EPA SWMM5 for Novice/Advanced Users
EWRI2025 Pre-Conference Workshop, May 17, 2025 (Anchorage AK)

Exercise 2: Extend a Model to Include Snowmelt and Groundwater

This exercise uses the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM5, 64-bit version of build 5.2.4) and is in U.S. customary units. It is assumed that you are sufficiently familiar with the SWMM5 user interface, so that only the key commands and input values are highlighted in bold.

Key Learning Objectives

1. Learn how to prepare a design storm model for continuous simulation.
2. Update a model to include snowmelt.
3. Update a model to include groundwater and understand how to set initial conditions.

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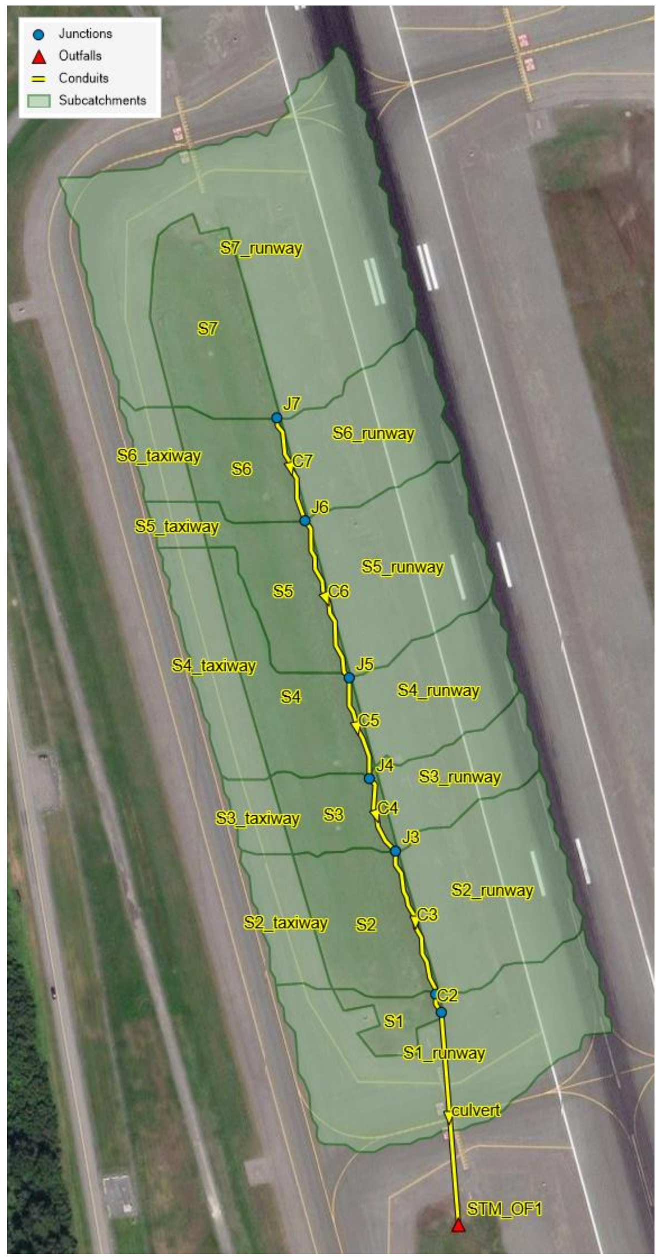
1 Prepare Model for Continuous Simulation

This exercise will extend an existing culverted ditch model so that it includes snowmelt and groundwater for a representative water year. The base model represents a portion of the airport drainage at the Ted Stevens Anchorage International Airport and is shown in the image on the right.



The hydrology model represents the paved runway and taxiway areas along with the paved and grassed safety areas in between. The hydraulic model represents the ditches and culverted conveyance system.

Pervious subcatchments represent the ditches and are numbered S1-S7 and the impervious areas are differentiated between runway and taxiway surfaces. Impervious areas run-on to the corresponding pervious area. That is, subcatchments S6_runway and S6_taxiway discharge onto S6.

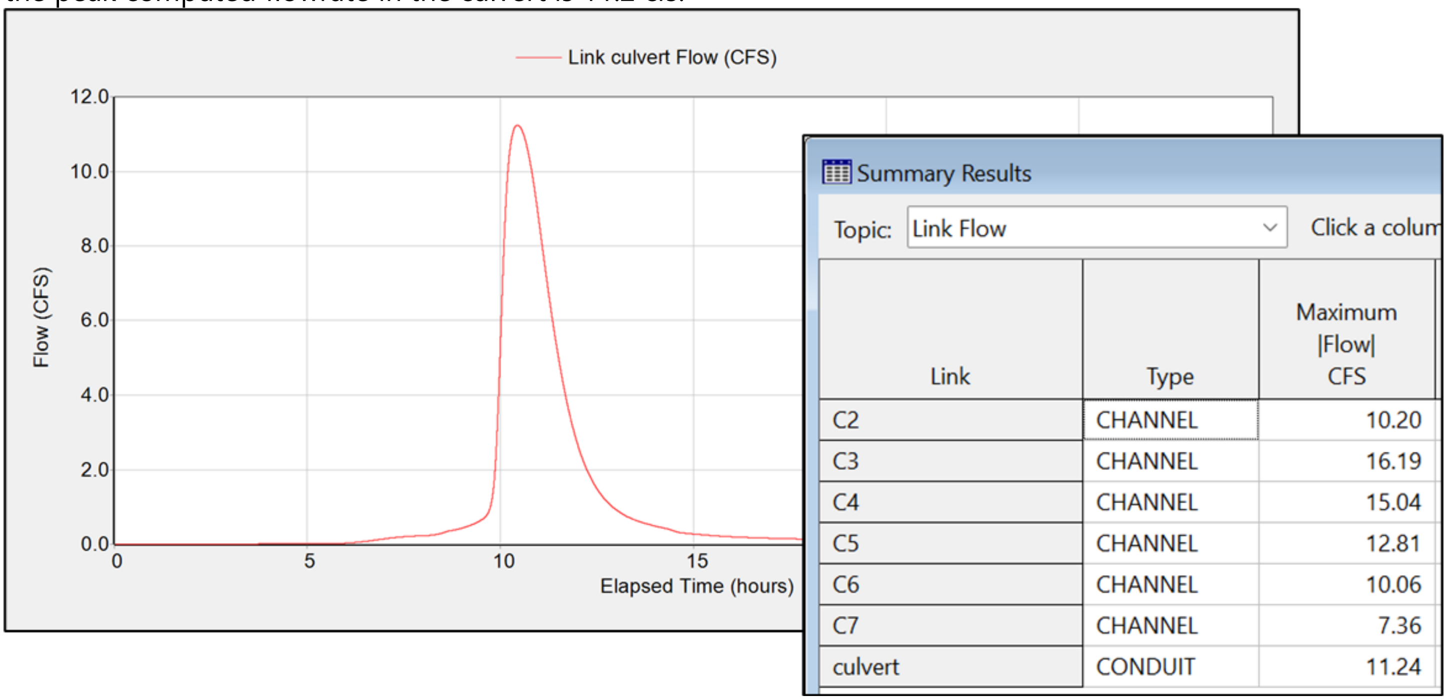
The ditch is represented by irregular shaped transects between junctions J1 and J7, which discharge into a 24-in diameter culvert, terminating at the outfall STM_OF1.

The base model was developed for design storm applications and will be updated to run continuously for a representative water year, defined as the period beginning on October 1 of the prior year and ending on September 30. A rainfall analysis was conducted to determine that WY2010 (October 2009 through September 2010) most closely matches the local long-term rainfall intensity pattern found in the 1990-2019 hourly rain dataset measured at the airport.

1-1 **Unzip** the contents of the file "**ANC2_SCS100yr24hr_SW52.zip**" into an empty folder and **launch SWMM 5.2** (executable file "epaswmm5.exe", version 5.2.4, 64-bit edition, downloaded from the EPA website at https://www.epa.gov/water-research/storm-water-management-model-swmm).

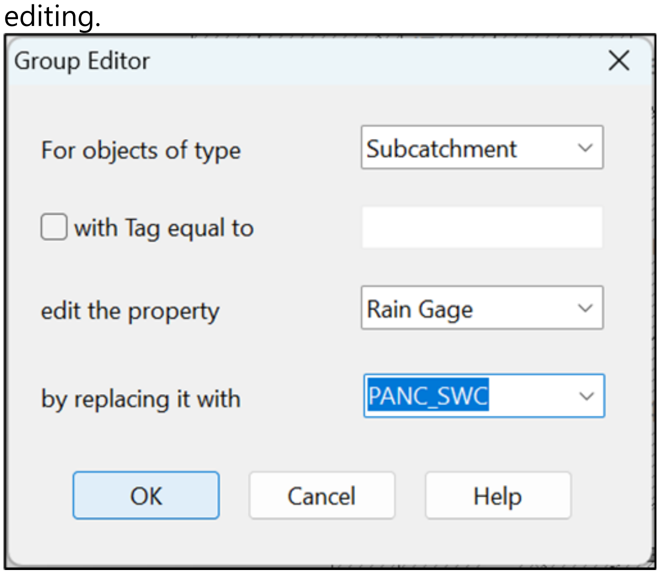
1-2 **Open** the project "**ANC2_SCS100yr24hr.inp**" in SWMM 5.2 and **Run** the model.

1-3 Plot the **Flow hydrograph** in the **culvert** (i.e., the southernmost conduit in the model, which represents the culvert in the airport runway ditch). Review the **Link Flow** section of the Summary Results and note the peak computed flowrate in the culvert is 11.2 cfs.

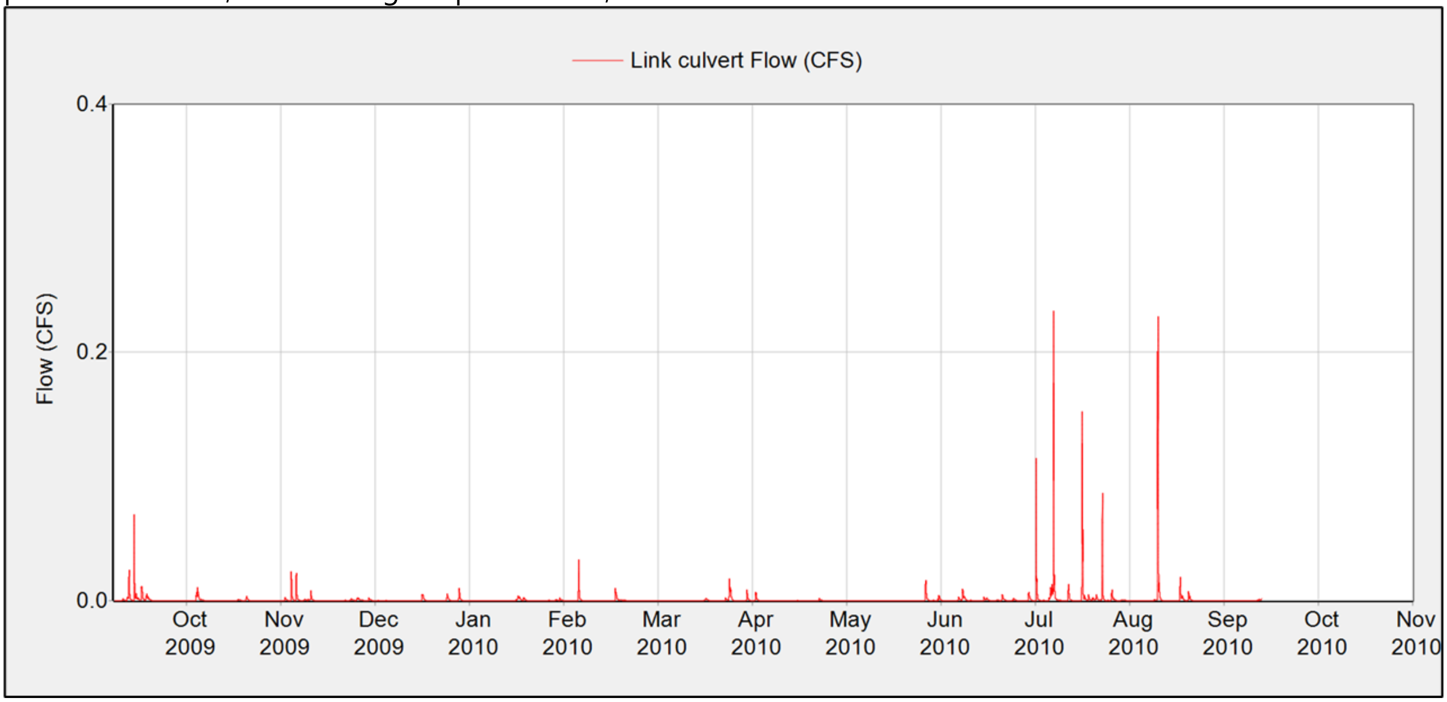


1-4 **Save the Project As** "**ANC2_2010WY**". In the **Dates** tab of the Simulation Options dialog, change the **Start Analysis On** and **Start Reporting On** dates to **10/01/2009 at 00:00**, and change the **End Analysis On** date to **10/01/2010 at 00:00**.

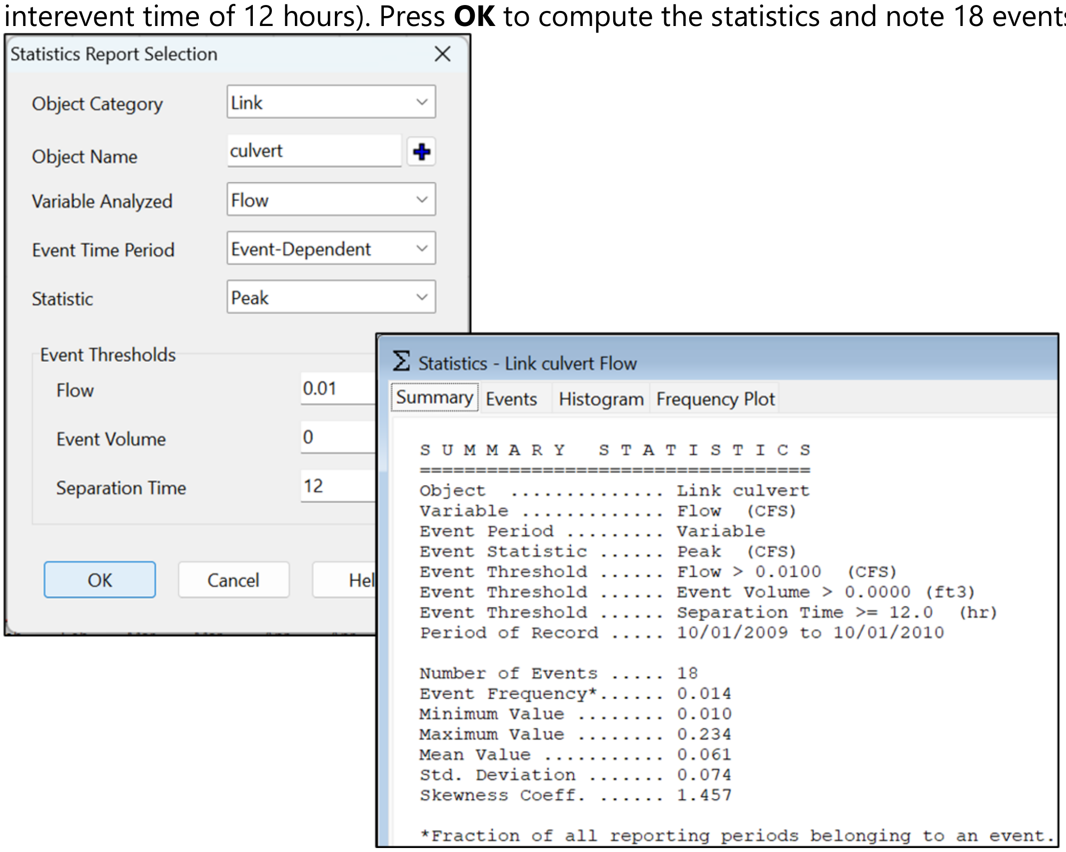
1-5 Select all 19 subcatchments by selecting the **Subcatchments** entities in the Project panel and then **Edit | Select All**. Open the Group Editor (**Edit | Group Edit...**) and then change the **Rain Gage** property to **PANC_SWC**. A pop-up message will confirm that 19 subcatchments were changed. Press **No** to stop editing.



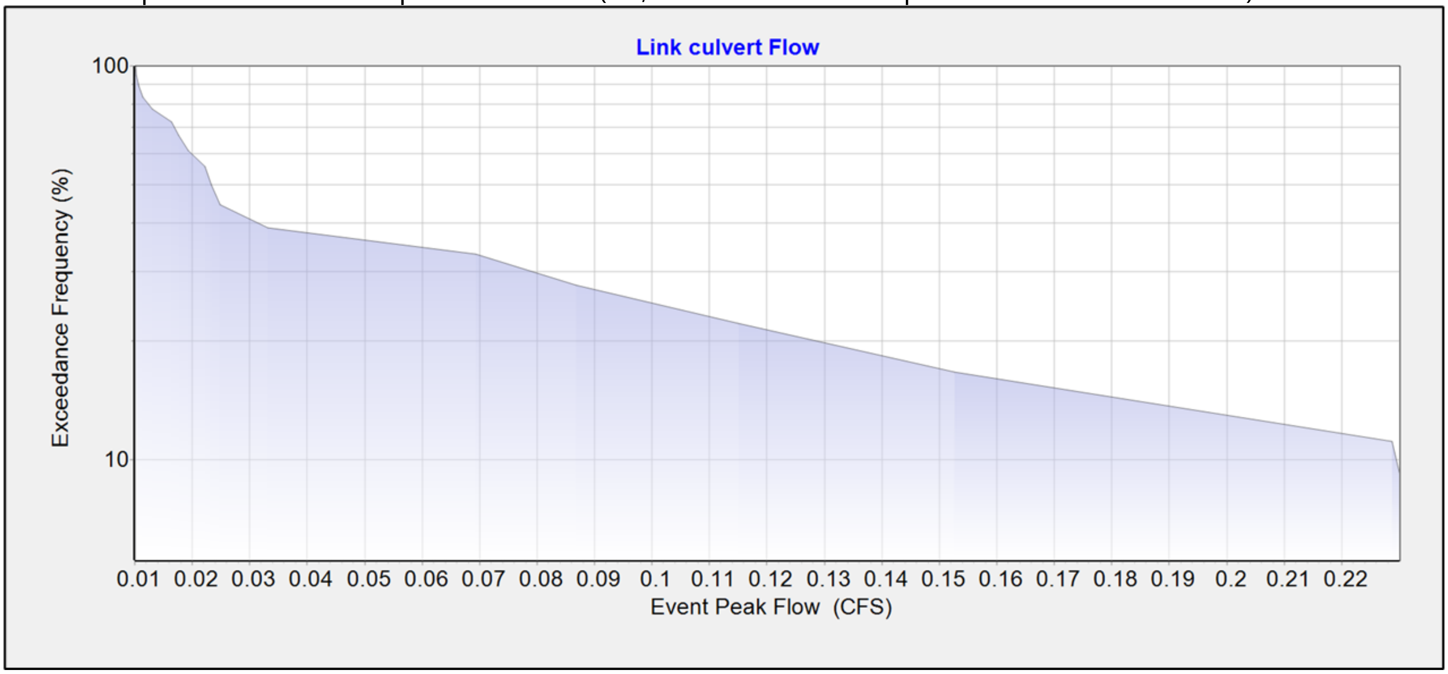
1-6 Run the model and note the simulation could take 1-3 minutes to complete, depending on your computer. When complete, plot the **Flow hydrograph** in the **culvert**. Note the peak flowrate for the period October 1, 2009 through September 30, 2010 is 0.23 cfs.



1-7 With the culvert selected, open the Statistics Report Selection dialog (**Report | Statistics**), select **Flow** as the Variable Analyzed, select **Event-Dependent** as the Event Time Period, and **Peak** as the Statistic to be analyzed. Specify a minimum **Flow threshold of 0.01 cfs** and a minimum event **Separation Time of 12 hours** (i.e., the flow hydrograph will be parsed into discrete events that are separated by a minimum interevent time of 12 hours). Press **OK** to compute the statistics and note 18 events in the **Summary tab**.

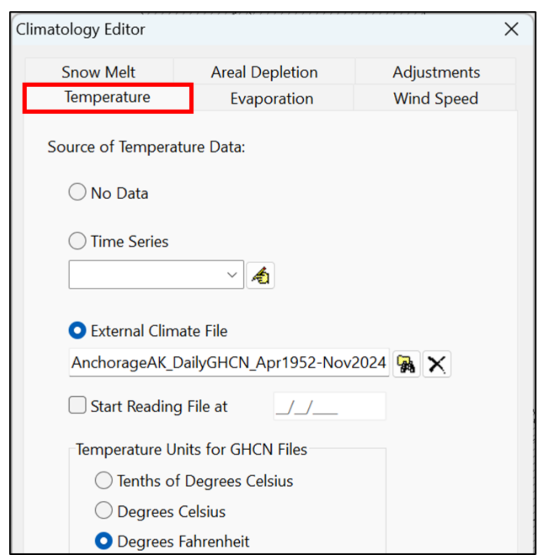


1-8 Note the resulting flow events are individually ranked in the **Events tab**, along with the exceedance frequency (P_E) and return period based on the Weibull plotting position formula. The flow duration curve is plotted in the **Frequency Plot tab**, with P_E on the log y-axis and the corresponding flow value on the x-axis. Note percentile is 100-P_E. For example, the plot shows that 30% of flows equal or exceed 0.08 cfs, which is equivalent to the 70th percentile flow (i.e., 70% of flows are equal to or less than 0.08 cfs).



2 Update Model for Potential Evapotranspiration

Design storm applications typically zero out evaporation and transpiration, since it is an insignificant component of the water budget during a single rainfall event. This would be a serious oversight for continuous simulation, as evapotranspiration often represents a large component of the water budget over a long period of rainfall events and the dry weather intervals between. Further, evapotranspiration affects the snowmelt and groundwater computations in SWMM5. In this exercise, potential evapotranspiration (PET) will be estimated using Hargreaves method, based on the daily maximum/minimum temperatures contained in a climate data file.



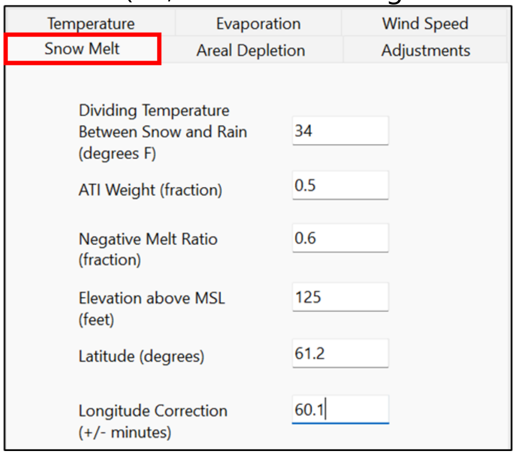
2-1 Save the Project As "ANC2_2010WY_withPET".

2-2 In the **Temperature tab** of the Climatology Editor, check **External Climate File**, select **Browse** and then choose **Text Flies (*.TXT)** from the dropdown list. Navigate to the file "**AnchorageAK_DailyGHCN_Apr1952-Nov2024.txt**", click **Open**, and then check **Degrees Fahrenheit**.

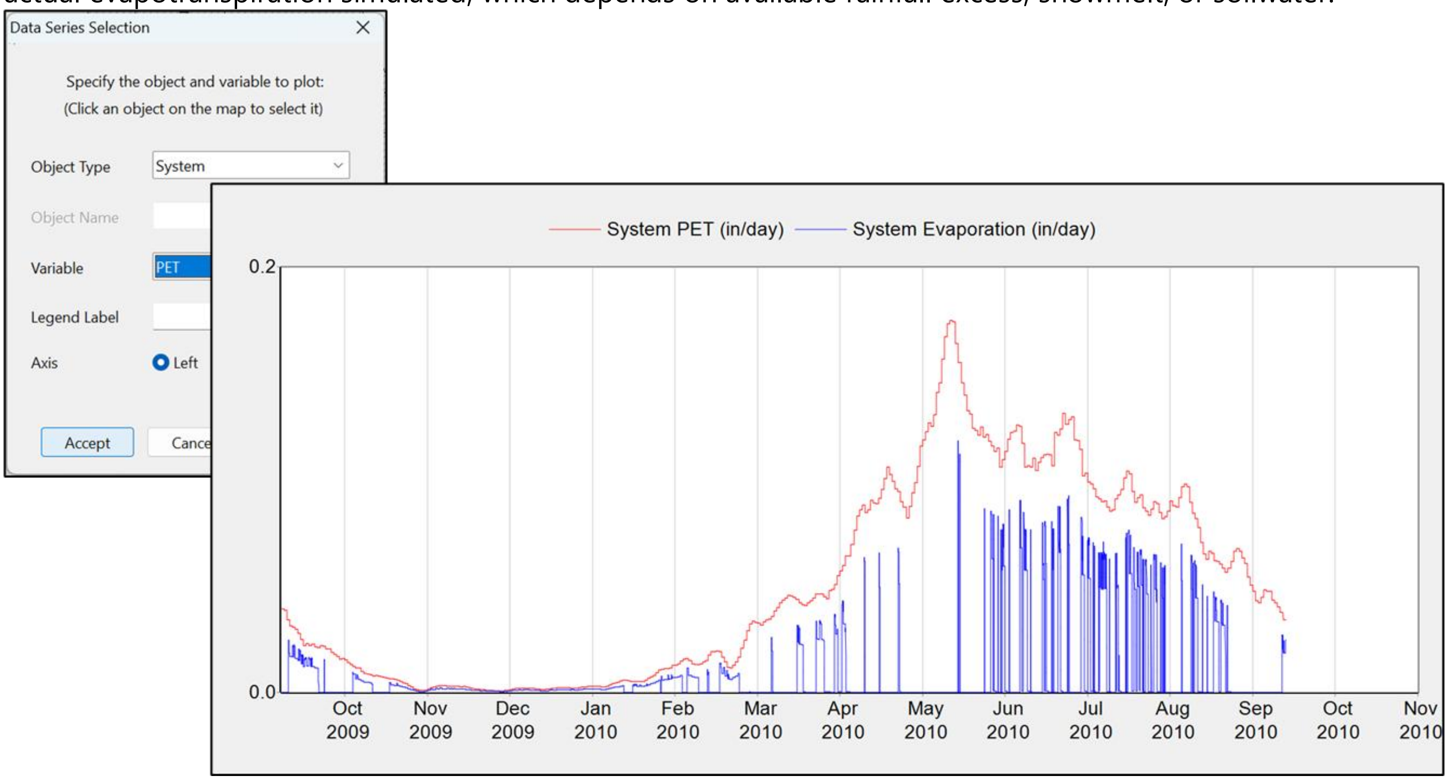
2-3 In the **Evaporation tab**, select **Temperatures** from the Source of Evaporation Rates dropdown list. In the **Wind Speed tab**, check **Use Climate File Data**.

2-4 In the **Snow Melt tab**, set **Elevation Above MSL to 125 ft**, **Latitude to 61.2**, and the **Longitude Correction to 60.1 minutes**. Press **OK** to close the Climatology Editor. Although snowmelt is not represented at this point, use of the Hargreaves method requires two parameters that are shared with the snowmelt computations in

SWMM5 (i.e., latitude and longitude correction).

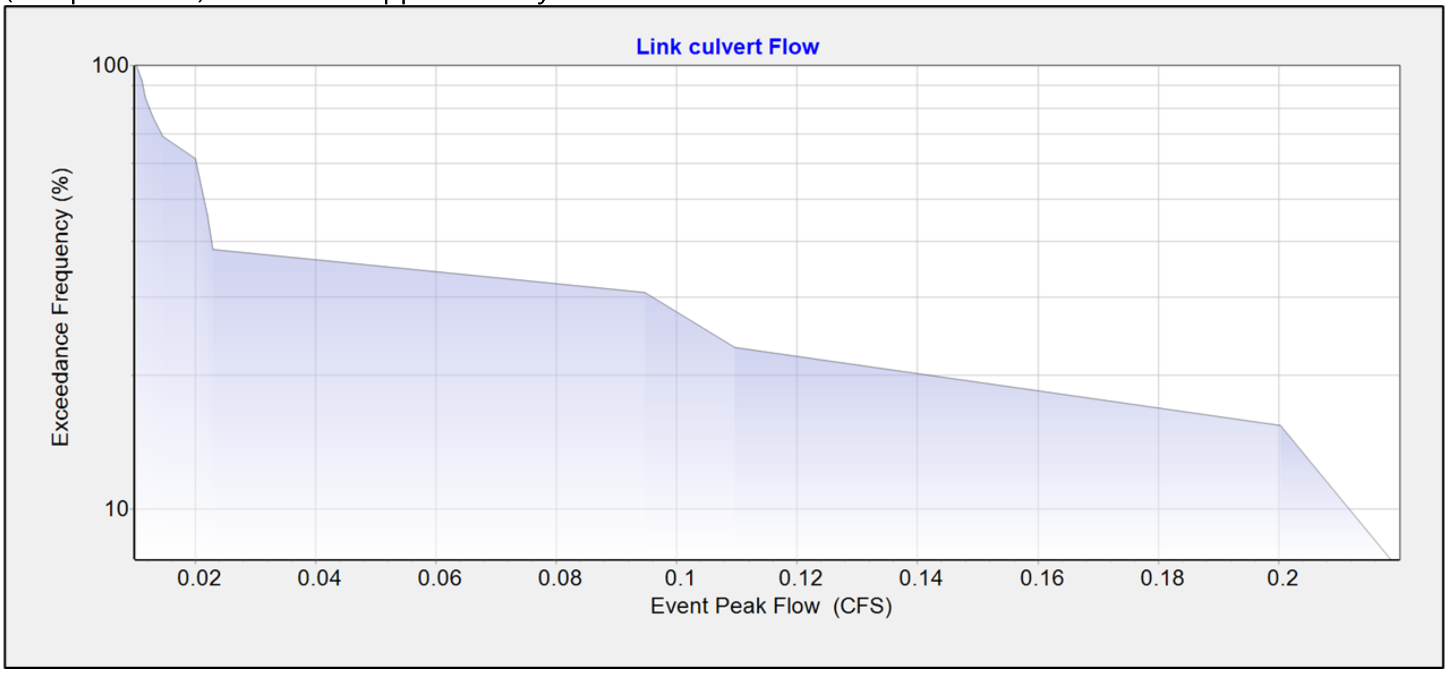


2-5 **Run** the model and when complete, plot the **System PET** and **System Evaporation** timeseries The former is the overall potential evapotranspiration computed by Hargreaves method and the latter is the actual evapotranspiration simulated, which depends on available rainfall excess, snowmelt, or soilwater.



2-6 Select the **culvert** and open the **Statistics Report Selection dialog**. Select **Event-Dependent** as the Event Time Period, **Peak** Statistic, minimum **Flow threshold of 0.01 cfs**, and a minimum event **Separation Time of 12 hours**. Press **OK** to compute the statistics and note there are now only 13 events in the Summary tab. Review the event listing, histogram, and frequency plots, noting that the 30% P_E.

(70th percentile) flow is now approximately 1 cfs.

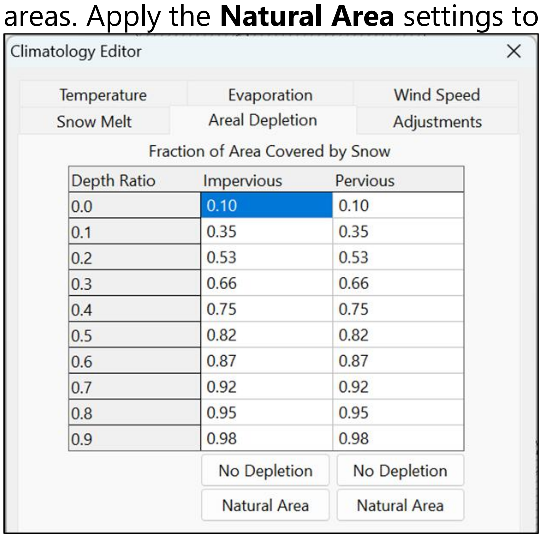


3 Update Model for Snowmelt

In this set of steps, snow accumulation and melt parameters will be added to the model, including snow cover depletion curves, and snowpacks for two types of winter snow-removal operations (i.e., FullPlow assigned to the runways and taxiways, and NoPlow within the ditch).

3-1 Save the Project As "**ANC2_2010WY_withSnowmelt**".

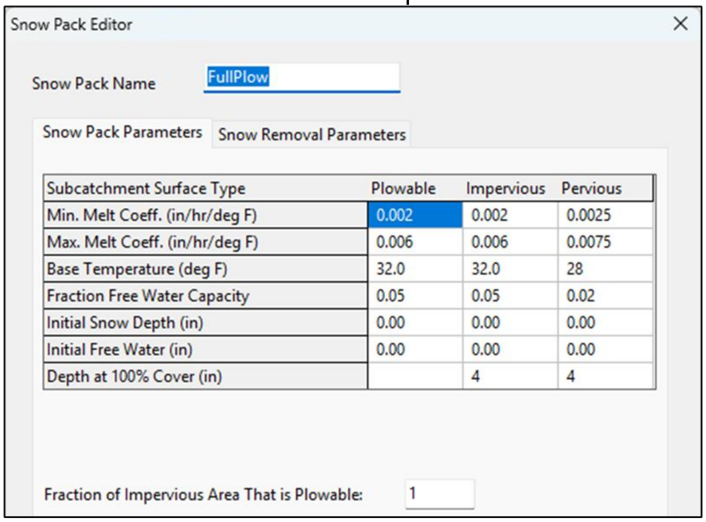
3-2 In the **Areal Depletion tab** of the Climatology Editor, replace the default settings with areal depletion curves that characterize the fraction of snow coverage at various snow depth ratios for typical "natural" areas. Apply the **Natural Area** settings to both Impervious and Pervious surfaces.



3-3 Add a new Snow Pack object with the **Name "FullPlow"** and enter the following **Snow Pack Parameters** (respectively for the Plowable, Impervious, and Pervious surfaces):

- Minimum Melt Coefficient: 0.002, 0.002, and 0.0025 in/hr/°F
- Maximum Melt Coefficient: 0.006, 0.006, and 0.0075 in/hr/°F
- Base Temperature: 32, 32, and 28°F
- Fraction of Free Water Capacity: 0.05, 0.05, and 0.02

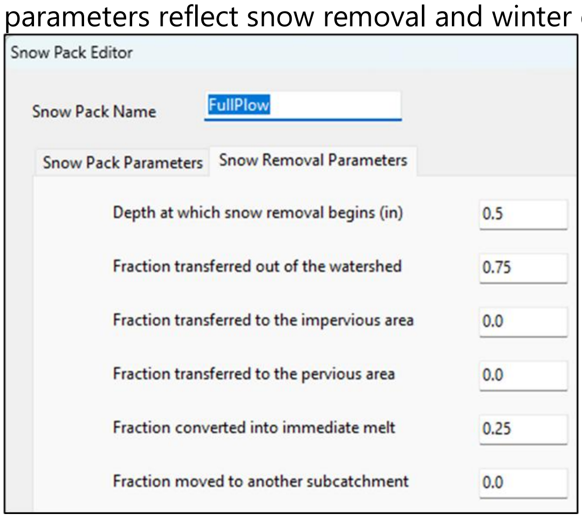
- Depth at 100% Cover: n/a, 4, and 4 inches
- Fraction of Plowable Impervious Area: 1



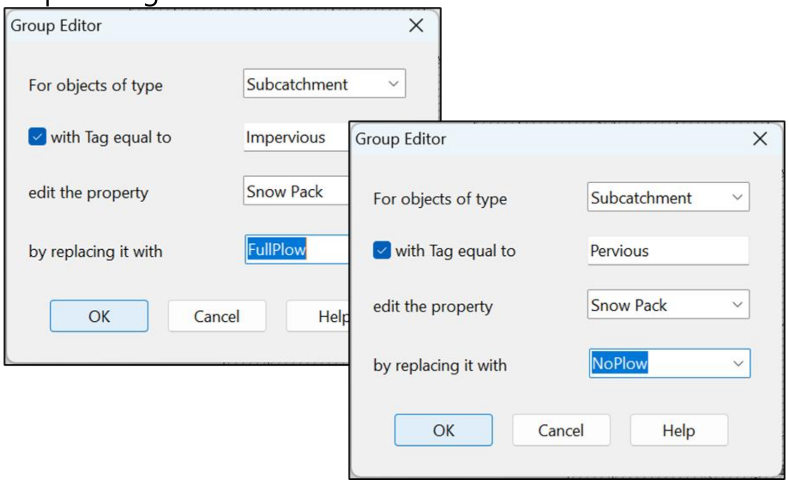
3-4 **Add a new Snow Pack** object with the **Name "NoPlow"** and enter the values in the previous step, except leave the **Fraction of Plowable Impervious Area as 0** (default).

3-5 In the **Snow Removal Parameters tab** of the **NoPlow** snowpack, change the default **Depth at which Snow Removal Begins to 99 inches** (i.e., so that there is no removal under any snow accumulation condition) and press **OK** to close the Snow Pack Editor.

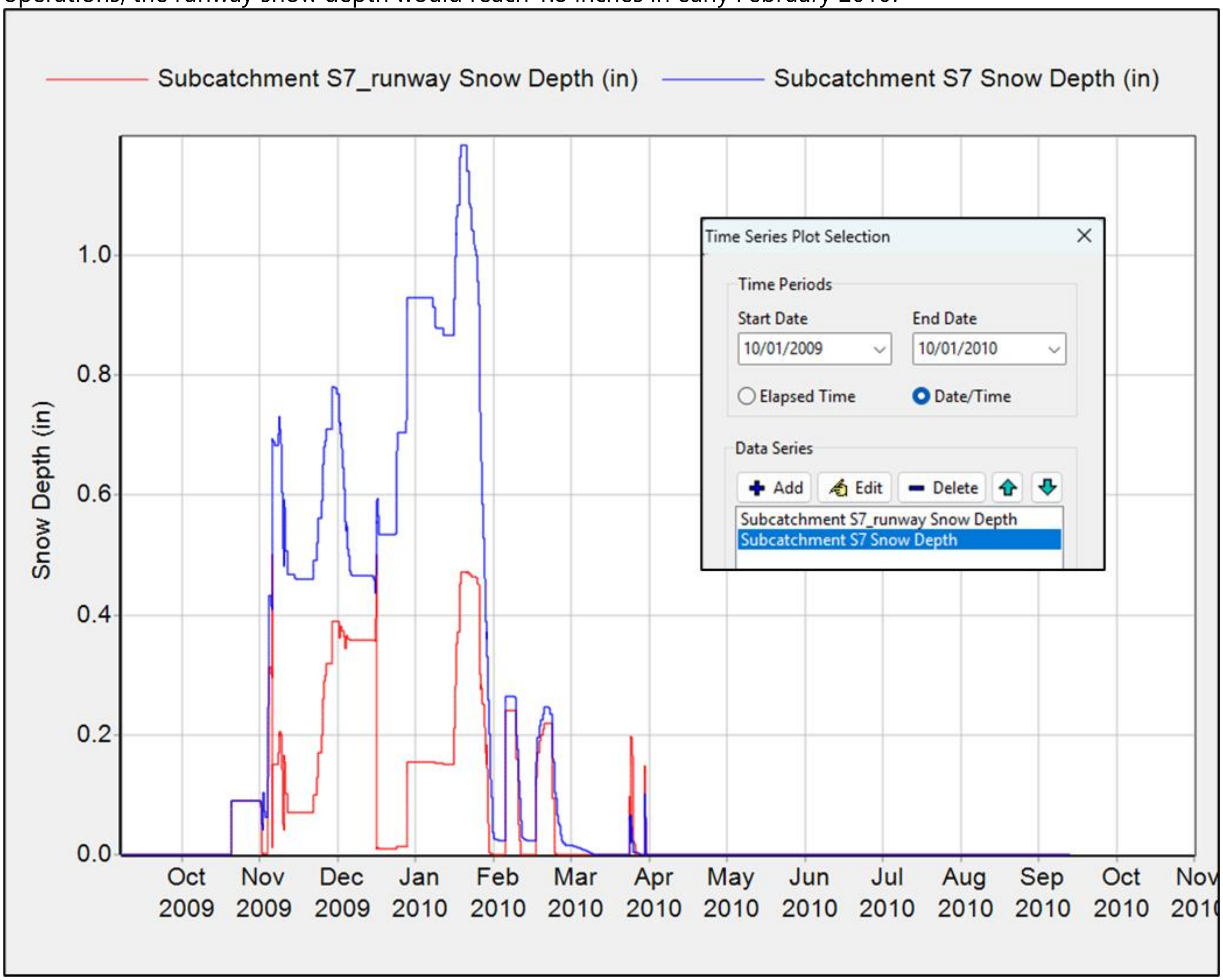
3-6 Select the **FullPlow** snowpack, and in the **Snow Removal Parameters tab**, set the **Depth at which Snow Removal Begins to 0.5 inches**, **Fraction Transferred Out of the Watershed to 0.75**, **Fraction Converted into Immediate Melt to 0.25**, and press **OK** to close the Snow Pack Editor. These parameters reflect snow removal and winter deicing operations for the runway and taxiway areas.



3-7 Use the **Group Editor** to select all subcatchments with **Tag = Impervious**. Set the **Snow Pack** property to **FullPlow**, and press **OK**. A pop-up message will confirm that 12 subcatchments were changed. Press **Yes** to continue editing. Select all subcatchments with **Tag = Pervious**. Set the **Snow Pack** property to **NoPlow** and press **OK**. A pop-up message will confirm that 7 subcatchments were changed. Press **No** to stop editing.



3-8 Run the model and when complete, plot the **Snow Depth** in the **S7 and S7_runway** subcatchments. Note the effectiveness of snow removal and winter deicing operations for the runway (without these operations, the runway snow depth would reach 1.8 inches in early February 2010.



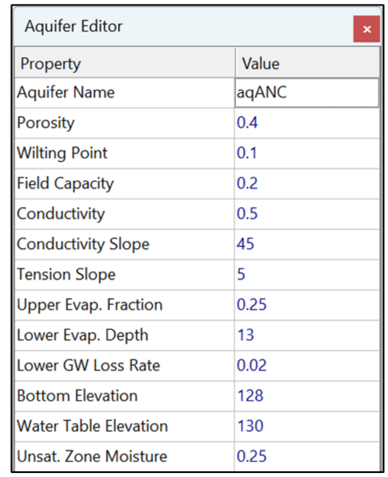
4 Update Model for Groundwater

Aquifer and groundwater parameters will be added to the pervious subcatchments in the model. The default SWMM5 groundwater flow equations will be replaced with a custom lateral flow equation to better represent Darcy flow and a custom deep loss equation.

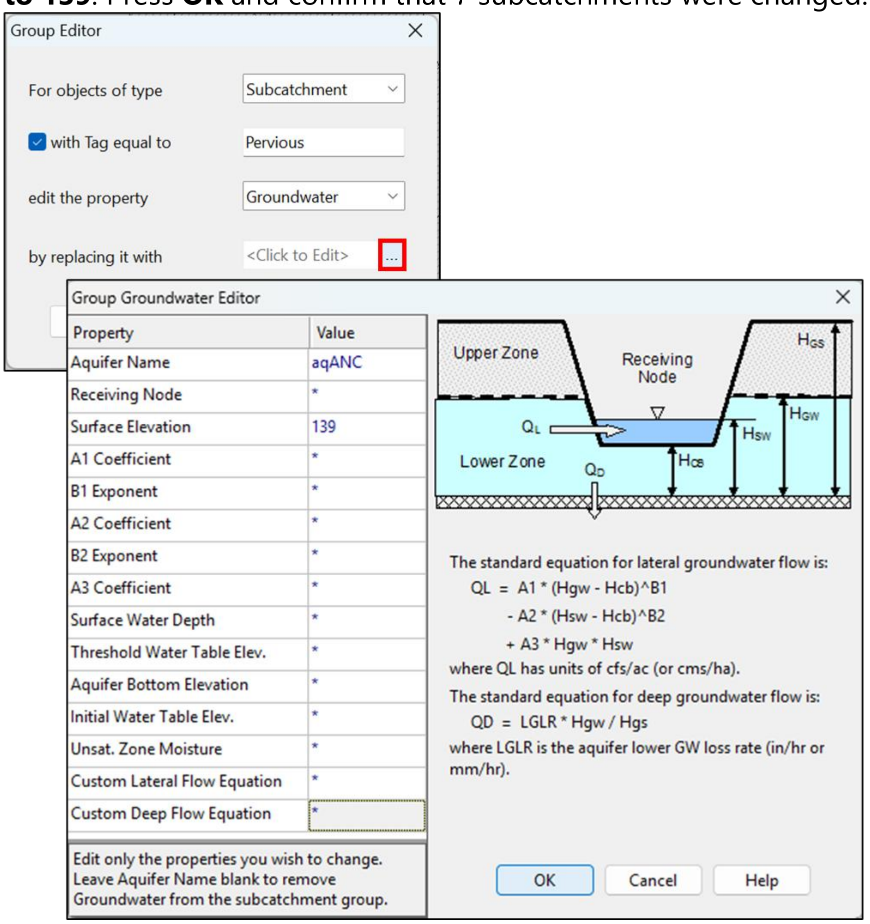
4-1 Save the Project As "**ANC2_2010WY_withGroundwater**".

4-2 Add a new Aquifer object with the **Name "aqANC"**, and enter the following parameters:

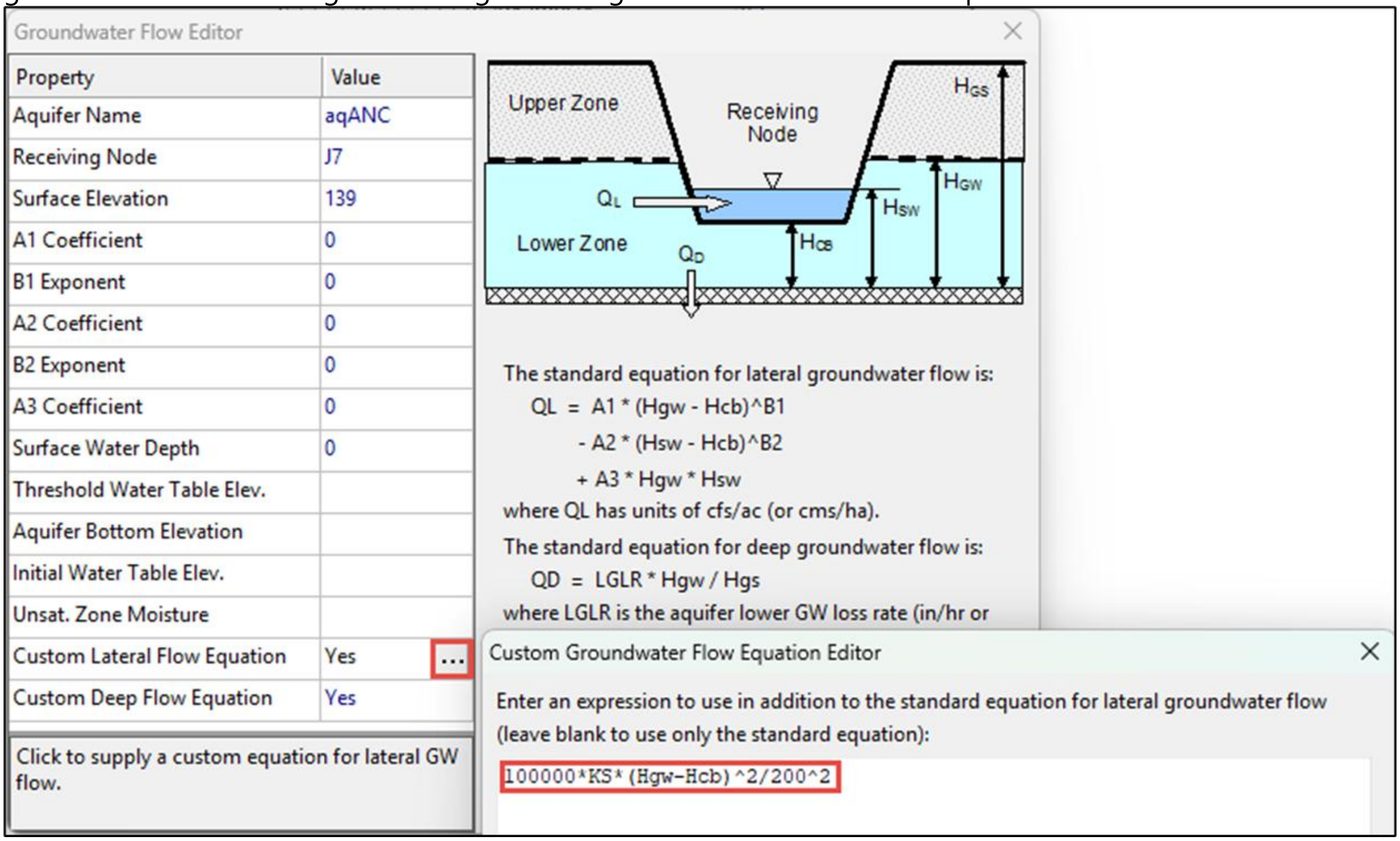
- Porosity: 0.4
- Wilting Point: 0.1
- Field Capacity: 0.2
- Conductivity: 0.5 in/hr
- Conductivity Slope: 45
- Tension Slope: 5
- Upper Evaporation Fraction: 0.25
- Lower Evaporation Depth: 13 ft
- Lower Groundwater Loss Rate: 0.02 in/hr
- Bottom Elevation: 128 ft-datum
- Water Table Elevation: 130 ft-datum
- Unsaturated Zone Moisture: 0.25



4-3 Use the **Group Editor** to select all subcatchments with **Tag = Pervious**. Select the **Groundwater** property for editing and then the **ellipsis** button to open the **Group Groundwater Editor**. Select **aqANC** from the dropdown list in the **Aquifer Name** field and set the **Surface Elevation to 139**. Press **OK** and confirm that 7 subcatchments were changed. Press **No** to stop editing.



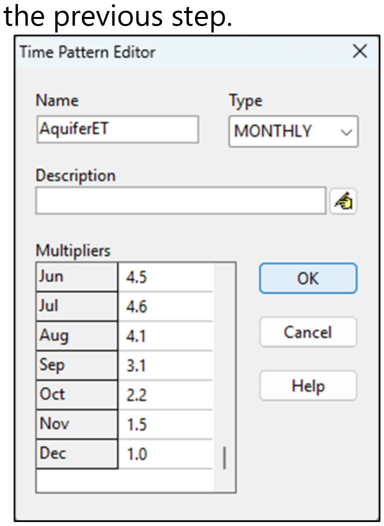
4-4 Select subcatchment **S7** and then the **ellipsis** button beside the **Groundwater** field. Assign the **Receiving Node as J7**. Assign the expression "**100000*KS*(Hgw-Hcb)^2/200^2**" to the **Custom Lateral Flow Equation** field (click the **ellipsis** button), where KS is the saturated hydraulic conductivity, Hgw is the height of the groundwater table, Hcb is the height of the ditch bottom above the aquifer bottom, and 200 ft is the characteristic length for flow through porous media per Darcy's law. Assign the expression "**0.01*Hgw/Hgs**" to the **Custom Deep Flow Equation** field, where Hgw is the height of the groundwater table and Hgs is the height of the ground surface above the aquifer bottom.



4-5 Repeat the above step for subcatchments **S6 through S1**, assigning the **Receiving Node as J6 through J1** respectively. Assign the same **Custom Lateral and Deep Flow Equations** as in the previous step.

4-6 **Add a new Time Pattern** with the Name "**AquiferET**" and enter the following monthly multipliers in the Time Pattern Editor:

- January: 1.0
- February: 1.3
- March: 2.0
- April: 3.1
- May: 3.8
- June: 4.5
- July: 4.6
- August: 4.1
- September: 3.1
- October: 2.2
- November: 1.5
- December: 1.0

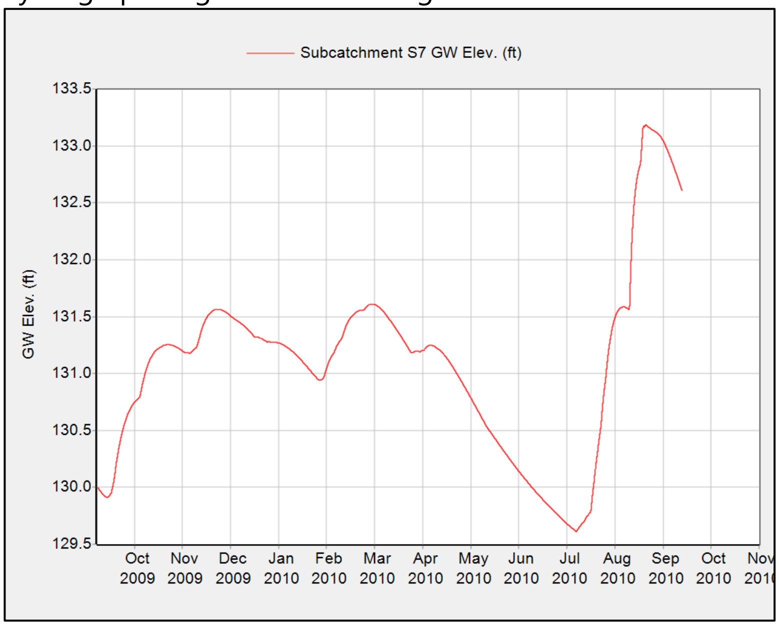


4-7 Select the aquifer **aqANC** and select the **AquiferET** time pattern from the Upper Evaporation Pattern dropdown list.

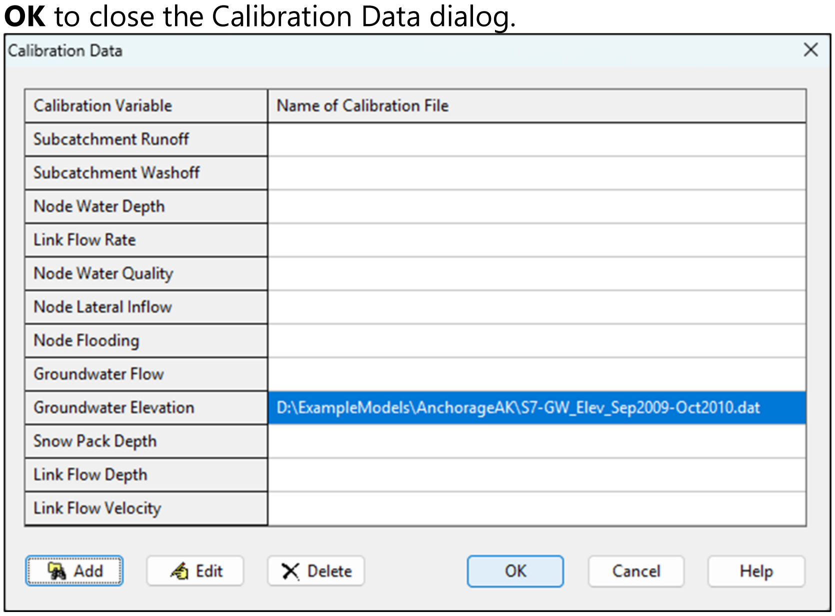
5 Set Groundwater Initial Conditions and Apply Model

Groundwater simulations are very sensitive to the initial groundwater level and initial soilwater content as specified in the Aquifer Editor (130 ft-datum and 0.25, respectively in this exercise). Given the slow response to rainfall and soilwater conditions (i.e., on the order of weeks and months), specifying the appropriate initial groundwater conditions for a single year simulation is critical. To ensure the starting conditions for the WY2010 simulation are appropriate, the present model was run for a long-term period (1990-2019). The resulting groundwater elevations and soilwater conditions in each of the pervious subcatchments were formatted as a SWMM5 Calibration dataset for WY2010. The calibration dataset for subcatchment S7 is saved in the file "S7-GW_Elev_Sep2009-Oct2010.dat".

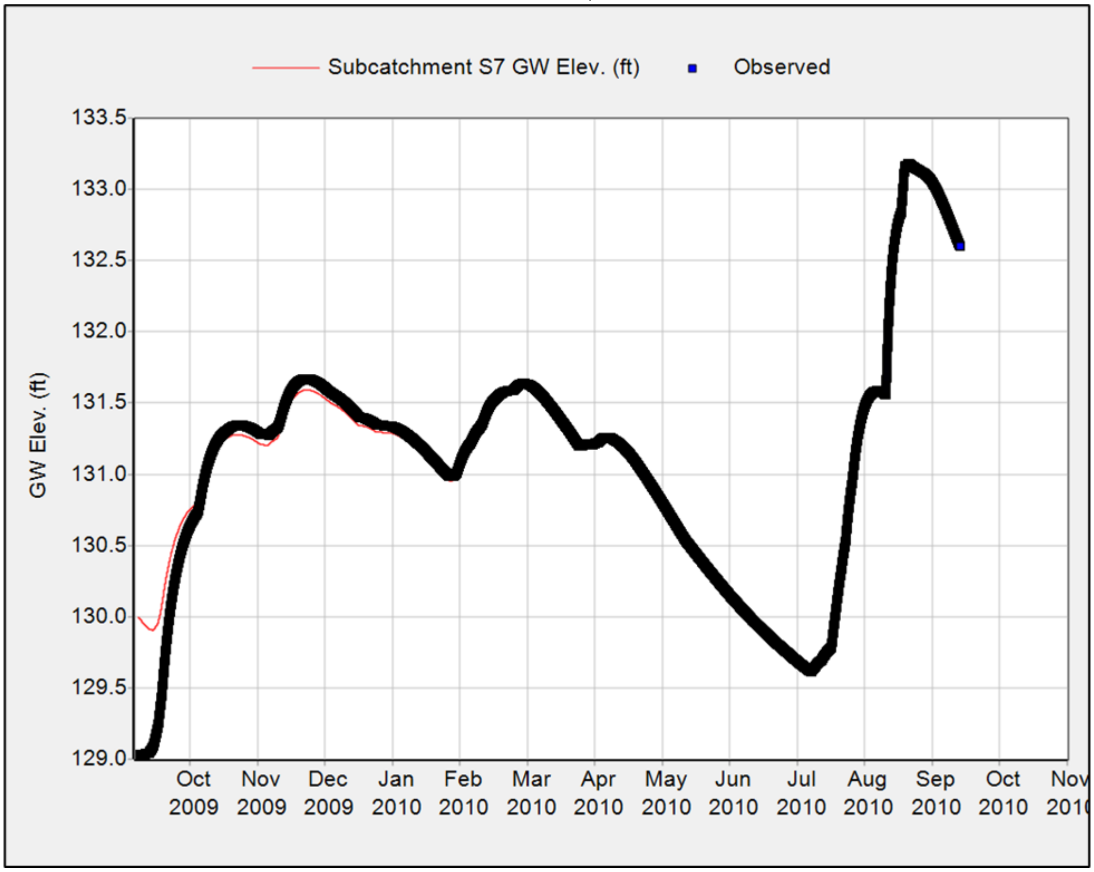
5-1 **Run** the model and when complete, plot the **Groundwater Elevation** in subcatchment **S7**. Note the hydrograph begins at the initial groundwater elevation of 130 ft-datum.



5-2 Open the Calibration Data dialog (**Project | Calibration Data...**), select the **Groundwater Elevation** field, and then **Add**. Navigate to the file "**S7-GW_Elev_Sep2009-Oct2010.dat**" and then **Open**. Select **OK** to close the Calibration Data dialog.



5-3 Plot the **Groundwater Elevation** in subcatchment **S7**. Note the plot now includes the "Observed" dataset, indicating that the initial groundwater elevation should be 129 ft-datum. A similar analysis showed a soilwater content of 0.264 on Oct 1, 2009.

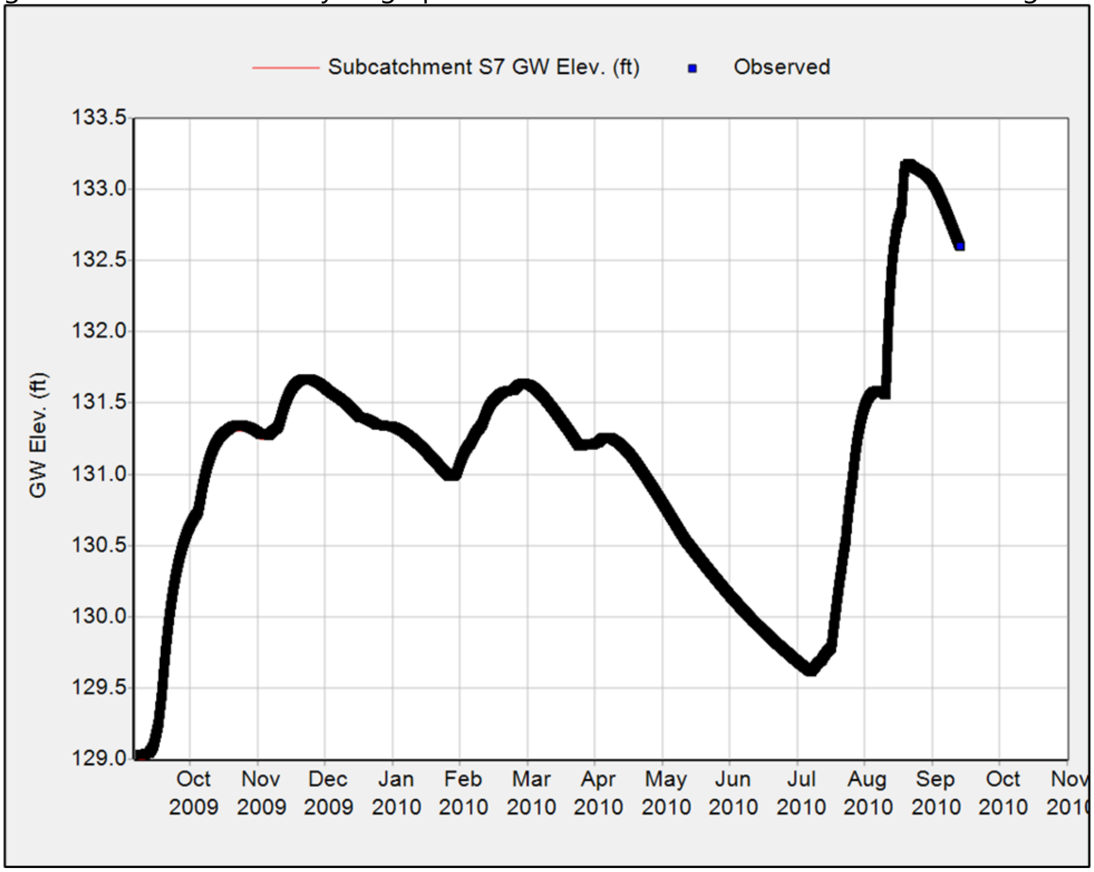


5-4 Select subcatchment **S7** and then the **ellipsis** button beside the **Groundwater** field. Assign an **Initial Water Table Elevation of 129 ft-datum** and an **Unsaturated Zone Moisture content of 0.264**.

Groundwater Flow Editor

Property	Value
Aquifer Name	aqANC
Receiving Node	J7
Surface Elevation	139
A1 Coefficient	0
B1 Exponent	0
A2 Coefficient	0
B2 Exponent	0
A3 Coefficient	0
Surface Water Depth	0
Threshold Water Table Elev.	
Aquifer Bottom Elevation	
Initial Water Table Elev.	129
Unsat. Zone Moisture	0.264

5-5 **Run** the model and when complete, plot the **Groundwater Elevation** in subcatchment **S7**. Confirm the groundwater elevation hydrograph for the WY2010 simulation matches the long-term hydrograph.



5-6 For completeness, assign the following initial conditions for the other pervious subcatchments and re-run the model:

- S1 subcatchment: 128.4 ft-datum initial groundwater elevation, 0.32 initial soilwater fraction
- S2: 128.3, 0.24
- S3: 128.6, 0.22
- S4: 128.6, 0.22
- S5: 128.7, 0.23
- S6: 128.7, 0.23