Anonymous Referee #2
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General Comments:
The manuscript "Subcatchment characterization for evaluating green infrastructure using the Storm Water Management Model" demonstrates a new discretization approach within SWMM for better representing green infrastructure (GI) components in urban storm water modeling. The topic is well placed and tackles an increasingly popular area - high-resolution hydrologic modeling as a result of increasing availability of high-resolution imagery. However, the lack of key information on model setup and modeling processes made it very difficult to understand how flow connectivity and thus hydrologic response were better represented on the subcatchment level through finer classification of impervious and pervious areas. I am not convinced by the 'reduced-order' calibration approach, and do not believe that this approach is transferrable to other systems given its fundamental issue (see detailed comments). Lastly, the authors should provide references and/or justifications to many modeling assumptions regarding parameterization in particular.

General Response to Reviewer 2.
⇨ *The fundamental criteria for the presented approach to GI analysis in SWMM is 1) to base the subcatchment delineation on landscapes draining to storm sewer inlets and 2) configure the subarea routing within each subcatchment so that the real relevance of differences among DCIA, ICIA, and BPA are accounted for in the SWMM parameterization. The first part requires knowing the location of the storm sewer inlets and the second piece relies on the highly resolved spatial database to conduct the set-up.*
⇨ *Flow connectivity within a drainage area is presented in Figure 6. We introduced a new concept of buffering pervious area (BPA) for improving the physical representation of hydrologic response. In common SWMM modeling, all pervious area is treated the same (as in Options 4 or 5 in Figure 6), even though only the BPA can receive waters from impervious area, specifically from ICIA. As shown in Figure 8, simulated runoff by Options 4 or 5 would be very inaccurate, especially for the <1 year small storms. We explain in the MS why Options 4 and 5 resulted in dissimilar responses as they depart significantly from physical reality for SWMM set up.*
⇨ *We are not trying to argue that the approach to SWMM set-up is a 'better' representation of hydrologic response. While we do expect this to be the case for GI simulation, specifically, we have no way of actually testing this because we lack data on the effect of GI on hydrology post implementation. What we can say exactly about our approach is that it allows for a more realistic expression of reality in the SWMM model set-up. This should make the model output more accurate by reducing overall model uncertainty, but again, because we have no way to directly test this assertion we will be sure to 'tone-down' such implications where they exist in the MS. We due compare the performance of our recommended subcatchment set-up approach to others in Figures 6 and 8. While Option 1 should be the most accurate among all options presented, we advocate option 6 for GI analysis in SWMM because options 1, 2, and 3 would result in many more subcatchments to parameterize, and more effort would have to be placed adjusting model set-up to account for GI scenarios. Furthermore, Option 6 allows for subcatchment delineation based on topography and, therefore, has a physical meaning within the context of a watershed approach, while Options 1 through 3 would require disassociating the subcatchment context from reality to a more conceptual basis in the model. We will add this explanation to the MS.*
⇨ *Our approach to calibration in SWMM is no different than what would be considered the more typical approach in terms of the actually modeling steps required, i.e., sensitivity analysis followed by one at a time adjustment, re-run, compare simulated vs. observed. What is different is that we argue that the number of parameters that one might consider to adjust during calibration can be quite large if each subcatchment has unique values, or has been considered independently of all the other*

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subcatchments, or as we describe it j x k number of parameters. We rely on the detailed spatial resolution of reality and the relatively small subcatchment size (driven by the storm sewer inlet, delineation requirement), to standardize parameter values across them. The Reviewer is correct to point out that in some watersheds spatial heterogeneity in topography and soils may nullify the assumption of commonality among all of them. If a land cover does not maintain the sufficient level of homogeneity within the target watershed for modeling, we need to use more than one set of parameters for the land cover. In this case, we should divide the land cover into sub-groups that represent the heterogeneous hydrologic properties independently. We will add more details and discussion to address this valid concern.

Detailed Comments:

1) P2 Line 16: Please provide references of relevant studies.

⇨ *References will be provided, e.g., the recently published SWMM review paper by Niazi et al. (2017).*

2) P3 Line 32: Explain and provide references of unit-area based analysis.

⇨ *As mentioned in the manuscript (P10, L22), a unit-area is a hypothetical area, which represents a typical urban drainage area. SWMM can model a drainage area with various level of spatial aggregation, as shown in Figure 6. We arranged the unit-area based analysis demonstrate a "balanced" way for subcatchment characterization, based on the level of effort in model set-up and the accuracy in modeling results particularly for GI analysis.*

3) P5 Line 27: Add 'to' following 'adjacent'.

⇨ *We will add 'to'.*

4) P6 Line 5-10: It is not clear to me how the 'intersect' tool was used to separate BPA and SPA. It is also unclear how the buffer widths (0.30, 0.61, and 1.52 m) were chosen.

⇨ *We used ArcGIS to process the intersect analysis. As mentioned earlier, we feel it is inappropriate for this MS to call for a tutorial on how to use certain functions in ArcGIS. To provide more details on using the intersect and other functions in ArcGIS, we are preparing the USEPA report. The buffer width was selected when we calibrated the model. We arranged three SWMM models that represent three different sizes of BPA. We determined which one among the three cases of sizing BPA provided the more accurate simulation compared to the observed flow data. In this way, the BPA width was treated as a calibration parameter (see Figure 10).*

5) P6 Line 18-22: How was 0.5 acre chosen? Why subcatchments of similar size help maintain hydrologic continuity?

⇨ *Before conducting subcatchment delineation, we rather arbitrarily chose 0.5 acre to combine a drainage area with a neighboring subcatchment to minimize effort in model setup. In the actual analysis this happened only a few times. Maintaining similarity among subcatchment sizes confines the hydrologic loads received by the drainage system to a narrow range that helps to minimize errors in the simulation that might arise from surcharging or flooding due to mis-matched pipe network sizing. We can add this to the MS.*

6) P7 Section 2.4.1: 1) Move the description of calibration procedure from section 2.5 to here; 2) What are the values of Suct and IMD, and how were they initialized? Please also include them in Table 1; 3) Please provide how subarea routing was characterized within each subcatchment?

⇨ *We don't think it makes better sense to discuss model calibration until all of the major aspects of model parametrization and set-up are attended to. Based on the soil type, the values for Suct were selected using the SWMM User's Manual. The actual IMD is dynamically updated at every modeling time step. As presented in P10, L1-2, the developed SWMM model for the study area was run for a*

six-month period (01 April 2009 to 31 August 2009) where the first four months of this period were used to stabilize the continuous simulation. While IMD was modeled using the default values in the EPA-SWMM, the IMD at the beginning of reporting the modeling results may not be affected (or minimally affected) by the initial values in model setup. We will provide more explanation of how subarea routing is configured in SWMM.

7) P8 Line 8-10: The authors stated that the initial values for "Length" were decided by averaging multiple field measurements of perceived overland flow lengths for each land cover type. How was overland flow length measured and generalized for each land cover that are spatially dispersed in the catchment? Plus, it is not reasonable to rescale the lumped flow lengths for each land cover to subcatchments with distinctive spatial connectivity to their respective outlet. The conventional SWMM approach is much more reasonable in this context.

⇨ *We measured length based on the physical overland flow path of each individual land cover type. For example, length for a building is measured from roof crest to gutter. Length for street is measured from pavement crest (or centerline) to curb (or pavement boundary). Length for a driveway is measured as the distance between the house and street. The SWMM Applications Manual (Gironás et al., 2009), cited in the MS (P8 Line 12), suggests "If the overland flow length varies greatly within the subcatchment, then an area-weighted average should be used."*

⇨ *We don't understand what the Reviewer means by "it is not reasonable to rescale the lumped flow lengths for each land cover to subcatchments with distinctive spatial connectivity to their respective outlet". We acknowledge that maintaining spatial homogeneity among subcatchments properties should be a priority in the application of our approach, and as discussed above will provide content to explain what to do in the spatial database set-up to account for this.*

⇨ *We can't be completely sure of what the Reviewer means by 'conventional approach". Nonetheless, we did not intend to imply that our approach is 'better', generally. However, a common approach to subcatchment set-up is studied in Options 4 or 5 of Figure 6. Using either of these makes the application of GI an implicit consideration. We will add this explanation and clarification to the MS. In this study, we intended to examine an alternative for characterizing a drainage area.*

8) P8 Section2.4.2: I do not understand how BPA and SPA was represented and spatially connected in SWMM. Based on the description, BPA was modeled as an LID component that receives flow from ICIA of subcatchment(s)? Looking at Figure 3&4, however, BPA seems to be lumped into a subcatchment. Why choosing the buffer width of 18.3m? Please clarify.

⇨ *We will clarify as follows: In SWMM, BPA is modeled as vegetated swale. The size of BPA can be defined for each subcatchment. The % contributing impervious area to the BPA can be also defined for each subcatchment, which is ICIA/TIA where TIA=DCIA+ICIA. Since the total pervious area (TPA) remains identical for each subcatchment, the sizes of SPA for individual subcatchments can be decided as SPA = TPA – BPA for the three different sizes of BPA (which were derived by applying three different distances for proximity analysis in GIS). When we calibrated the model, we checked which one, among the three cases of sizing BPA, would calibrate the best for various storm sizes. More clarification will be added to the figures also.*

9) P10 Section 2.5: It is common in both spatially distributed and lumped hydrologic modeling that the land cover- and soil-specific parameters are fixed across the catchment. However, it is inappropriate to aggregate and calibrate by land cover the parameters of slope and overland flow length that are much more topography than land cover dependent. I can't agree with author's argument that this calibration approach is efficient or can be transferrable to other systems.

⇨ *The Reviewer is correct to point this out, and we will qualify our statements about transferability accordingly. If a land cover does not maintain the sufficient level of homogeneity across the target watershed we need to use more than one set of parameters for the land cover. In this case, we should*

divide the land cover into sub-groups that represent the heterogeneous hydrologic properties independently. As noted above we will explain the relevance of this issue and provide a remedy for it in the MS. While we agree that it is more accurate to select values for slope and overland flow length based on topography, generally speaking, SWMM subcatchment areas as defined by modelers tend to be somewhat topographically homogeneous, otherwise accurate model representation is difficult. Also, urban sewer collection systems are zoned in a manner accounting for local variation in topography. Even land use generally follows topography, therefore, land cover is a reasonable surrogate.

10) P10 Section 2.6: 1) If I understand it correctly, SWMM was calibrated using the option 6 setup. The calibrated parameters include overland flow lengths and slopes as in Table 1. In this section, the authors provide new sets of flow lengths and slope parameters for different cover type, which are different from the values given in Table 1. Did all 6 options use the same parameterization or not? If yes, why not using the calibrated parameters? If no, the comparisons do not seem fair – calibrated option 6 vs. non-calibration options.

⇨ *Table 1 shows the initial and calibrated parameters for the study area, not the hypothetical unit-area analysis. Therefore, there seems to be some confusion here, so we will attempt to clarify further in the MS. For the hypothetical area analysis, all of the 6 options were arranged using the same spatial and hydrologic characteristics as presented in P11, L23-30. However, the ways to model DCIA, ICIA, BPA, and SPA are different among the options. For the hypothetical unit area analysis calibration was not necessary.*

11) P14 Line 16-18: Why option 4 has the highest peak flow (in Figure 8a) if only DCIA discharges runoff?

⇨ *In option 4, the entire impervious area is modeled as DCIA, i.e., ICIA is also modeled as DCIA. There is no runon from impervious to pervious areas in option 4. (Please also see the responses under the comment #19 for Reviewer 1.)*

Figure 2: I suggest that the authors label the ID and show the baseline flow path of each surface record so the readers can better understand the difference between DCIA and ICA.

⇨ *The figure will be amended. The attribute table shown in the figure will also be amended to minimize any miss-interpretation.*