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Discussions

Interactive comment on "Water displacement by sewer infrastructure in the Grote Nete catchment, Belgium, and its hydrological regime effects" *by* D. Vrebos et al.

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Anonymous Referee #1

We are grateful to Anonymous Referee #1 for the thorough and constructive review.

General comments:

We will provide more information in the methods section to make it better understandable. Concerning the calibration, a step-wise calibration of the model has been done. This calibration and the overall performance of the model is discussed in: (Vansteenkiste et al., 2012).

Copied from the Material and Methods section of Vansteenkiste et al. (2012):

The parameters of the different MIKE SHE components must be assigned on a grid scale, resulting into high amounts of parameters to calibrate. However, the number of parameters subject to adjustment during calibration of MIKE SHE should be kept as small as possible (Refsgaard and Storm, 1995). Therefore, key parameters were first identified on the basis of sensitivity simulations, which were then forwarded to the calibration process. The sensitivity analysis was conducted by varying individually the values of the parameters one by one common to Xevi et al. (1997). The most sensitive parameters of the model were identified as the drain parameters, the hydrogeological properties of the different geological formations, the roughness parameters of the land surface and the river–aquifer interaction. Similar key parameters in MIKE SHE modelling studies were identified by Al-Khudhairy et al. (1999), Feyen et al. (2000) and Thompson et al. (2004). The calibration procedure itself involved adjusting these key parameters by trial-and-error between predefined limits until best estimates are found for the observed discharges and groundwater heads. This was performed by visual inspection of the model evaluation plots shown in Model results section and by evaluation of the goodness-of-fit statistics, also reported in Model results section. These limits represent the physical acceptable intervals and have been assessed on the basis of data from previous modelling studies on the Grote Nete catchment (Rubarenzya et al., 2007; Woldeamlak, 2007) and literature (Chow, 1959; Anderson and Woessner, 1992; Vázquez et al., 1999; DHI, 2008).

A summary of this and of the model evaluation plots and statistics applied during model calibration will be added to the revised manuscript.

The discussion section is indeed limited in its comparison with recent literature. The discussion section will be adapted by incorporating a comparison with other recent work, including that special issue of Journal of Hydrology. An extra paragraph will be added to the discussion incorporating the following text:

Previous studies have demonstrated that models can have difficulties to model base flows in (peri-)urbanized areas (Elliott, Spigel, Jowett, Shankar, & Ibbitt, 2010). Our model results revealed overestimations of low flow, while other recent studies have reported underestimations (Furusho, Chancibault, & Andrieu, 2013). Hydrology in peri-urban catchments are typically a combination of fast and slow hydrological responses (Braud, Fletcher, & Andrieu, 2013). But the combination of fast and slow responses is in general case-specific and a result of the historical development of the anthropogenic system. Although some characteristics in our catchment (e.g fragmented land uses and related sewer system) are specific for the region, interbasin transfers of waste water are not rare and can play at different scales in many peri-urban catchments. Impacts of these transfers in peri-urban catchments should therefore be analyzed and if necessary incorporated in the model. Bach & Ostrowski (2013) conclude, based on a semi-distributed model, that flow process representation in peri-urban models should take place on a high temporal and spatial resolution. Although FDPMs give a spatially detailed description of the hydrological processes, our results illustrate the challenges for sewer system integration in FDPMs.

Extra references will be integrated in the other parts of the discussion section.

Specific comments:

1) The reviewer is right. Given the uncertainties, the two decimals will be changed to one decimal.

2) Abstract, lines 10-12. Quantification of changes in % can indeed be misleading in some cases. But in this case the relative changes give an indication of the relative impact of the sewer system on the catchment runoff. Small changes in absolute numbers (e.g. m^2) can have large consequences in small catchments. By presenting absolute numbers this interpretation would be more difficult to make.

3) P.7426, line 25. The line will be changed as suggested.

4) P.7427, lines 3-6. Hamel et al. (2013) concluded, based on their review, that many different parameters, both natural and anthropogenic, influence baseflow behaviour in peri-urban catchments. In combination with inconsistencies in assessment methodologies many uncertainties remain regarding baseflow responses to urbanization. Lines will be adapted to incorporate these main conclusions. More detailed information from the article will be incorporated in the discussion.

5) P. 7427, lines 15-25. This reference will be studied and cited. The different methods used in the article for catchment delineation will be cited as references in the introduction to better situate current knowledge on catchment delineation.

6) Study area. Most of the sewer network is still a combined sewer system. Only small parts, including the new parts, of the sewer system separate waste- from rainwater. SODs are present at several locations in the catchment. A more thorough description of the sewer system will be given in the study area description.

7) P.7430, line 19 and section 2.6. Both hourly and daily discharge data were collected from the same data source and used in the article. The hourly discharge data were used to calibrate, validate and run the model, while daily data were used to analyze the low flow behavior. This will be stated more clearly in the article.

8) P.7431, land use mapping. The final map used in the analysis is based on photographs from 1998. However, the final map was finished over a period of 10 years and includes the more recent buildings up to the year it was finished. The map can therefore not be used to quantify the urbanization increase in the catchment between 1998 and 2007. Urbanization rates are only available on higher administrative levels and other time periods. The origin and description of the land use map will be made clearer.

9) P.7431, line 14. Impervious areas were selected out of 47 different land use classes and incorporate roads, different types of buildings and paved areas. Gardens, parks etc. are not included, but categorized as grassland and mixed forests. Most of the

gardens in the region consist for large parts of lawns. Parks generally consist of a mixture of different forest and vegetation types. A clear definition of imperviousness will be given in the revised article. A table that describes the 47 land cover classes and the categories they were assigned may be provided as well.

10) P.7431, line 22-23. The EIA is estimated on the basis of 2 different GIS-maps that describe the sewer system. Houses connected to the sewer system are described in zoning maps. These maps indicate on a household level which houses are connected to the sewer systems and which drain directly to a nearby stream. Streets that are connected to the sewer system are selected based on a line-polygon of the sewer system. Streets that are situated on top of the sewer system were selected for the EIA. Sewers that separate waste-rain water were left out from this part of the analysis. This more detailed description of the methodology will be provided in the revised article.

11) P.7432, section 2.4. See our reply to comment 6). A more thorough description of both the sewer system and presence of SODs will be given in the study area description. Implications of the SODs for the model and analysis will be described in the discussion.

12) P.7432, line 25. Only one land cover is associated to each grid. To create the 250X250m land cover map different methods of resampling (Nearest neighbor assignment, Majority resampling, etc) were applied. The grid that best preserved the land use distributions of the 1 meter map (nearest neighbor) was used in the model.

13) P.7433, liens 10-30. A description of the parameters will be provided in the article.

14) P.7434, section MIKE-SHE calibration. See our reply to the general comments regarding the model calibration.

15) Section 2.7. As mentioned above in response to comment no._9: gardens are not part of the impervious areas. However, the section will be rewritten to make the methodology better understandable to the reader.

16) P.7437, lines 17-21. The presentation of the results will be rewritten to make it clearer. This includes adapting the figures 5a and 5b.

17) P.7438, line 8. Data with an hourly time step were used to calculate the model performance statistic. This information will be provided in the revised article.

18) P.7439, line 16. As replied to the general comments, model calibration was done using a step-wise approach; optimizing groups of parameters based on the evaluation of model performance for peak flows, low flows, cumulative volumes, frequency distributions of peak and low flow extremes, etc. The authors believe that in this way the best possible model performance was achieved. Running the model without calibration would seriously reduce the models performance.

19) P.7442, line 23. The catchment area of the model is based on the natural catchment boundaries. Therefor the model does take into account the impervious areas that are situated within this catchment area. However it does not incorporate the EIA that is situated outside of the catchment boundary, but is connected to a WWTP that is situated inside of the catchment. As a result the current model is not capable of modeling the impact of these waste water imports. In order to evaluate this, sewer models have to be integrated with the catchment hydrological model. We will adapt this part of the discussion to make our statement more clear.

20) An extra paragraph, as given as reply to the general comments, will be incorporated in the discussion integrating previous studies including the recent papers in the Journal of Hydrology special issue.

21) Table 2 captions. The statistical performance for model calibration and validation was calculated for the hourly time step. This will be clarified in the table caption.

22) Figures 5 and 6. Grey levels were only included to give a better distinction between positive and negative results. Grey levels will be removed to prevent this confusion. Both figures are used to demonstrate the effect that sewer systems have on upstream

(impervious) areas in catchments. The text in the method section and result section will be changed to better clarify how and why the figures were made. Captions of both figures will be modified as follows:

Fig 5: Histogram of the change in upstream impervious areas. For different points (n = 131) in the catchment, upstream impervious areas were calculated based on the natural catchment and after taking the sewer system into account. Differences between both types of upstream impervious areas were calculated as % change for each point. The histogram demonstrates the impact of sewers on upstream impervious areas.

Fig 5: Histogram of the change in upstream areas. For different points (n = 131) in the catchment, upstream areas were calculated based on the natural catchment and after taking the sewer system into account. Differences between both types of upstream areas were calculated as % change for each point. The histogram demonstrates the impact of sewers on upstream areas.

23) Figure 7. Figure 7 will be changed to provide averaged data over a larger time step. In this way the figure will still give an overview of measured and modeled flow and illustrate the difference in flow between seasons and years.

24) Figure 9. This type of figure has been used in recent articles discussing hydrological model performance. But considering the large amount of figures in the article and the limited amount of information it provides, Figure 9 will be removed from the article.

25) Figure 11. The figure is used to demonstrate how the share of the WWTPs in modeled flow differs compared to the measured discharge data. During low flow periods the model simulates lower relative contributions, underestimating the part of flow that comes from WWTPs. This has implications for the reliability of the model for scenario analysis (e.g. climate change or land cover change). Extra information will be given in the text and caption to better clarify the meaning and implications of the figure.

26) Y-axis will be changed to make the difference between the plotted points clearer.

References

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