## Options for Adding User Nodes into a SWAM Network

The following supplemental question was asked during discussions of the Modeling Approach for the Saluda Basin:

> *"What are the different ways of adding incremental flow between nodes, and what does the user need to do if a new node is added in between?"*

There are two ways of adding incremental flow between nodes, and it is important to understand their differences when considering how future nodes may be added to an established network in SWAM:

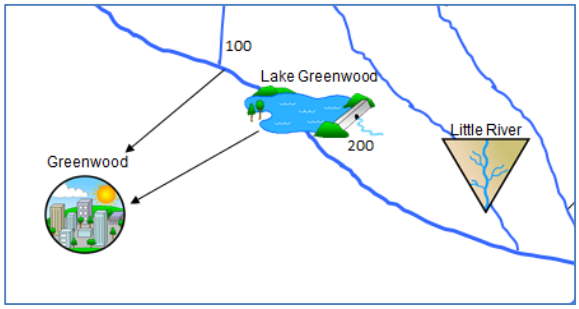
a) **Embedded Method:** One way to add incremental flow between two nodes is to use UIF or stream gage data throughout the network to calibrate hydrologic gains or losses within a reach, which can be input directly into SWAM. These gains or losses are added to the river network on a unit length basis, approximating watershed contributions equally over linear stream reaches.

b) **Explicit Method:** Another way to add incremental flows is to calculate them explicitly as the mathematical difference between a UIF upstream and a UIF downstream, and add the incremental flow as an explicit timeseries using the TRIBUTARY object in SWAM to represent aggregate gains and losses.

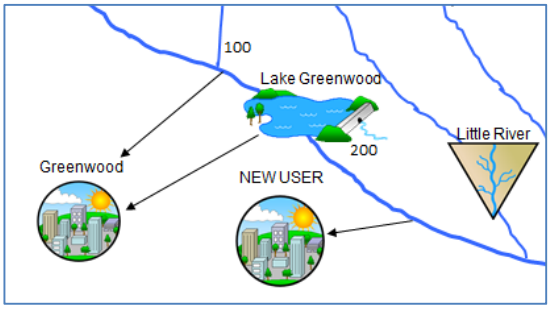
Both methods have advantages and disadvantages. The Embedded Method (a) allows for rapid addition of new nodes in between existing nodes, with automatic redistribution of reach gains by linear distance ratios. It also can be used to more accurately represent diffuse, rather than point, gains or losses where such hydrodynamics are known to occur. The disadvantages of this method are that the gains/losses are calibrated rather than calculated, and as such exhibit more uncertainty. Additionally, incremental reach gains/losses are computed by linear distance, which the model tracks, and not by upstream drainage area, which the model does not track or compute. Hence, the embedded method will generally be recommended for reaches that are not extremely long (reaches that are bounded by nodes within ten miles of each other, for example). The Explicit Method (b) offers the opportunity for more mathematical precision in incremental flows (they are calculated directly from the UIFs bounding a reach) and more flexibility in representing time-variable flows. When incremental gains are known to be point discharges (e.g. small streams or springs), the explicit method is the obvious preferred option. However, the explicit method does not accurately capture diffuse flows, and adding new nodes to the reach could be problematic. Diffuse flows would not be automatically redistributed to the new nodes. In this case, the user would have to redistribute incremental tributary flows upstream and downstream of the new node, though the benefit of doing this outside the model is that drainage area could be easily factored into the redistribution.

A graphical example may help better explain the options. Consider the following – A modeler wishes to add a Water User node in between Lake Greenwood and the Little River Confluence:

Before New Node



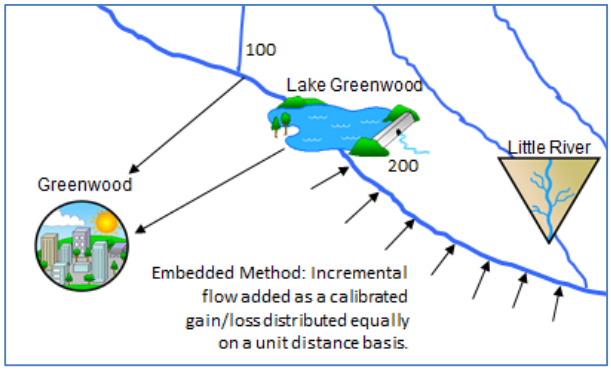

With New Node:



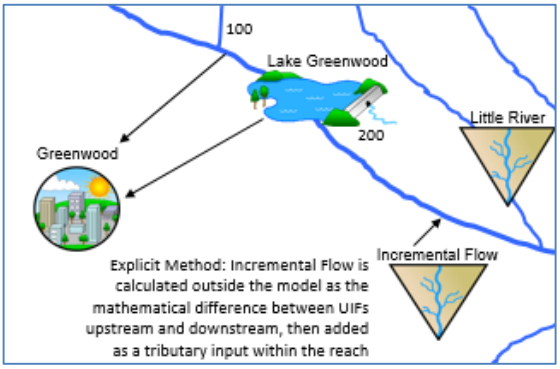

First, we will look at the two ways of specifying the incremental flow between Lake Greenwood and the Little River Confluence in the original model setup, assumed to be diffuse, and then how these decisions would affect the subsequent addition of a new USER node in between.

The figures below show how the incremental flow between Lake Greenwood and the Little River Confluence could be programmed into the initial model:

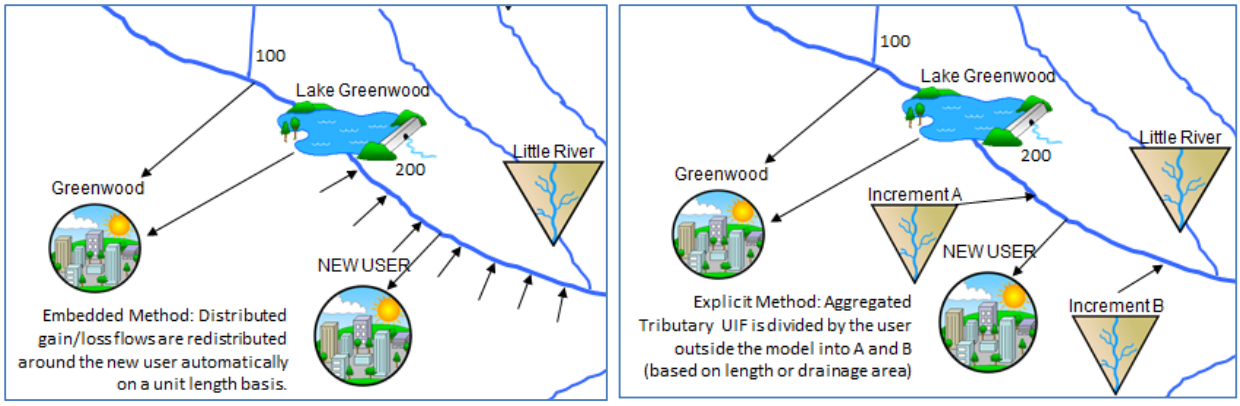
**EMBEDDED METHOD**




**EXPLICIT METHOD**




*Now add a new user in between nodes:*




Within SWAM, the available water at a given node is then calculated with the following equation:

$$Q^{i}_{phys} = \sum_{j=i-1}^{j=0} Q^{j}_{HW} - Q^{j}_{diversion} + Q^{j}_{ReturnFlow} + Q^{j}_{release} + Q^{j}_{HW} * GainLossFact * mileMarker^{i}$$

where index $i$ designates the relative downstream position of the node (as specified by the user) and $j$ designates the upstream locations of tributary inflows ("HW" denotes tributary headwater), node diversions, node return flows, and reservoir releases. Note that the first and last terms represent the two alternatives above: Either the Gain/Loss factor is applied to compute incremental flow changes per unit distance, or incremental flow can be added as an additional tributary. Additionally, based on specified mile markers, SWAM can calculate all upstream contributing inflows and withdrawals and all downstream higher priority nodes (such as instream flow requirements, etc.) that are relevant to the legal availability calculation. When the embedded method is applied, as new nodes are added with specified mile markers, SWAM automatically calculates the net result of all upstream inflows and withdrawals in the physical flow calculation. Reach gains or losses, if specified by the user (on a per unit length basis), are incorporated based on the total distance from the top of the given reach to the node location (i.e. the user-specified mile marker).