General Notes from the Authors:

- ⇨ *We included our original detailed responses (in italics) to reviewer's comments submitted on 09/02/2017. In those we highlighted how we WOULD change the manuscript in response to the comment. Here, after considering the Editor's response to our original comments, we include the location of those changes and give further explanations as appropriate (in bold and italicized).*
- ⇨ *We amended the title to reflect changes we made in the manuscript to try to avoid confusion around the term "Subcatchment". In the original we were using subcatchment to describe both real-physical landscape areas as well as a fundamental modeling component in SWMM. In this version we use the term subcatchment only when writing about the SWMM model, as this is the term that the model developers use. We use drainage area or hydrologic response element (HRE) to refer to physical landscape areas draining to the stormwater conveyance system.* ***Please see P3/L8-15 in the revised manuscript.***
- ⇨ *We made major changes to one of the key Figures (now Figure 5) to help clarify what changes were made in the hypothetical HRE analysis (previously referred to as hypothetical unit-area analysis).*
- ⇨ *We added a new figure, Figure 6, that diagrams the workflow for developing the baseline SWMM model and adding GI scenarios.*
- ⇨ *Section 2.6 in the previous version is relocated to Section 2.4. The section title is also amended.*

Anonymous Referee #1
Received and published: 27 June 2017

The article by Lee et al tackles an interesting topic in the field of green infrastructure. The research approaches the paper investigated are meaningful for GI under smaller storm events. Some of the assumptions used in the paper need to be better explained and argued. The conclusions are not attended yet due to insufficient description of their methods, model settings, estimation of key parameters, in particular the part 2.2-2.4. Nonetheless, I think that the article had good potential for being published, provided that the following comments are adequately addressed.

General comments:

1. The research approach replies on a highly resolved spatial database of urban land cover, stormwater drainage feature and topography, what about its potential application in a general context? Most of urban areas may not have such detailed dataset or require extensive surveying and modeling efforts.

- ⇨ <u>*Original Response:*</u> *Indeed, highly resolved spatial databases are not always available for many urban areas. This is because these GIS databases can be expensive to develop and maintain; and/or may not be required for conventional stormwater management purposes. However, in our experience more and more municipalities in the U.S., at least, are developing and improving their spatial databases of stormwater infrastructure. To address this comment we would add the following content to section 2.2.1: "Existing databases that include the details for the stormwater infrastructure in this watershed are not always readily available to the modeler. In these cases, to adopt the subsequently described approach to GI scenario modeling in SWMM could require considerable ground-truthing and site surveying. In lieu of onsite visits, and as will become apparent from the descriptions below, what would be most important is determining the spatial location of storm sewer inlets. These are often visible from readily available aerial photographs. When elevation data for the storm sewer network is unavailable, much can be inferred using surface elevation data and assuming local construction codes for stormwater infrastructures, such as catch basin depths, and conveyance pipe diameters and slopes were applied. Such approximations would suffice for GI scenario analysis considerations, where storm sewer design is not the primary focus.*
    - ***Please see P5/L14-21 of the revised manuscript where this information is included.***

- ⇨ *<u>Original Response</u>: Also, the reviewer includes land cover and topographic information in his/her assessment on data availability. For land cover, the availability is somewhat irrelevant, as our approach requires land cover analysis and detailed digitization to do the subarea parameterization in SWMM that we describe in the manuscript (MS). This land cover and subsequent Subarea categorization is described in fairly specific detail in section 2.2.2. We struggled with how detailed the descriptions needed to be during the preparation of earlier drafts. Two internal reviewers, prior to submission to HESS, suggested the detail was too much and that the MS was too long. To address this issue we have prepared a companion report that will be published as a USEPA, Office of Research and Development contribution, that will be freely available to anyone interested. We will reference this report in the final version of the HESS MS, should it be accepted for publication.*
    - ***We added more details as well as adding the USEPA report (Lee et al., 2017) as reference.***

2. Relevant references are needed to support statements in the text, see specific comments for details. The key definitions (e.g., DCIA, ICIA, SPA, BPA) are given, but a conceptual model characterizing these key processes in a watershed and their spatial connections should be provided.

- ⇨ *<u>Original Response:</u> We will add a new figure that will depict a conceptual schematic that provides context to the DCIA, ICIA, SPA, and BPA categorization. This can be in the form of a side view of a home situated along a street with storm sewer infrastructure depicted.*
    - ***Please see Fig. 5 of the revised manuscript. We significantly changed this figure to better explain how the different subareas could be represented in SWMM.***
- ⇨ *<u>Original Response</u>: It is important to note, however, that these areas are defined within a subcatchment for SWMM modeling, not at the watershed scale. A watershed in SWMM consists of a number of subcatchments, which interact based on the existing storm collection system.*
    - ***The areas (e.g., DCIA, ICIA, SPA, BPA) are defined within a SWMM subcatchment, not at the watershed scale. This clarification is made with the new use of the term hydrologic response element (HRE) coined to help distinguish physical landscape and modeled areas.***

3. The land cover characterization in GIS is an essential step to provide inputs for hydrological evaluation in SWMM. Very limited information is given to understand how it is done in GIS analysis. Also readers need more details on how the four types of subareas are subsequently modeled in SWMM (e.g. parameter settings), e.g., how to parameterize BPA, ICIA, SPA for subcatchments.

- ⇨ *<u>Original Response:</u> As noted under 1. above, we struggled with the level of details to provide. Our intent for the MS was to focus on evaluating the performance of the approach to modeling GI in SWMM. For readers that want specific guidance on implementing the approach the USEPA report is being prepared. This can be referenced in the final version of the MS. It includes details on how to process clip, intersect, union, and manipulating attribute data in ArcGIS. Much of this will be familiar to users of ArcGIS, so we tried to strike a balance in the MS. If the Editor prefers a different tact to providing this information we could try to include as a supplemental section or appendix.*
    - ***Please see P6/L2-11, P7/L8-16, and P9/L6-9 of the revised manuscript.***
    - ***We referenced the companion USEPA (Lee et al., 2017) report that provides relevant details.***

4. A better description of model calibration process is recommended, e.g., summary of parameters, inputs and outputs, criteria of performance.

- ⇨ *<u>Original Response:</u> We disagree with this comment. We provide quite a bit of detail on our approach to calibration in section 2.5 and show results of sensitivity analysis in figure 10; a standard approach to model calibration, as well as giving initial and calibrated values of the sensitive input parameters in Table 1. What we failed to include was the initial and calibrated value for the width of BPA. This* *will be added to Table 1 in the final version of the MS. The output of calibration, along with performance statistics (i.e., NSE and R2) is provided in figure 11. So, we believe the level of detail is sufficient and actually contrary to what the reviewer suggests.*

- ***Please see the addition to Section 2.6 and <u>the new Fig. 6</u> of the revised manuscript. Hopefully this extra description and clarification***

Specific comments:

1. P1, L21-24: it is confusing to mention the dimension and details of calibration parameters in the abstract before the relevant descriptions are provided.

⇨ *<u>Original Response:</u> This text in the abstract is not meant to note dimension and details of specific calibration parameters, rather to note a significant aspect about the approach to SWMM set-up that is presented in this study. What the text indicates in the abstract is that adopting the approach reduces the number of parameters that might be considered during calibration. However, while Reviewer 1 likely misunderstood the context for the description, Reviewer 2 correctly points out some inaccuracies in this statement (see general responses above and specific responses below) so we will eliminate it from the abstract*

- ***Please see P1/L21-23 of the revised manuscript. The text was removed and replaced with a more accurate statement to account for both Rev1's and Rev2's comments.***

2. P2, L13-15: there are conflicting conclusions about the cost-effectiveness of GI, please provide references for your statements. In particular, the detention pond can be costly in terms of the construction and maintenance costs.

⇨ *<u>Original Response:</u> That is why we put the word "may" in the sentence on L12. We will add the following to the sentence at L13: "…., like detention ponds, especially in cases where land is not available or very expensive."*

- ***Please see P2/L13-14 of the revised manuscript.***

3. P2, L27-30: how the upstream area is discretized and the subcatchment are parameterized matter both in the modeling and calibration. Typical way to discretize subcatchments replies on GIS-based hydrological and landuse analyses to achieve reasonable characterization of natural drainage divisions. Any references to support your statements?

⇨ *<u>Original Response:</u> We will try to include the presented criteria by the reviewer with relevant references, e.g., SWMM Reference Manual (Rossman and Huber, 2016).*

- ***Please see P2/L34-P3/L9 of the revised manuscript.***

4. P3, L32: please define "a unit-area based analysis"

⇨ *<u>Original Response:</u> The term unit-area is a relatively common term in the field of stormwater modeling that refers to normalizing model output by using a common spatial dimension, e.g., in our case, 1 acre. We don't think it is warranted to define this relatively standard term in the introduction. Furthermore, in addition to the spatial dimension we define the land cover characteristics of the unit-area specifically for this study beginning on P10, L22.andat P11, L4. We will add to this sentence the word 'unit' to "hypothetical area" to help clarify.*

- ***We reconsidered this original response. The original term used was jargon and not adequate to describe an important piece of our approach to GI modeling. We have made significant changes in the revision as a result:***
  - ***We changed "unit-area" to "hydrologic response element (HRE)" to minimize confusion.***
  - ***Please check Section 2.4 and, Fig. 5 in the revised manuscript.***
  - ***Please see P3/L8-15 of the revised manuscript.***

5. Figure 1: No legend for background landuse

- ⇨ <u>Original Response:</u> *Good catch. A relevant legend for the land use categorization will be added to the map.*
    - ***Updated. Please see Fig. 1 of the revised manuscript.***

6. P4, L15-20: A sketch of mentioned drainage system (manholes, pipes) is missing. Can author provide more information about the current drainage in the area? How many pipelines and manholes? what is the current service level of the system?

- ⇨ <u>Original Response:</u> *The existing drainage system is presented in Figure 5. A legend will be added to the figure to help define it. We don't see how statistics on number of pipes and manholes or 'current service level' of the system is relevant.*
    - ***Please see Fig. 7 of the revised manuscript. Relevant legends were added in the figure.***
    - ***Please see P18/L31-P19/L1 of the revised manuscript for a short description of the existing drainage system.***

7. Section 2.2.2: Details are needed to understand the spatial analysis used in the study. what are the inputs and resolution? What types of GIS tools and processes are used to identify and digitize the 16 land covers? how do you estimate the future potential for GI implementation (e.g., to evaluate the potential of downspout disconnection for a main building) and which parameters are used?

- ⇨ <u>Original Response:</u> *We used 0.76 m LiDAR as noted in P6, L18. We felt the level of detail called for by the reviewer unwarranted for the specific purpose of this MS, which is to highlight the specific aspects and provide results of the analysis of performance of the approach developed for GI Analysis in SWMM. And as mentioned earlier, details on GIS analysis are included in the USEPA report that will be referenced in the final version of the MS, or if this is deemed insufficient, we can try to cut and paste relevant sections for addition to supplementary materials section or appendix. The referenced report includes how to process clip, intersect, union, and manipulating attribute data. For the third question; a systematic approach to 'estimate the future potential for GI implementation' would be quite difficult given uniqueness of place considerations, and is beyond the scope of this research.*
    - ***We used 0.76 m LiDAR as noted in the manuscript (P5/L13, P7/L20).***
    - ***We referenced the companion USEPA report (Lee et al., 2017) that provides relevant details (P6/L20-21).***

8. P6, L1-L10: Though Figure 3 depicts the different boundaries of BPA, I still don't understand how to set the BPA in SWMM and which parameter do you use to represent BPA? how did you choose the buffer widths in this study? Can author provide more information on how to use the "intersect" tool for estimating the BPA and SPA?

- ⇨ <u>Original Response:</u> *The description of how to set-up the BPA in SWMM starts on P8, L31. We note that the original widths of the BPA are arbitrarily determined and explain why this has to be the case on P6. To provide more details on using the intersect and other functions in ArcGIS would require a step-by-step approach to using ArcGIS software. We, in fact, provide this detail in the USEPA report that is undergoing internal review and will be referenced in the MS, but we feel it is inappropriate for this MS to call for a tutorial on how to use certain functions in ArcGIS. An interested reader can find this information searching the help menu and user guides of the ArcGIS software.*
    - ***Please see P7/L3-16 and P9/L6-9 of the revised manuscript. We added more description to help clarify.***
    - ***We referenced the companion USEPA report (Lee et al., 2017) that provides relevant details.***

9. P7, L15-16: Authors considered DS-IA and DS_PA in subcatchments, could authors show how the two parameters are obtained? Is it a simple characterization of the dry ponds and detention areas in subcatchment?

- ⇨ *<u>Original Response:</u> DS stands for depression storage, as noted in the list of abbreviations. DS is a standard term used in urban hydrology that denotes the depth of water that can collect on urban surfaces, due to surface roughness properties. The initial value assigned to DS per land cover type was assigned based on recommendations or defaults described in the SWMM User's manual, as noted on P8, L19. DS has nothing to do with dry ponds or other built detention areas.*
    - ***As noted in the manuscript, the initial value assigned to DS per land cover type was assigned based on recommendations or defaults described in the SWMM User's manual, as noted on P12/L11-14.***

10. P7, L16-20: How did you choose the values for Scut and IMD? Can you provide more details on the division of IA into areas with or without DS? Also you mentioned several ways to route the internal flows, how do you model it in SWMM?

- ⇨ *<u>Original Response:</u> We assign these values, in particular, using recommendations from the SWMM user manuals as noted on P8, L2: We will make note of this for the infiltration parameters earlier in this same section to help clarify. As for the other questions posed here, these can be answered for interested readers by consulting the SWMM user's manual documentations already referenced. We don't think addressing these questions with new additions to the text is warranted. It becomes more apparent with each comment that this reviewer has little experience using SWMM, we feel it is only necessary to go into the details of how to model urban hydrology using SWMM as they pertain to the described approach to GI scenario analysis. It is not our job to provide a tutorial on how to use SWMM. These are available at the SWMM download site, which will be referenced in the revision.*
    - ***Please see P12/L14-20 of the revised manuscript.***

11. Section 2.4.2: (a) vegetation swale (VS) seems an appropriate option to represent BPA, how the authors determined the parameters for VS, e.g., berm height, vegetation volume fraction? (b) how the authors determined the values of initial saturation and % of subcatchment imperviousness draining to the BPA from the geoprocessing steps? (c) I am confused about the way to model BPA, is it modeled as a VS (LID competent), or an individual catchment, or changes in subcatchment imperviousness and width? Why set the width (60 feet) for BPA?

- ⇨ *<u>Original Response:</u> We will try to clarify further in the revision, but generally we already state that parameter values are set based on guidance from the SWMM user manuals or from our experience working in urban areas. All of these details will be added to help clarify, including, berm height (0.1-in or 2.54-mm to minimize any storage effect within the berm, which is the case for real BPA), vegetation volume fraction (0, this is assumed to be negligible.), % imperviousness draining to the BPA (ICIA / TIA, where TIA = DCIA+ICIA). BPA is modeled as a VS (SWMM LID option) within a subcatchment, not as an individual subcatchment. We further acknowledge that many aspects of the BPA are unverifiable, and rationalize why this is not relevant to the integrity of the approach in section 2.3.2.*
    - ***Please see P9/L6-9 and P12/L33-P13/L7 of the revised manuscript.***

12. L9, L18-19: can authors give an detailed example on the evaluation of the groundwater flow in the study region? Is it calculated using Eq. 3 (then how the authors incorporated the equation in SWMM for groundwater simulation?) or just the difference between individual subcatchment surface and its nearest stream bottom?

⇨ *<u>Original Response:</u> No, we cannot provide more detail on groundwater flow. As mentioned in the manuscript, there was no observational data on groundwater flow. This is typically the case in urban modeling applications using SWMM. We will clarify that groundwater modeling parameters were defined using the SWMM Reference Manual and users' group knowledge base (e.g., https://www.openswmm.org/Topic/1465/groundwater-parameters; https://www.openswmm.org/Topic/4840/groundwater-values). The remaining questions in this response are irrelevant to our study.*

- ***Amended. Please see P13/L20-24 of the revised manuscript.***

13. Figure 5: what is the difference between Figure 4 and 5? it seems that both figures mainly give the depiction of the subcatchments. Adding regional drainage network (manholes, pipelines) are recommended.

⇨ *<u>Original Response:</u> Figure 4 is map of the watershed with relevant land cover and subcatchment delineation. Figure 5 is the conceptual representation of the area being model in the SWMM software, which includes the configuration of the storm sewer drainage network. As mentioned earlier, we will add a relevant legend to Figure 5, to help clarify.*

- ***Updated. Please see Figures 4 and 7 in the revised manuscript.***

14. P10, L26- 28: Conceptual illustrations of the 6 options are well presented in Figure 6, but I find it difficult to understand how the 6 options are modeled in SWMM in details? for example, which subcatchment parameters are used to represent the different subareas (e.g. ICIA, TIA) and how to control the flow or routing directions?

⇨ *<u>Original Response:</u> As shown in the legend, each rectangular represents a subcatchment in SWMM, and the dotted line divides subareas within the subcatchment. A rectangle without a dotted line means the subcatchment consists of a single (homogeneous) subarea, either 100% impervious or pervious. The arrows represent flow routing directions. We will add these clarifications. The legend in the figure will be updated.*

- ***Amended. Please see Fig. 5 in the revised manuscript. It has undergone significant changes to help clarify.***
- ***Please see P9/L6-9 of the revised manuscript.***

15. P11, L20-24: any reference to support your assumptions on the lengths for overland flows and surface slopes?

⇨ *<u>Original Response:</u> Length of overland flow means the flow length where the flow is maintained as overland flow (or sheet flow). It doesn't mean the physical length of a drainage area. This has long been a point of confusion in SWMM modeling. We will attempt to clarify in the revision. Surface slopes of typical urban drainage features are based on construction code or are inferred based on the GIS. The relevant references will be added.*

- ***Please see P9/L12-13 of the revised manuscript.***

16. P12, L2: A brief explaining of the method is recommend.

⇨ *<u>Original Response:</u> The following brief description will be added: "The 95th percentile rainfall event is defined as the measured precipitation depth accumulated over a 24-hour period for the period of record that ranks as the 95th percentile rainfall depth based on the range of all daily event occurrences during this period."*

- ***This brief description was added at P9/L30-32 of the revised manuscript.***

17. P12, L7-10: one way to represent the GI can be the decrease of DCIA, which impacts the subcatchment imperviousness directly. That is one side of the problem, another is to attenuate the surface flow and slow down the speed. Is there any measure to model this aspect in your approach?

- ⇨ *Original Response:* *The effect of GI scenarios on the temporal dynamics of runoff is considered by comparing storm hydrographs before and after GI addition to the model. To address this comment we will add a note on the temporal changes to the storm hydrographs shown in Figure 13 to the results. Namely something like this: "It is interesting to note from Figure 13 that the peak flow for the event depicted in the figure is slightly higher in the GI Scenario, but that the duration of flows slightly smaller than this peak is longer in the baseline scenario."*
    - ***Please see P15/L4-7 of the revised manuscript.***
    - ***Please also see P19/L31-33 of the revised manuscript.***

18. P13, Eq. 5-9: how to calculate the different Q values in SWMM? which result files are used to obtain these values?

- ⇨ *Original Response:* *This seems to be another question about SWMM modeling basics, to include the details of which are not appropriate for this MS. The reviewers question can be answered by consulting the SWMM user's documentation. If this question is based on the hydrograph separation procedure the calculations for the individual Q values are explained in the manuscript. Further action related to this comment is unwarranted.*
    - ***As described in the manuscript, the different Qs were the modeling results from the different SWMM models.***

19. P14, L16-18: I don't understand, if in option 4 where rainfall onto PA is completely captured by DS or infiltrated into soil, how come the simulated flow rates are much higher than the ones from the rest options?

- ⇨ *Original Response:* *The following description will be added to help explain the results observed for option 4: "Hydrologic connectivity is very important. In Option 4, the one-acre area is modeled as a single subcatchment with two subareas: IA and PA. Because this setup ignores the difference between DCIA and ICIA, the entire impervious area (subarea IA) is actually modeled the same as DCIA, which means all of the runoff is discharged to the storm drainage system directly with no abatement. Under a small storm (like <1-month storm), runoff occurs only from impervious area, more specifically only from DCIA. For small storms, runoff from ICIA is completely controlled by BPA (if ICIA exists), but no ICIA is modeled under Option 4. Because of this, modeled runoff from this option is higher than any of the other options.*
    - ***Please see P17/L14-20 of the revised manuscript.***

20. P17, L1-2: without field measurement for valuation, how do you interpret the results? Given the clay type soil, 48% is much higher than expected.

- ⇨ *Original Response:* *We think this comment is based on a mis-understanding of the term interflow. We validated the total flow at the outlet of the watershed for the baseline condition using observed flow data. By applying artificial modeling conditions (e.g., DCIA only, or excluding the groundwater component as described in the manuscript), we tried to show how to develop more effective GI implementation scenarios. These conditions are contemplative and do not actually exist, so they cannot be validated with measured data. The 48% interflow doesn't mean all the 48% flow discharges through the entire soil layer as groundwater. There would be considerable amount of very shallow subsurface flow that discharges through a shallow layer near the surface with a relatively high porosity. We will try to clarify in the revision.*
    - ***As described in the manuscript, the interpretations were based on the artificial modeling results to get additional insights on future GI implementation.***

21. P17, L15: can you provide some explanations on the increasing peak flow resulting from the GI scenario?

- ⇨ *<u>Original Response:</u> Definitely. We will add the following explanation: Overall the flow volume is reduced from the GI scenario. However, when the peak occurred around 15:30 (shown in Figure 13 the capacity of the GI for controlling stormwater was already exceeded. because of controlling runoff during the previous rainfall that occurred between 7:00 and 14:00. Under this saturated condition, even the direct rainfall to the GI area will be discharged with minimum abatement. If there is no GI (as in the baseline condition), the same area receives only direct rainfall, there is no additional run on from impervious area, and that rainfall is controlled by still available surface depression storage and not-saturated infiltration.*
  - ***Please see P20/L23-28 of the revised manuscript.***

Anonymous Referee #2
Received and published: 24 July 2017

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.

<u>Original Responses:</u>

- ⇨ *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 **(We coined the new term HRE in the revision to help clarify this aspect)**, 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 **(We've tried to clarify this matter in the revision)**.*
- ⇨ *Flow connectivity within a drainage area (**now HRE**) is presented in Figure 6 (**now Fig. 5**). 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 (**now Fig. 5**)), even though only the BPA can receive waters from impervious area, specifically from ICIA. As shown in Figure 8 (**now Fig. 9**), simulated runoff by Options 4 or 5 would be very inaccurate, especially for the <1 year small storms. We explain in the MS (**and added additional in the revision, see above**) 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 (**now fig. 5 and 9**). 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 actual modeling steps required, i.e., sensitivity analysis followed by one at a time adjustment, re-run, and 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 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, then 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.*
  - ***Please check the amended Fig. 5 in the revised manuscript.***
  - ***Please see P18/L7-9 of the revised manuscript.***
  - ***Please find a new figure (Fig. 6) and related descriptions in the revised manuscript.***

Detailed Comments:

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

- ⇨ *References will be provided.*
  - ***Please see P2/L18-24 of the revised manuscript.***

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

- ⇨ <u>*Original Response:*</u> *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.*
  - ***We changed the term "unit-area" to "hydrologic response element (HRE)" to minimize confusion.***
  - ***Please check Section 2.4 and, Fig. 5 in the revised manuscript.***
  - ***Please see P3/L8-15 of the revised manuscript***

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

- ***We added 'to'. (P6/L28 of the revised manuscript)***

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.

⇨ *<u>Original Response:</u> 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 (**now Fig. 11**)).*
   - ***Please see P7/L13-16 of the revised manuscript.***
   - ***We referenced the companion USEPA report (Lee et al., 2017) that provides relevant details.***

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

⇨ *<u>Original Response:</u> 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.*
   - ***Please see P7/L23-28 of the revised manuscript.***

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?

⇨ *<u>Original Response:</u> 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.*
   - ***We think it makes better sense to keep the sections.***
   - ***Please see P12/L14-20 of the revised manuscript.***
   - ***Please see P9/L6-9 and Fig. 5 of the revised manuscript.***

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.

⇨ *<u>Original Response:</u> 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 (**now fig. 5**). 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.*

- ***Please see P11/L18-30 of the revised manuscript.***

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.

⇨ *Original Response: 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.*

- ***Please see P9/L6-9, P7/L13-16, and P12/L29-P13/L7 of the revised manuscript.***

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.

⇨ *Original Response: 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.*

- ***Please see P14/L19-26 of the revised manuscript.***

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.

⇨ *Original Response: Table 1 (**now Table 2**) 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.*

- ***The table (Table 2 in the revised manuscript) shows the initial and calibrated parameters for the study area, not the hypothetical unit-area analysis (HRE in the revised manuscript).***
- ***We added more descriptions to clarify. Please see the amended Fig. 5 and P9/L19-21 of the revised manuscript***

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

⇨ <u>*Original Response:*</u> *In option 4, the entire impervious area is modeled as DCIA, i.e., ICIA is also modeled as DCIA There is no run on from impervious to pervious areas in option 4. (Please also see the responses under the comment #19 for Reviewer 1).*

- ***Please see P17/L14-20 of the revised manuscript.***

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.

⇨ <u>*Original Response:*</u> *The figure will be amended. The attribute table shown in the figure will also be amended to minimize any miss-interpretation.*

- ***Amended. Please see Fig. 2 of the revised manuscript.***