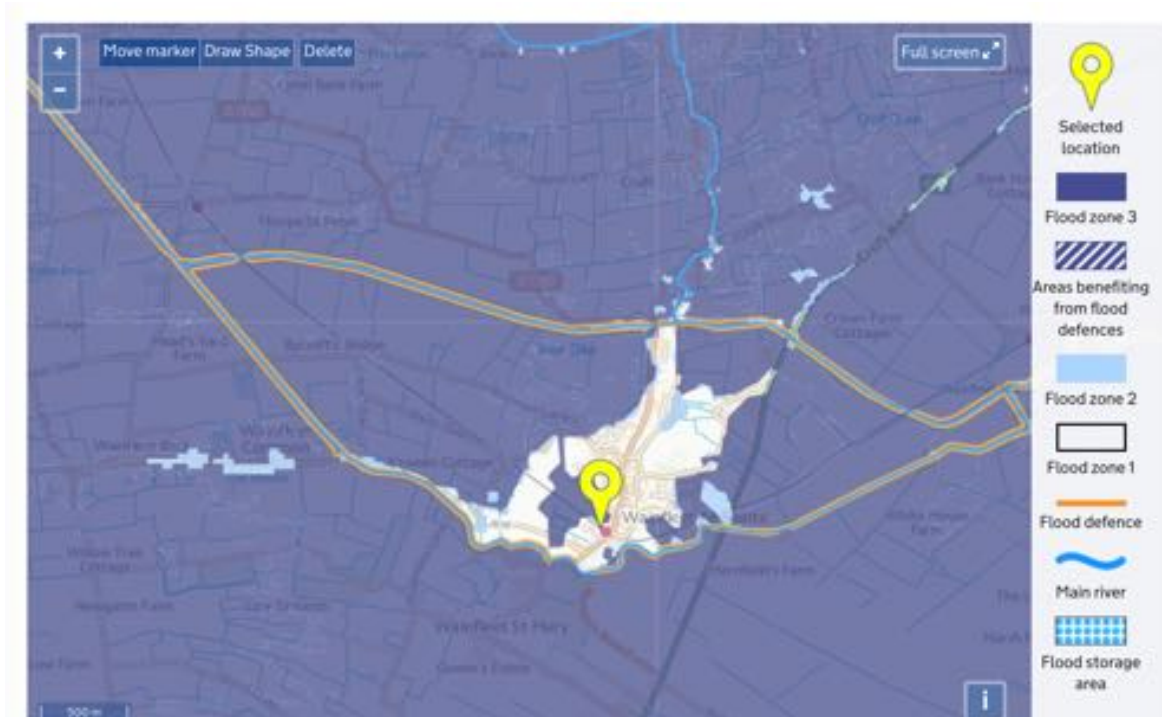


Fig. 2. The flood-risk map for Wainfleet shows that most of the area lies in flood zone 3, with a risk of 1% or more that flooding may occur. Flood-risk map from the EA.

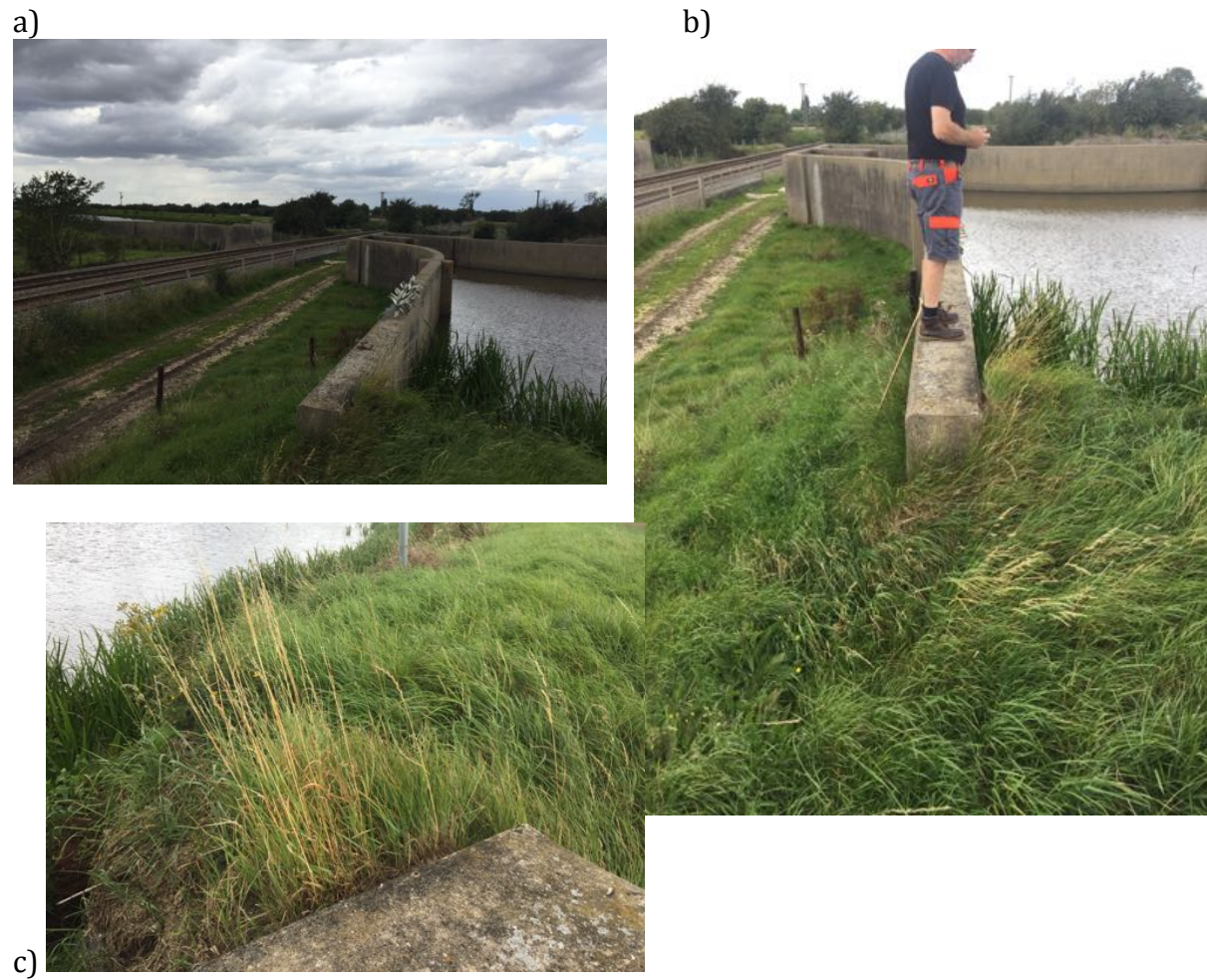


Fig. 3. Photos taken on 19-08-2019 of the weak point at the join of the southern dike along the alleviation canal and the venturi railway passage. NW corner on the map in Fig. 1. Photos "railwayweakpt...".

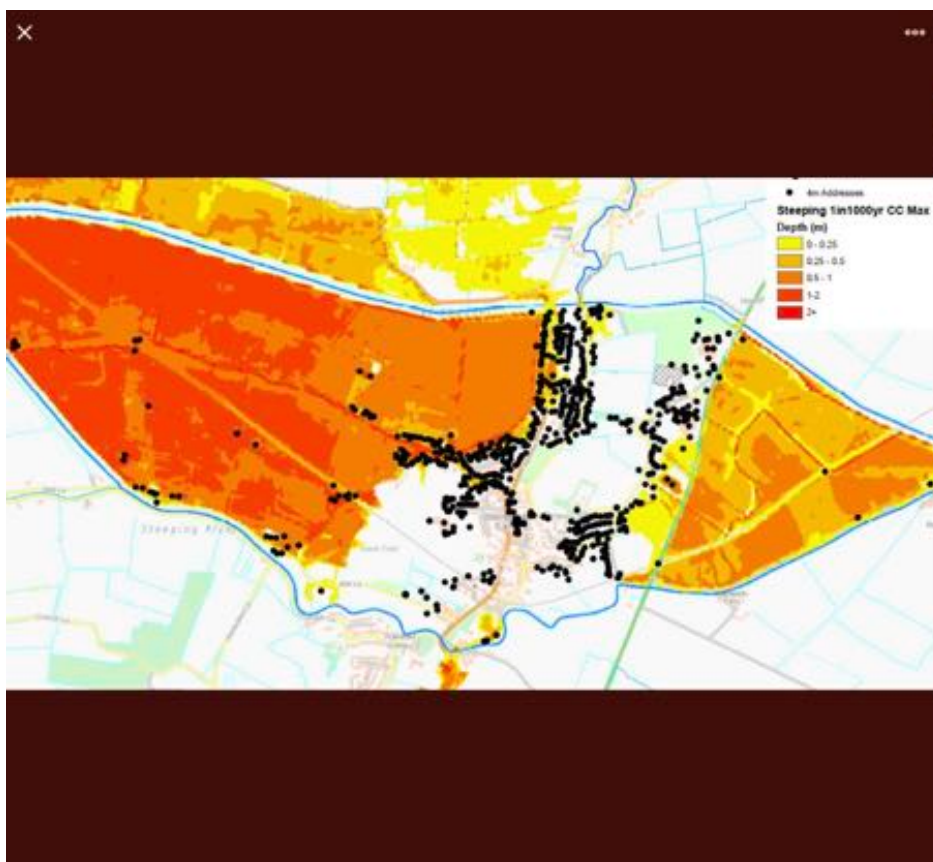




Fig. 4 a) Confluence of river and alleviation canal in the SE-corner of the map in Fig. 1. b) The splitting of the River Steeping into river (right in photo and southern branch) and alleviation canal (left in photo and northern branch) in the NW corner of the map in Fig.1. Photos “confluenceSteeping...” and “weirsplitrivercut”.



Fig. 5. Photos “no1 weir ...”: upstream and downstream (with the clear water and swans) in the SE corner of the map in Fig. 1.



a)



Fig. 6. a) 1:1000 year flood map (credit Lincolnshire Police at link <https://www.itv.com/news/calendar/2019-06-15/more-homes-evacuated-in-lincolnshire-flooding/>); and, b) photo of low-lying area in the NW corner of the map in Fig. 1.

## References

- Bokhove, O., Kelmanson, M.A., Kent, T. 2018: On using flood-excess volume in flood mitigation, exemplified for the River Aire Boxing Day Flood of 2015.  
<https://eartharxiv.org/stc7r>
- Bokhove, O., Kelmanson, M.A., Kent, T., Piton, G., Tacnet, J.-M. 2019a: Communicating (nature-based) flood-mitigation schemes using flood-excess volume. River Research and Applications.
- Bokhove, O., Kelmanson, M.A., Kent, T., Piton, G., Tacnet, J.-M. 2019b: Public empowerment in flood mitigation. Flood and Coast 2019, Telford UK, June 18<sup>th</sup>. Conference. (More) Accessible presentation  
<http://www1.maths.leeds.ac.uk/~obokhove/coastriverfev2019.pdf>
- Breckpot, M. 2013: Flood control of river system with Model Predictive Control; the River Demer as a case study. PhD Thesis, KU Leuven, Belgium.
- Breckpot, M., Agudelo, O. M., De Moor, B. 2013: Flood control with Model Predictive Control for river systems with water reservoirs. J. Irrigation and Drainage Engineering 139, 532–541.
- Twitter etc. 2019: Photos and movies of the breach found on social media:  
[https://twitter.com/Steven\\_Banham/status/1139553670754918400](https://twitter.com/Steven_Banham/status/1139553670754918400)  
<https://twitter.com/dronemanuk/status/1139873562280562689>  
<https://twitter.com/dronemanuk/status/1140607104174231552>  
<https://twitter.com/hashtag/wainfleetfloods>  
<https://twitter.com/EnvAgency/status/1142456853743448065/photo/1>

### **Appendix Additional information**

EA (message<sup>1</sup> of June 2019):

“The Wainfleet area has experienced two months’ worth of rain in just two days. The Environment Agency’s Ulceby rain gauge has shown 132mm of rain between the 10th-12th of June. To put that into context, the last major event we had the area in 2007, when Louth and Horncastle were badly affected, was after 68mm of rainfall. On this basis, this is considered by the EA to be an unprecedented event.”

Also note that EA (message<sup>1</sup> of June 2019):

“Average rainfall in a month in the area is 48-70mm. Met Office predictions are for up to 20mm more of rainfall in the Wainfleet area over the next two days (overnight Sat and Sunday) which will potentially put a further half-a-months rain on top of what there has already been.”

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<sup>1</sup> See: <https://www.lincs.police.uk/news-campaigns/news/2019/update-on-wainfleet-new-risk/>