Authors Response (AR) to RC #1

This paper presents a novel algorithm for deriving below-ground urban stormwater networks using graph theory concepts. The paper is well written, well-articulated, and presents application to both urban hydrologic modeling and broad Earth system modeling. Although the manuscript is heavy on the method description, the applicability of the algorithm is clearly illustrated with 4 case studies. I think some shifting of paragraphs are needed to make the paper flow better. I also have some minor comments for the authors to consider.

AR: We would like to thank the reviewer for the constructive comments and criticism. Below are our point-to-point responses to the comments.

1. *It might be helpful to explain what "edge" and "node" mean at the beginning. It was clear later that edge means pipe and node means users but providing some contexts at the beginning would be helpful.*

   AR: We will add the explanations of them at the beginning in the revised manuscript.

2. *On page 4, at the beginning, I was confused about line 92-94. It seems counter-intuitive that higher weight results lower weighted BC value. Also, "a higher weight suggests a larger resistance to water flow and thus a lower flow rate." This part also confuses me. If the pipe is made out of the same materials, how will a higher weight lead to larger resistance to water flow? Is it because the length of the pipe is longer? If that's the case, then the pipe should be included because of its importance, right? I think the weighting process needs to be better explained up front to avoid confusion.*

   AR: We agree that the "weight" concept in Graph theory is somewhat counter-intuitive. However, we note that for computing BC we are looking for the shortest paths, i.e., minimizing the sum of edge weights. Therefore, we need to define the properties of interest for assigning edge weights, accordingly. For example, in the context of BUSN properties, our goal is to assign a higher BC value to a pipe with a higher flow capacity. Additionally, we know that some pipe properties, such as diameter, have a direct relationship with flow capacity and others, such as roughness, have an inverse relationship. Therefore, to minimize the edge weights, we transform those properties with a direct relationship in such a way that higher values correspond to lower weights. In contrast, we should transform those properties with an inverse relationship so that higher values correspond to higher weights. We will rephrase our usage of the weight concept in BUSN to clearly reflect this direct/inverse relationship.

3. *On page 8, bullet point 8, "those components that are unreachable after converting the network to an undirected graph by ignoring edge directions", did you check if these pipes are actually not important edges? How rigorous is this approach?*

   AR: By unreachable we meant those isolated group of edges that form relatively small subgraphs that are not connected to the other parts. So, the approach is rigorous since we are only eliminating those isolated subgraphs that are very small in comparison to the

whole network. The key sentence in bullet point 8 is "Then, we find the number of streets for each subnetwork and remove those subnetworks whose number of streets is less than the average street count of the subnetworks."

4. *I got a lot of questions when I saw Figure 5. For example, I wonder how pipes sizes are assigned based on BC and permissible min/max diameter. I found out that these were explained later in the manuscript. I think some indications directing the readers to the section where these are explained would be helpful.*

   AR: We agree with this comment and will make necessary rearrangement in the revised manuscript, e.g., moving the Fig. 5 to the end of section 2 after all the detailed explanation.

5. *On page 11, line 204, "assigning two lanes to those road types not listed in Table 2", why?*

   AR: The road types that are not listed in the table are generally for local-access and are small percentage of the total number of roads. They are usually two-way roads, so we considered them as two-lane roads. We will add this explanation in the revised manuscript.

6. *On page 12, line 216, maximum discharge for a pipe when depth of water is flowing at 94% of diameter, not full!*

   AR: We agree that the actual flow capacity of a pipe is when the water depth is at about 94% the maximum height that leads to about 8% difference between the actual and nominal hydraulic capacities. We will make note of this in the revised manuscript. Essentially, in our algorithm we compare the hydraulic capacity of pipes to assign them weights and compute their "relative significance". So, since we are using the full pipe diameter to compare the capacity of pipes, using full or 94% does not make a difference in their "relative significance".

7. *In table 3, what does the LULC number mean?*

   AR: By LULC we were referring to the land cover class. We will spell it out in the table.

8. *On page 20, in table 6, the last column appeared for the first time without giving any context. It was explained later in the manuscript, but some explanations are needed when it first appeared.*

   AR: Thanks for catching this. We will move the table to the end of Section 3 to make sure all explanations are provided beforehand.

9. *On page 25, I don't see any drainage pipes captured for the center of the city. Why is that the case?*

AR: As we mentioned in Section 3.1, for example, when discussing Figure 9a, the publicly available BUSN data have poor quality and cover only a portion of the urban areas. For the Baltimore case (page 25) the existing BUSN is not publicly available in the city center. We are not sure exactly why they the local government did not make the data for the city center publicly available.

10. *The first sentence in Introduction does not flow well. Please revise.*

    AR: We will rewrite the sentence in the revised manuscript.

11. *Is Figure 1 an original creation or is it obtained from other sources? Please ensure that IP is not infringed.*

    AR: This figure is adapted from Town of Gilbert, AZ (2022) but with substantial modifications. Below please see the comparison between the original version and our version.
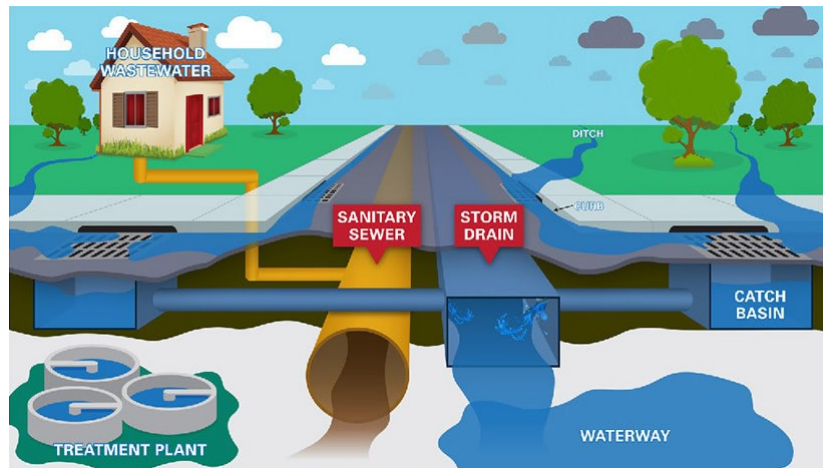

Figure R1. Source image from Town of Gilbert, AZ (2022)

Figure R2. Our adapted version of Figure 1