Wetbud Surface Water Components in the Basic Model

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Virginia Tech

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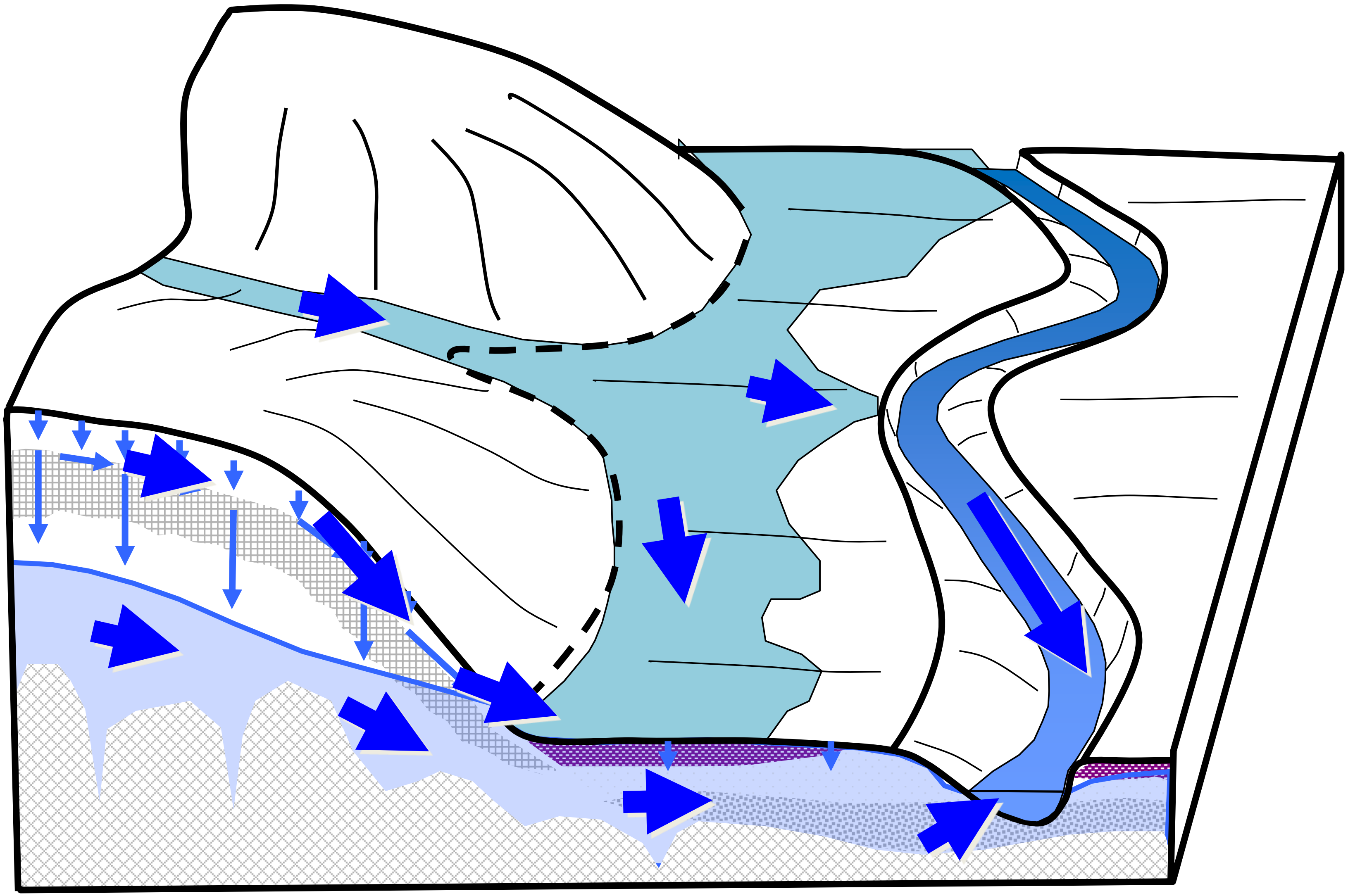
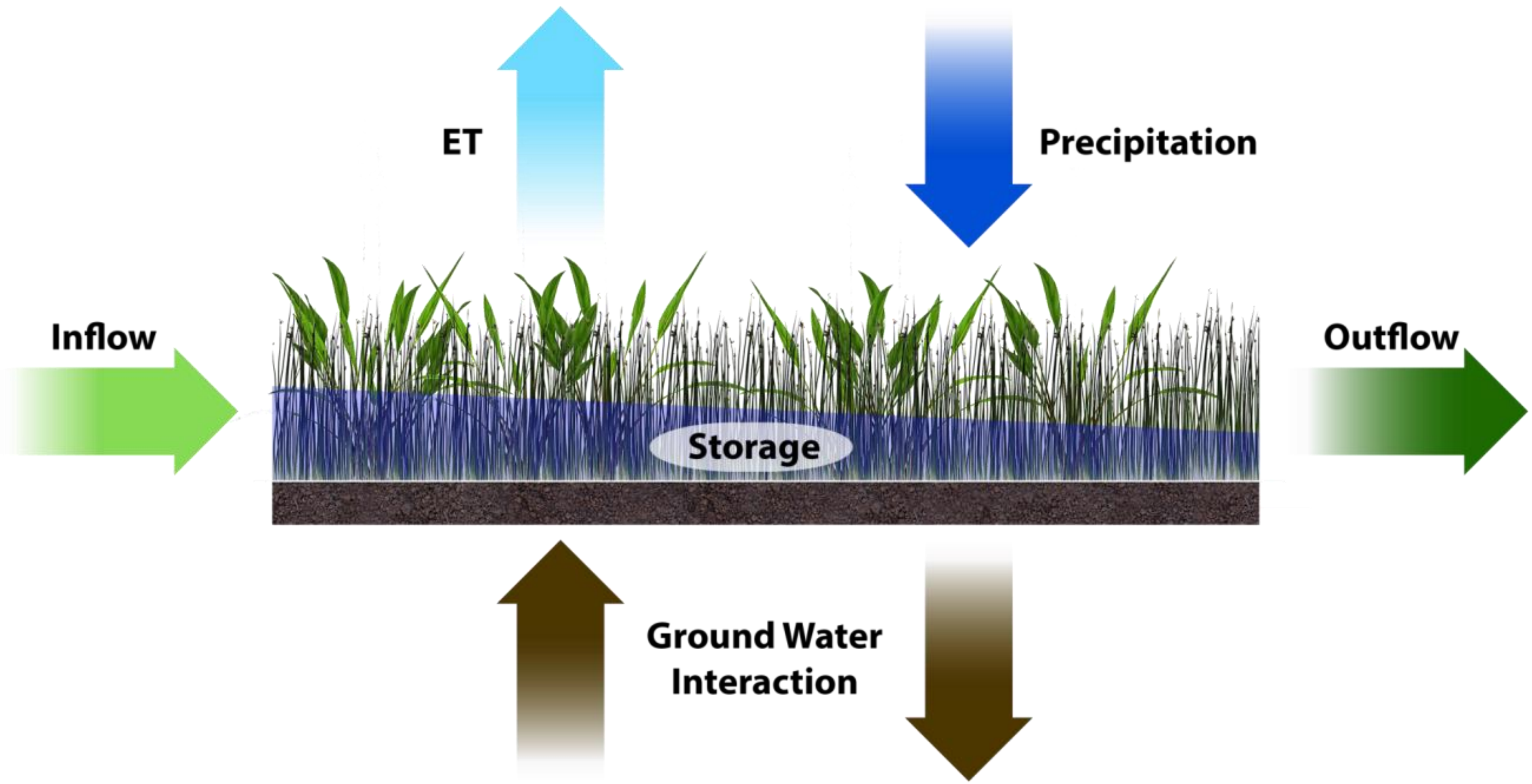
University of Kentucky

Special thanks to Dillon Conner with WSSI for the wetland graphics!

Piedmont wetlands are the interface between uplands, groundwater, and surface water

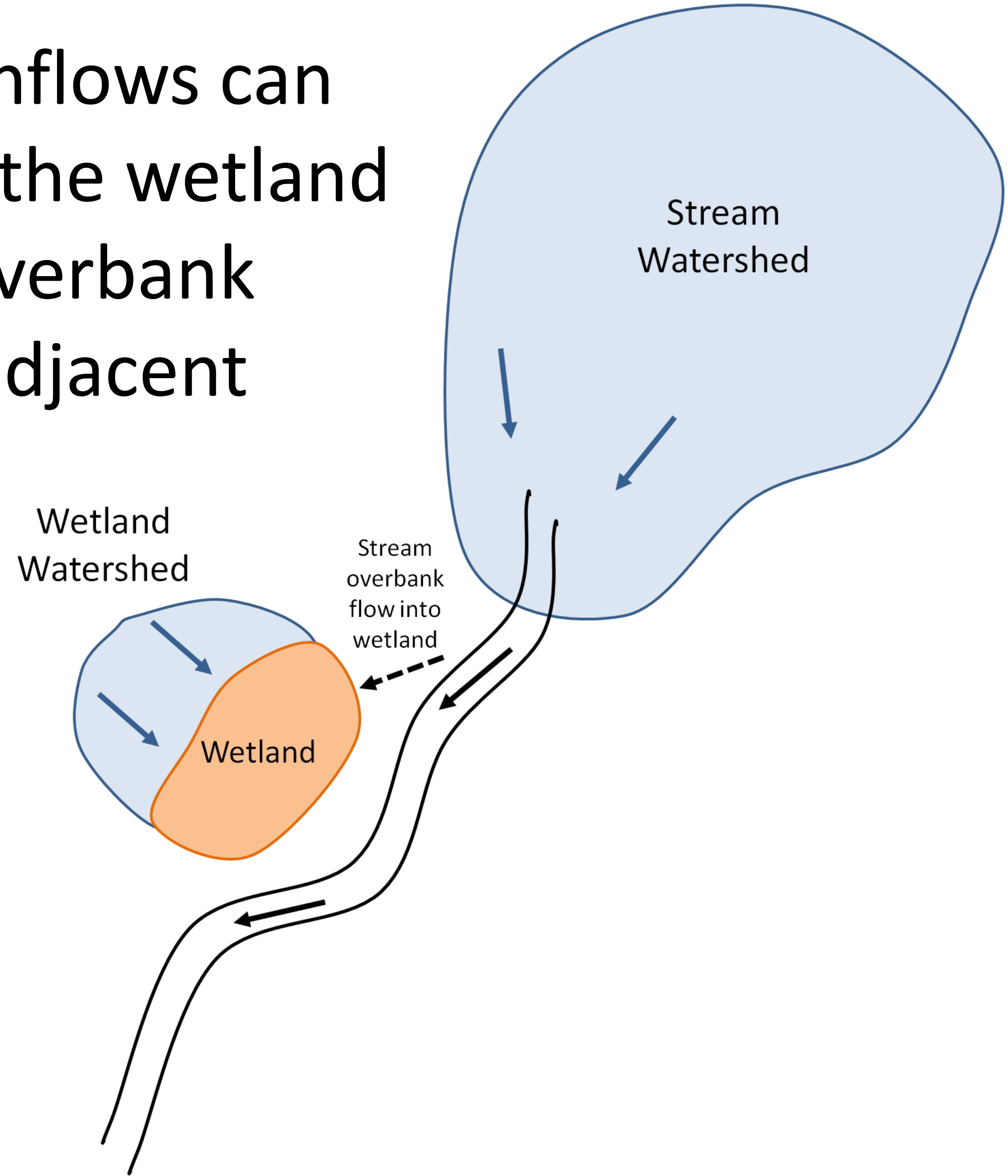


Water Inflows and Outflows



Inflows can be due to groundwater seepage, runoff from the surrounding hillslopes, or flood flows from adjacent streams.

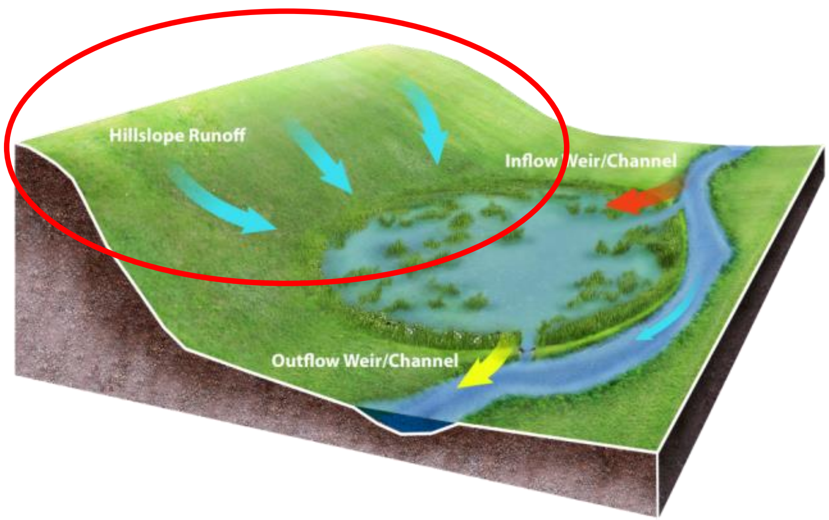
Surface water inflows can be runoff from the wetland watershed or overbank flows from an adjacent stream.



Hillslope runoff is computed using the NRCS curve number equation.

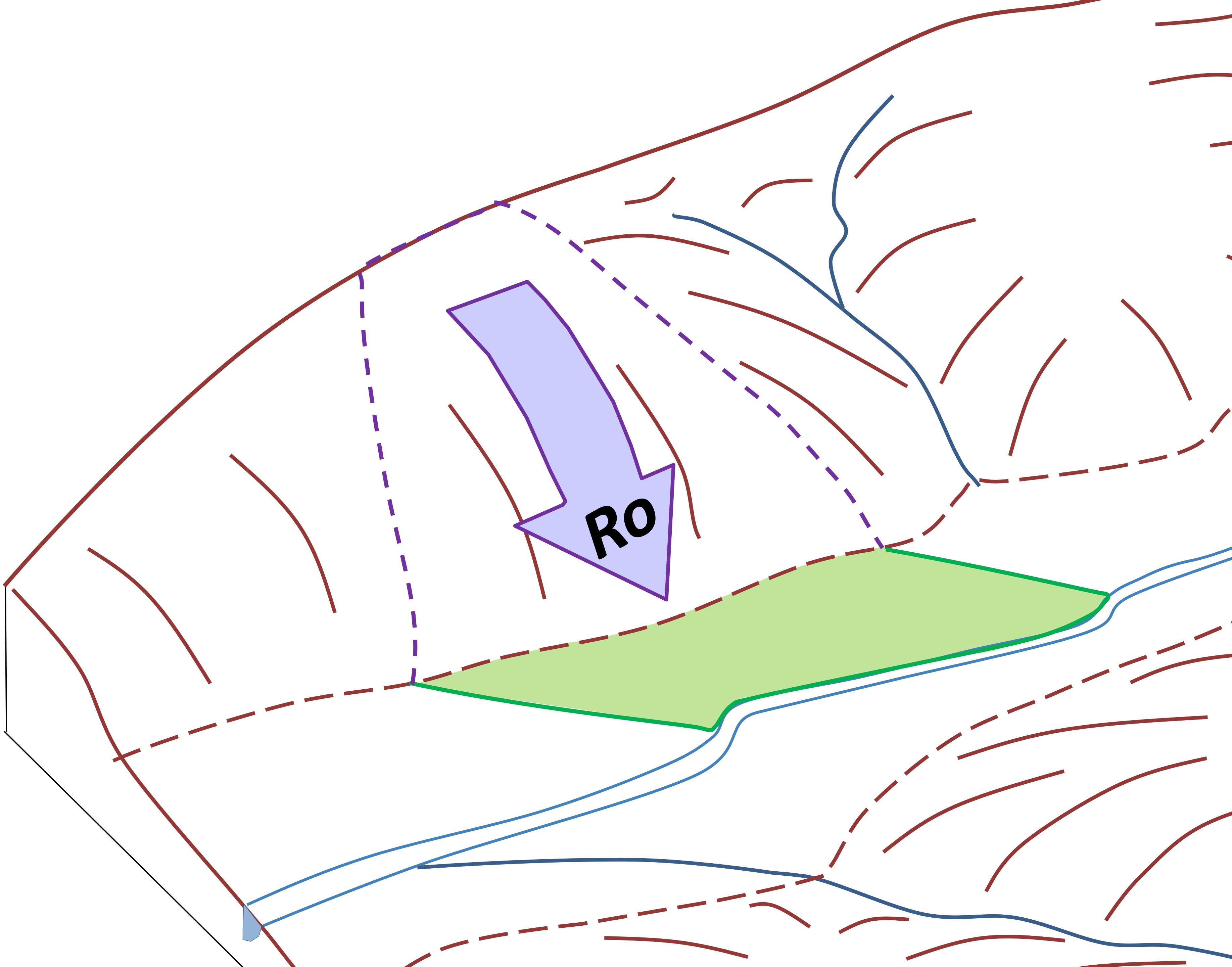
$$Q = \frac{(P - 0.2S_a)^2}{P + 0.8S} \text{ for } P > I_a$$

$$S = \frac{1000}{CN} - 10$$



where
- Q = actual runoff, aka "precipitation excess" (inches)
- P = actual rainfall (inches)
- S = potential maximum retention after runoff begins (inches);
- I_a = initial abstraction = interception plus infiltration during early parts of the storm plus surface depression storage = 0.2S (inches)
- CN = runoff curve number

Wetbud assumes all of the "precipitation excess" enters the wetland each day – there is no flow routing or hydrograph generation for inflows from the wetland watershed.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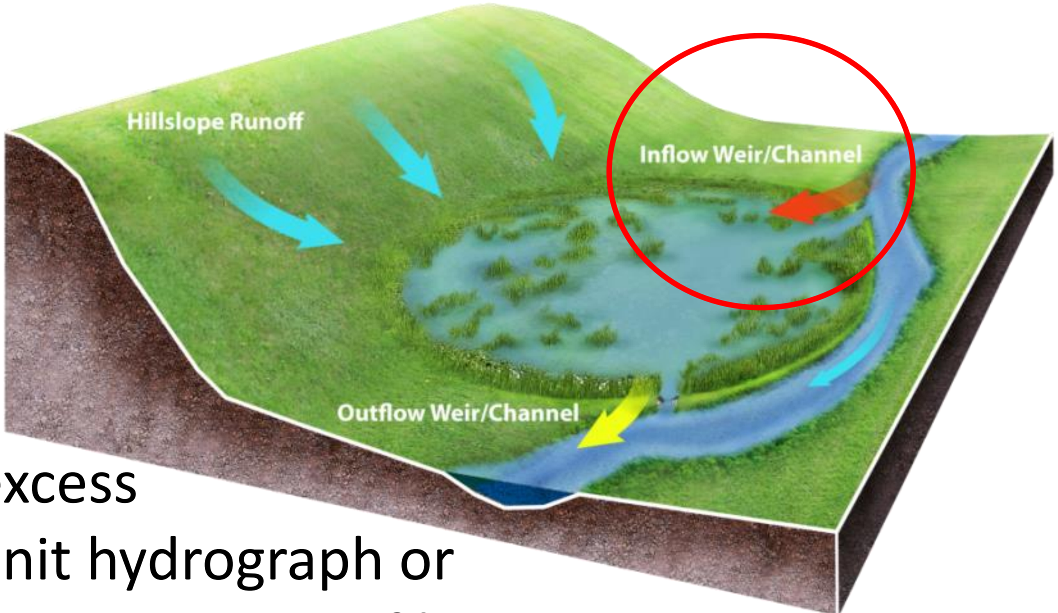
Overbank flows are determined using three steps:

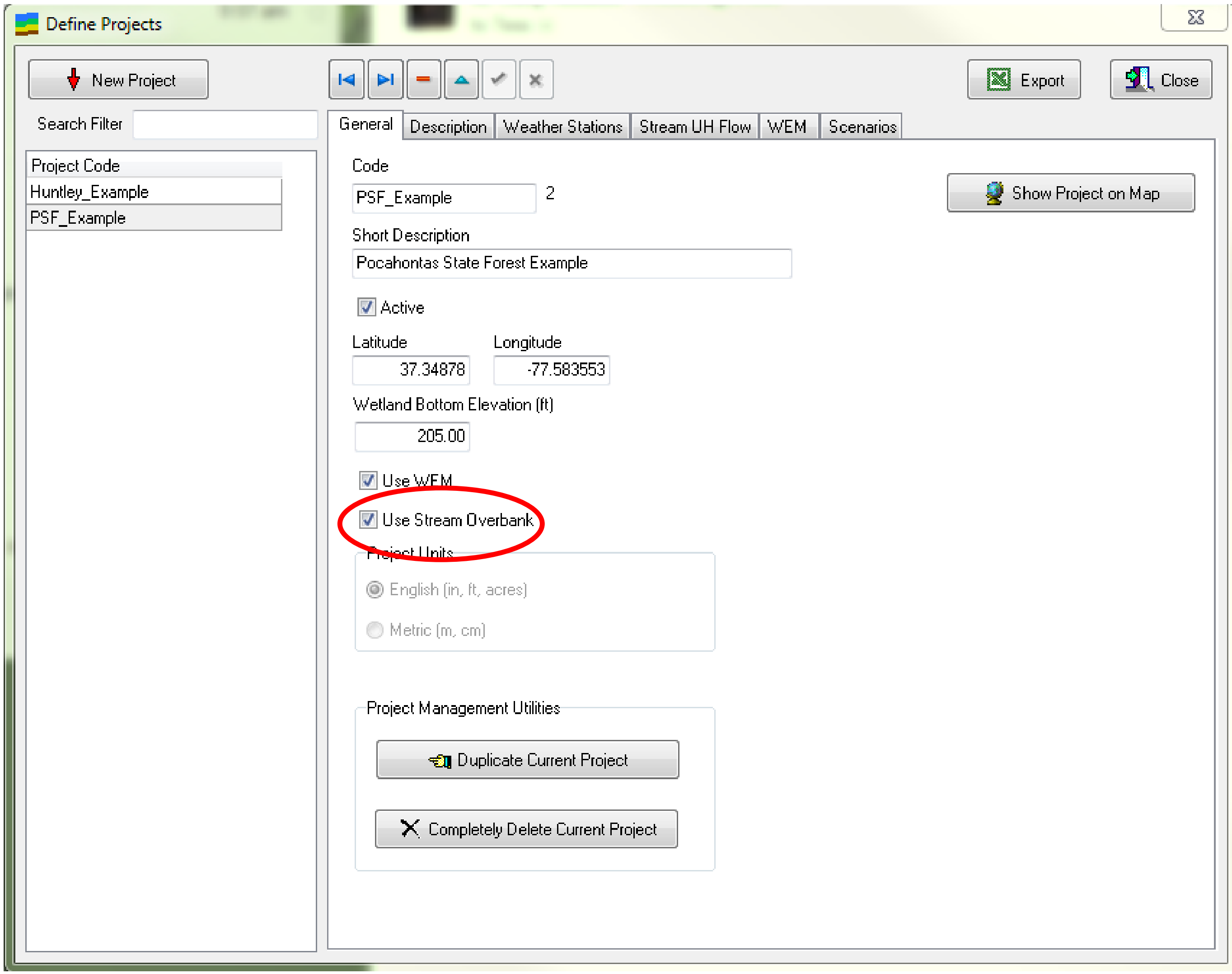


1. Compute a daily stream Hydrograph (stream discharge versus time) using 24-hr precipitation excess and NRCS dimensionless unit hydrograph or import stream discharge as a time series file

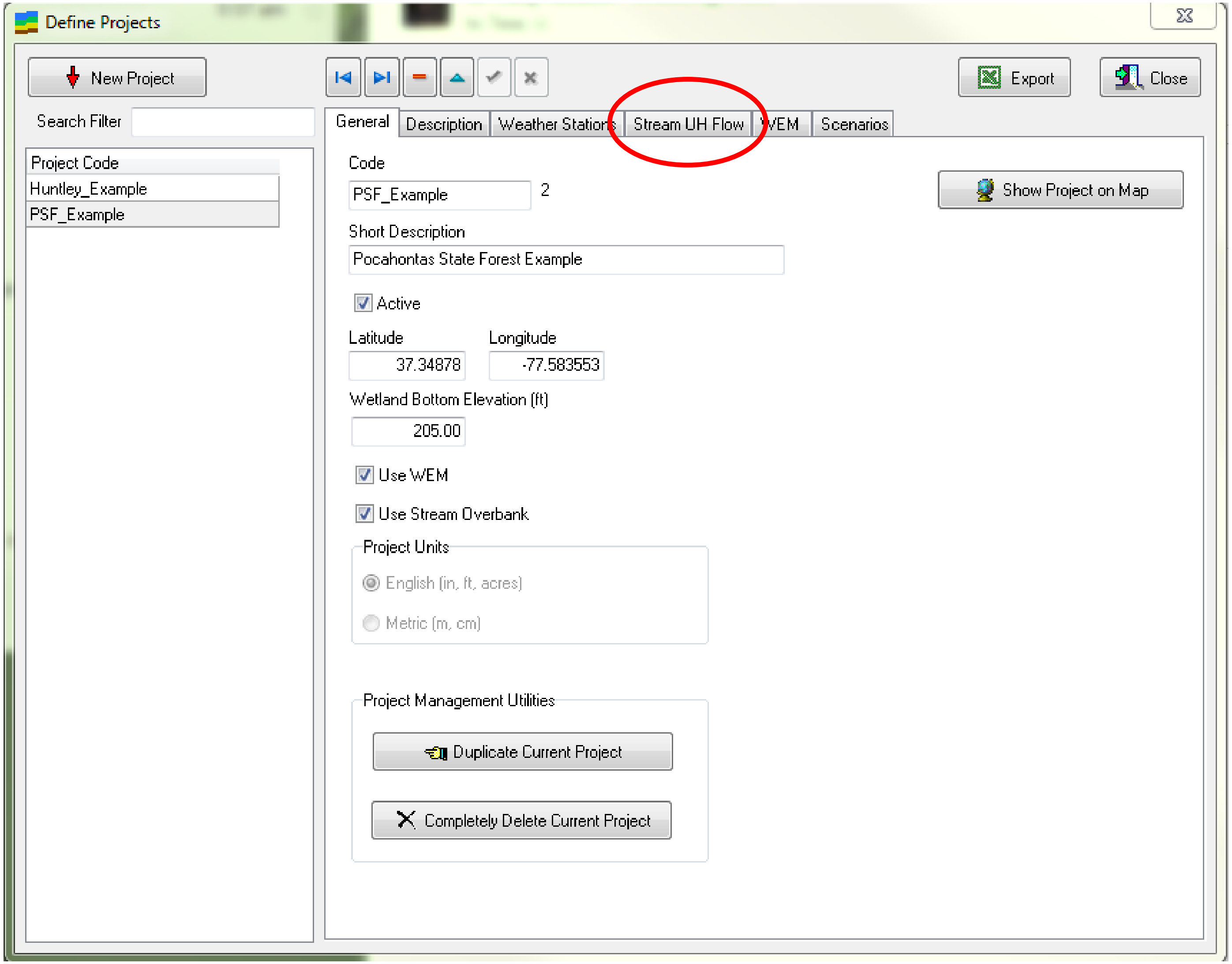
2. Calculate water depth in the stream each day and check to see if the stream is high enough to overflow into the wetland

3. Calculate amount of water that enters wetland from that 24-hr storm event

Overbank Step 1: Calculate stream flows



Overbank Step 1: Calculate stream flows



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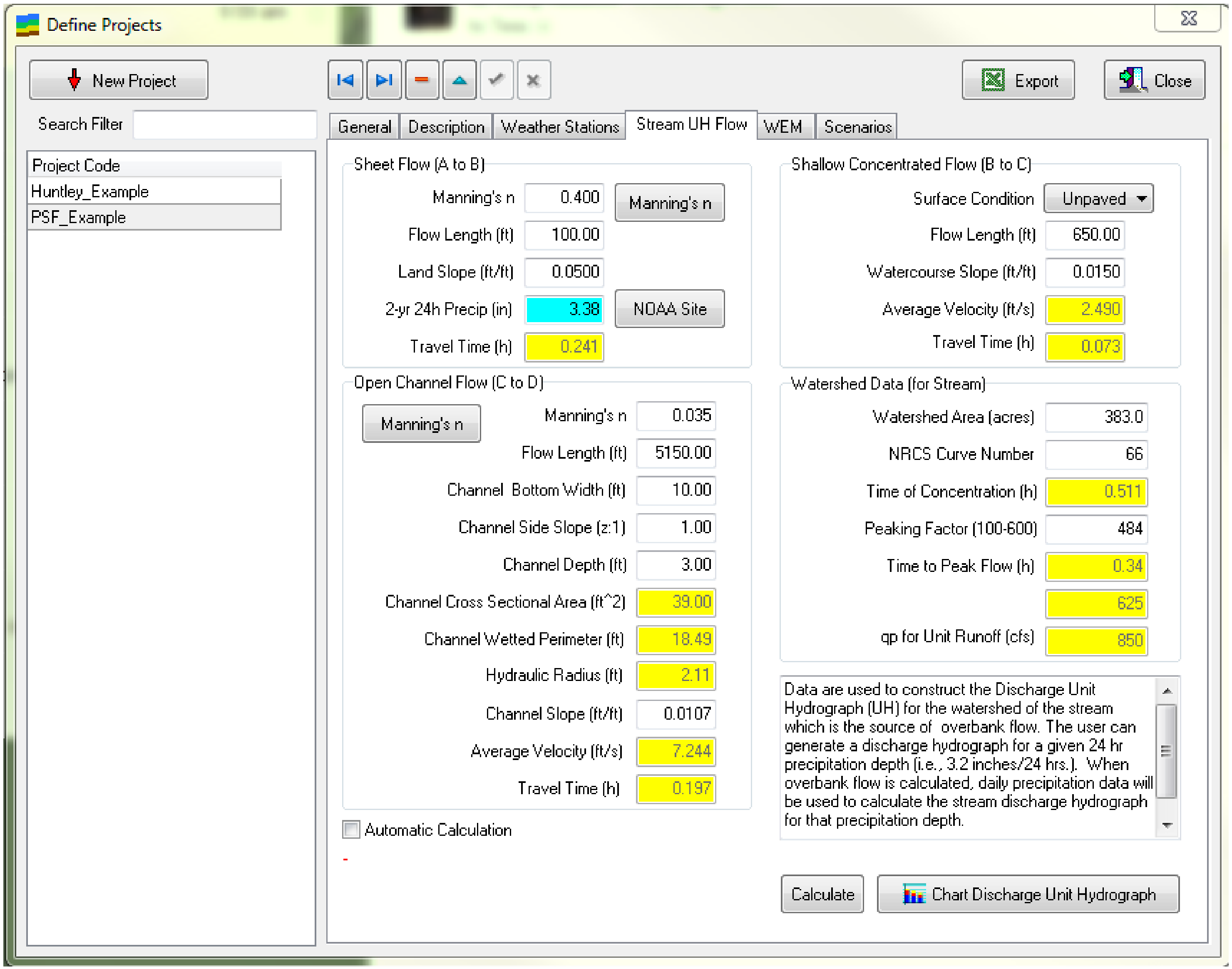
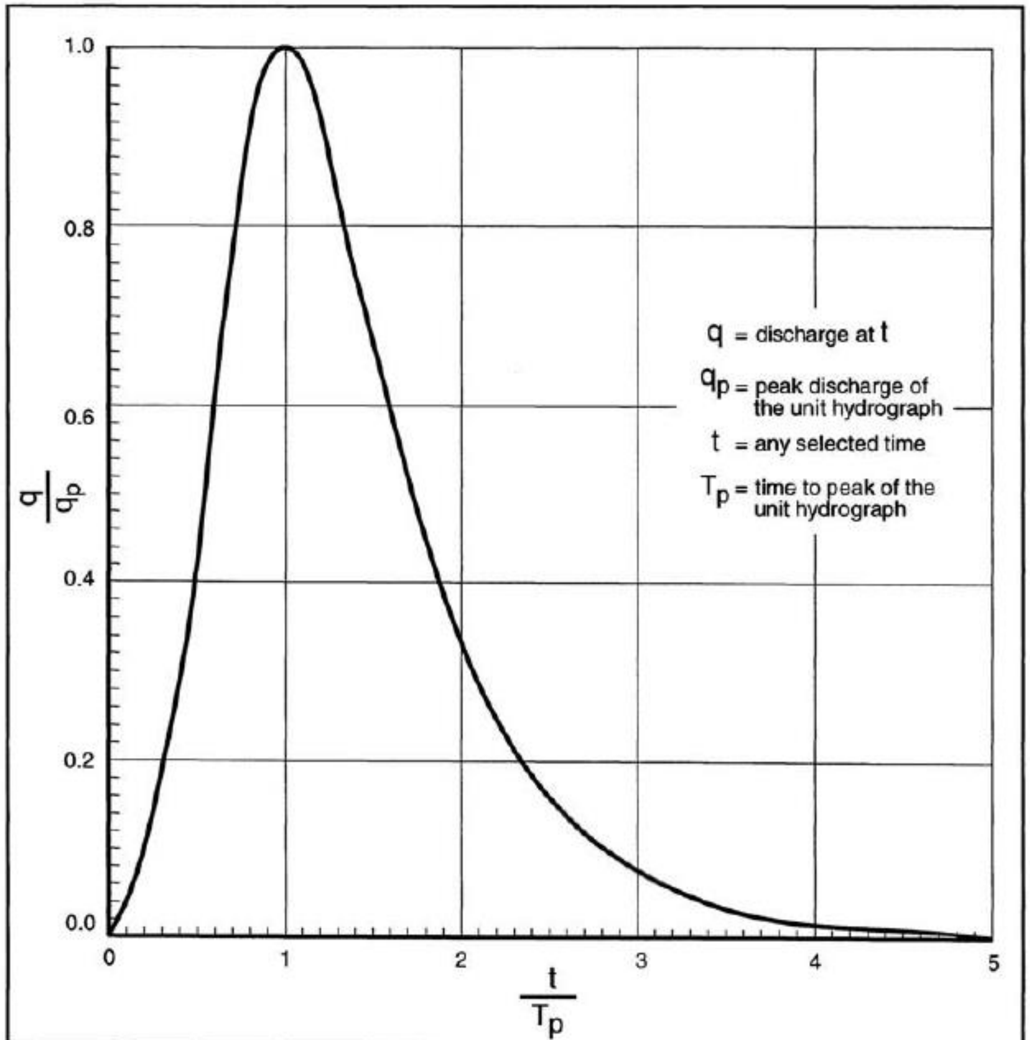
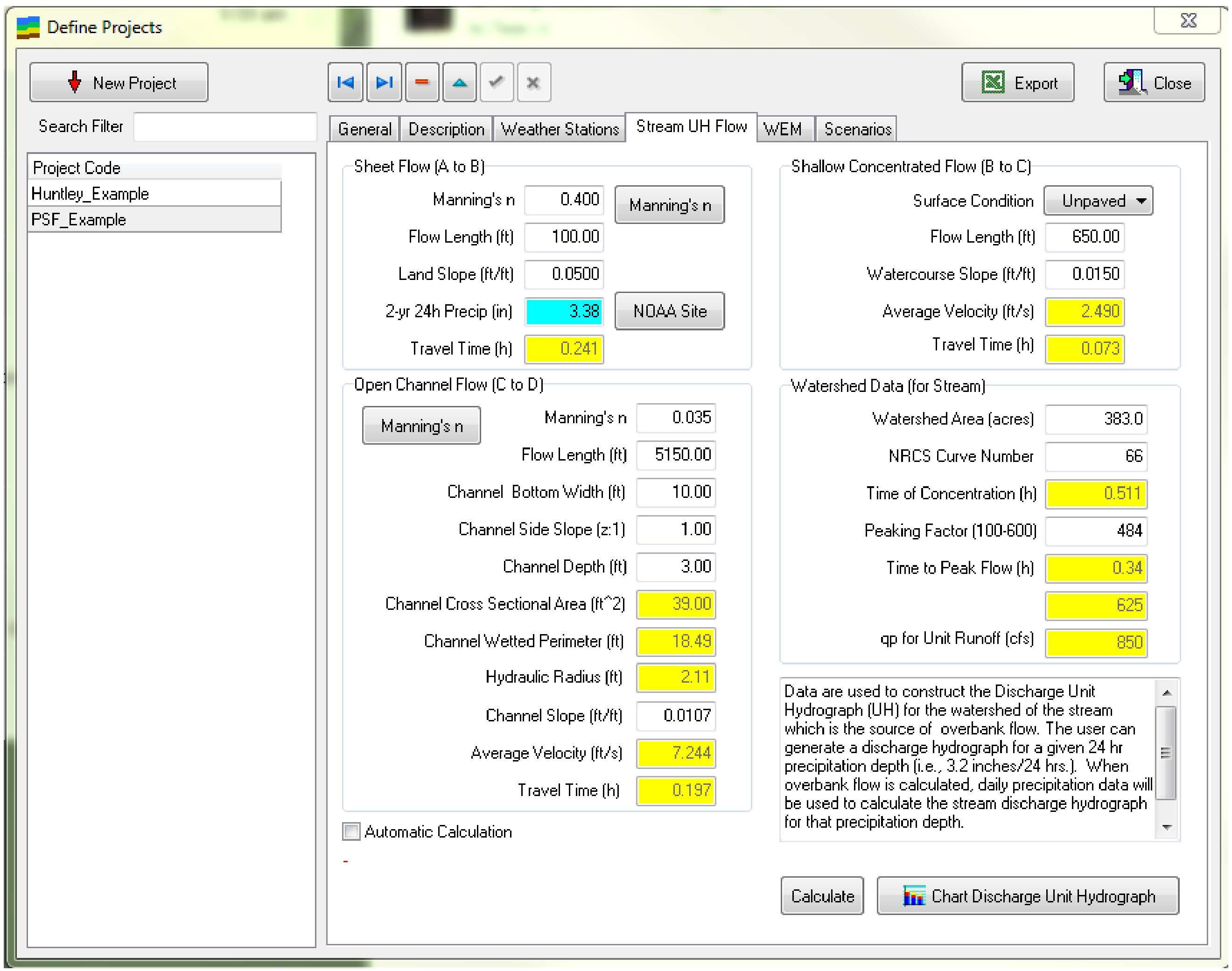


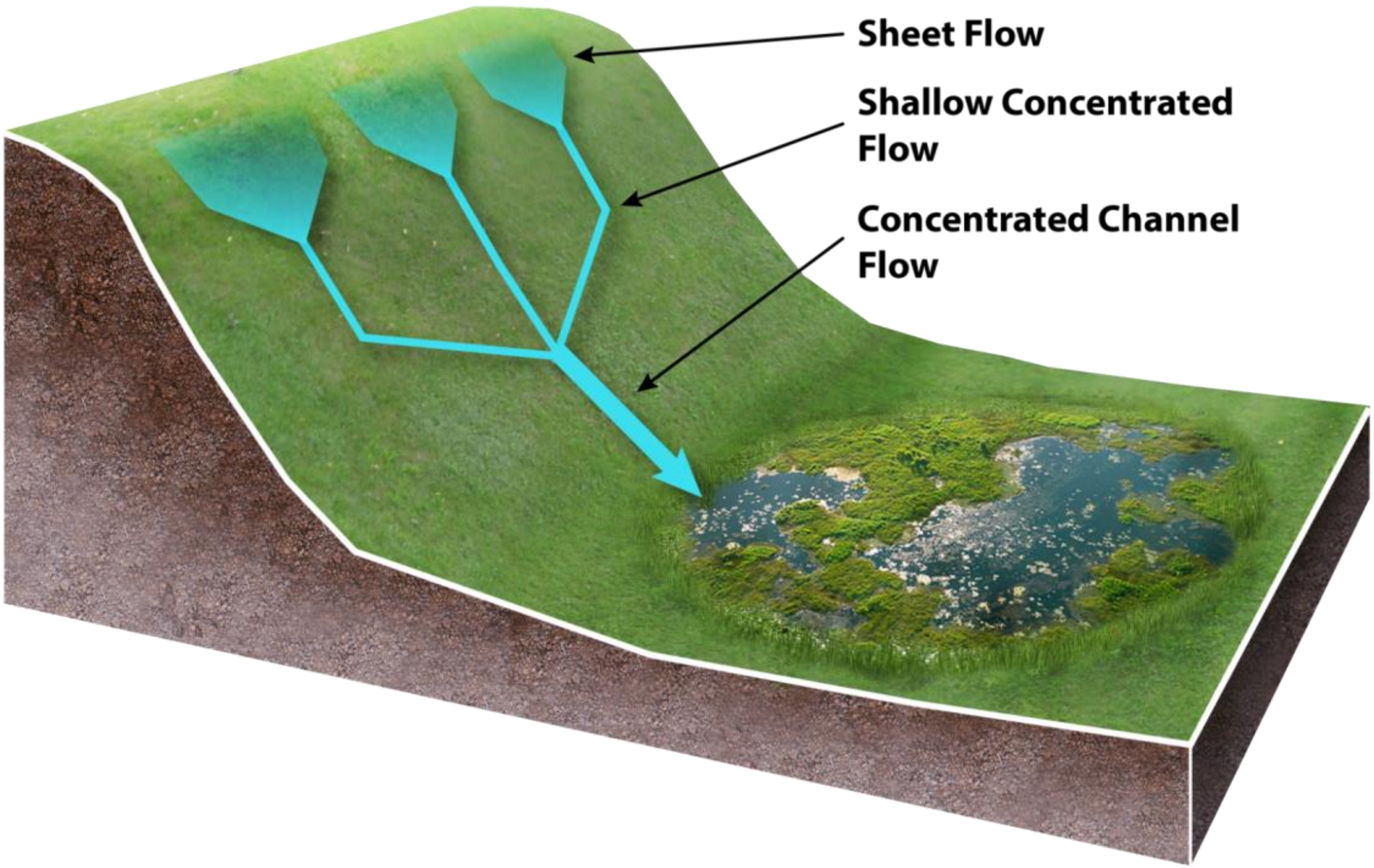
Stream flows are calculated in Wetbud using the NRCS Dimensionless Unit Hydrograph (DUH)



Overbank Step 1: Calculate stream watershed time to peak (T_p) and unit peak runoff (q_p, 1 in./day) as part of the overall project



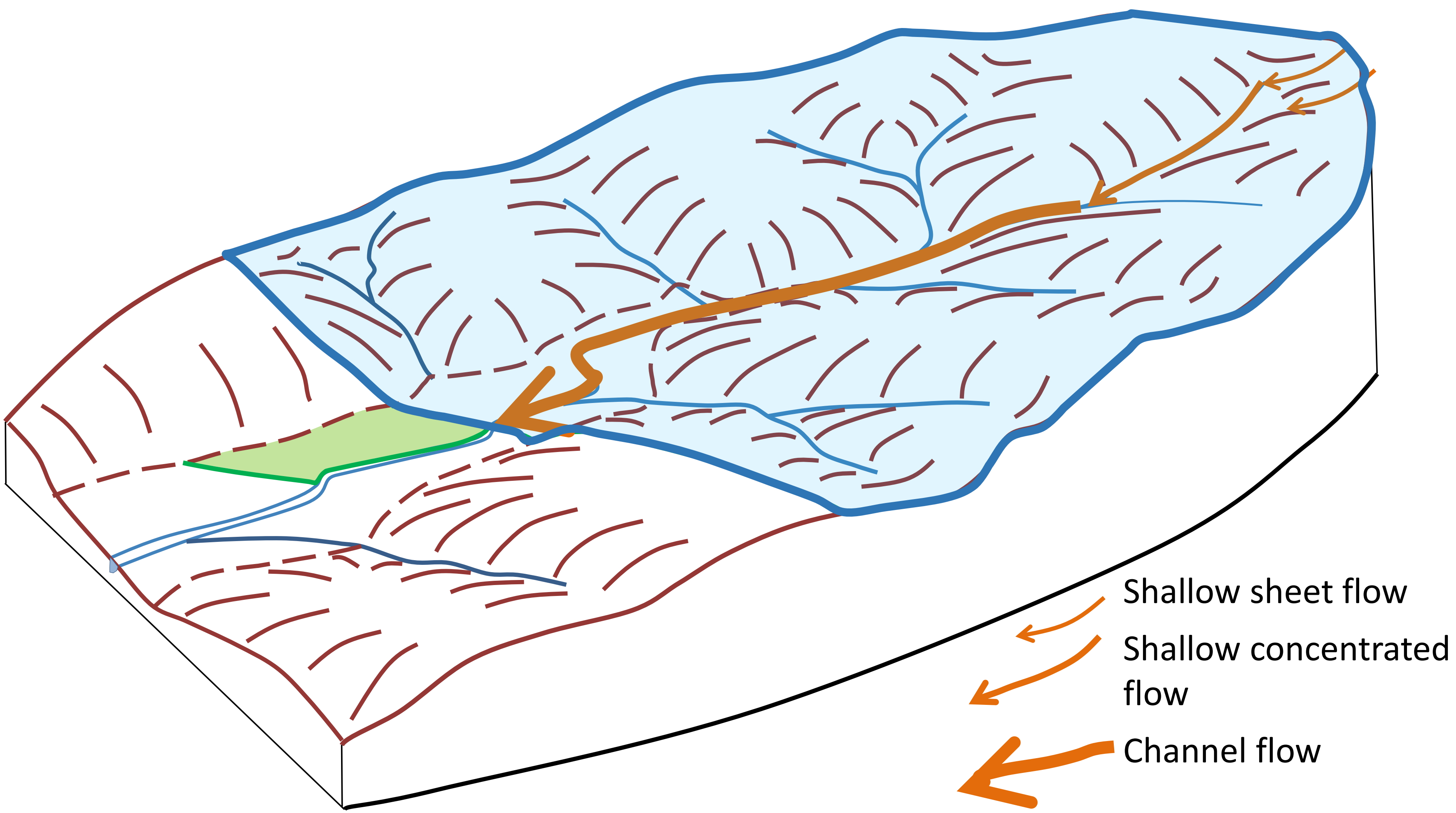
Time to peak is the sum of the travel times as sheet flow, shallow concentrated flow, and concentrated channel flow



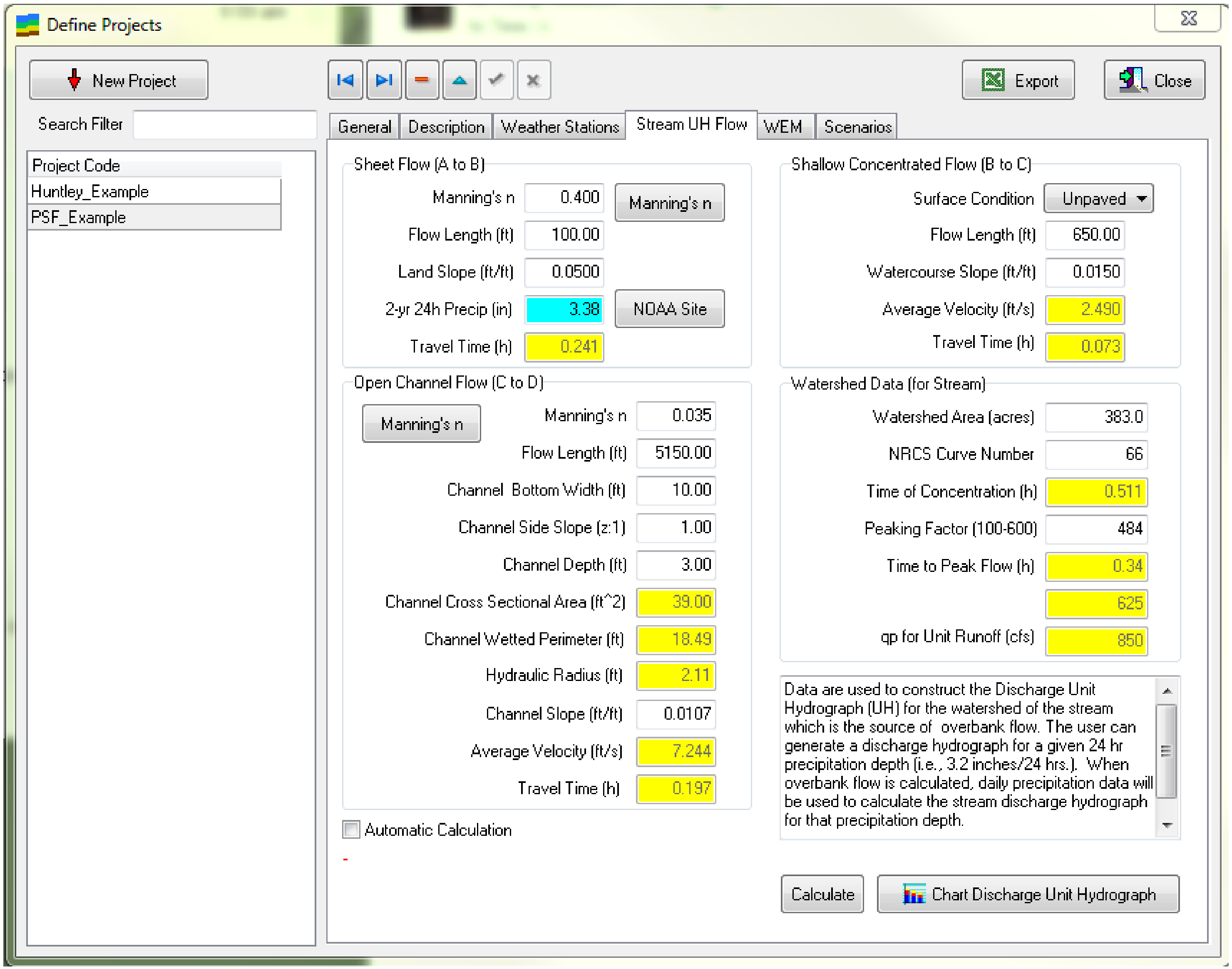
Compute flow velocities and divide flow length by the velocity.

Pocahontas Example Wetland

Calculate Time to Peak for longest flow path

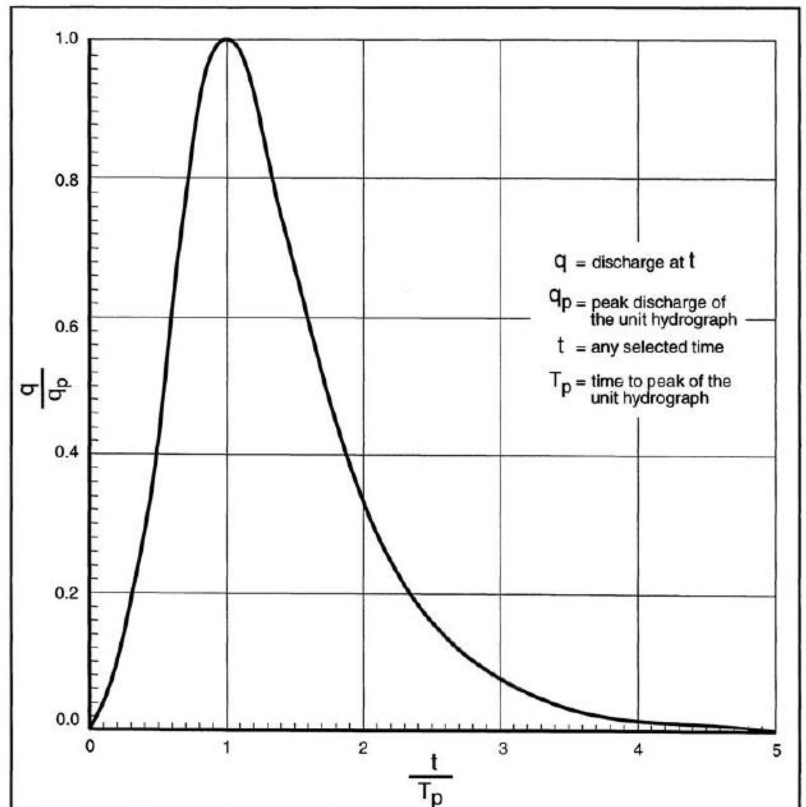


Overbank Step 1: Calculate stream flows

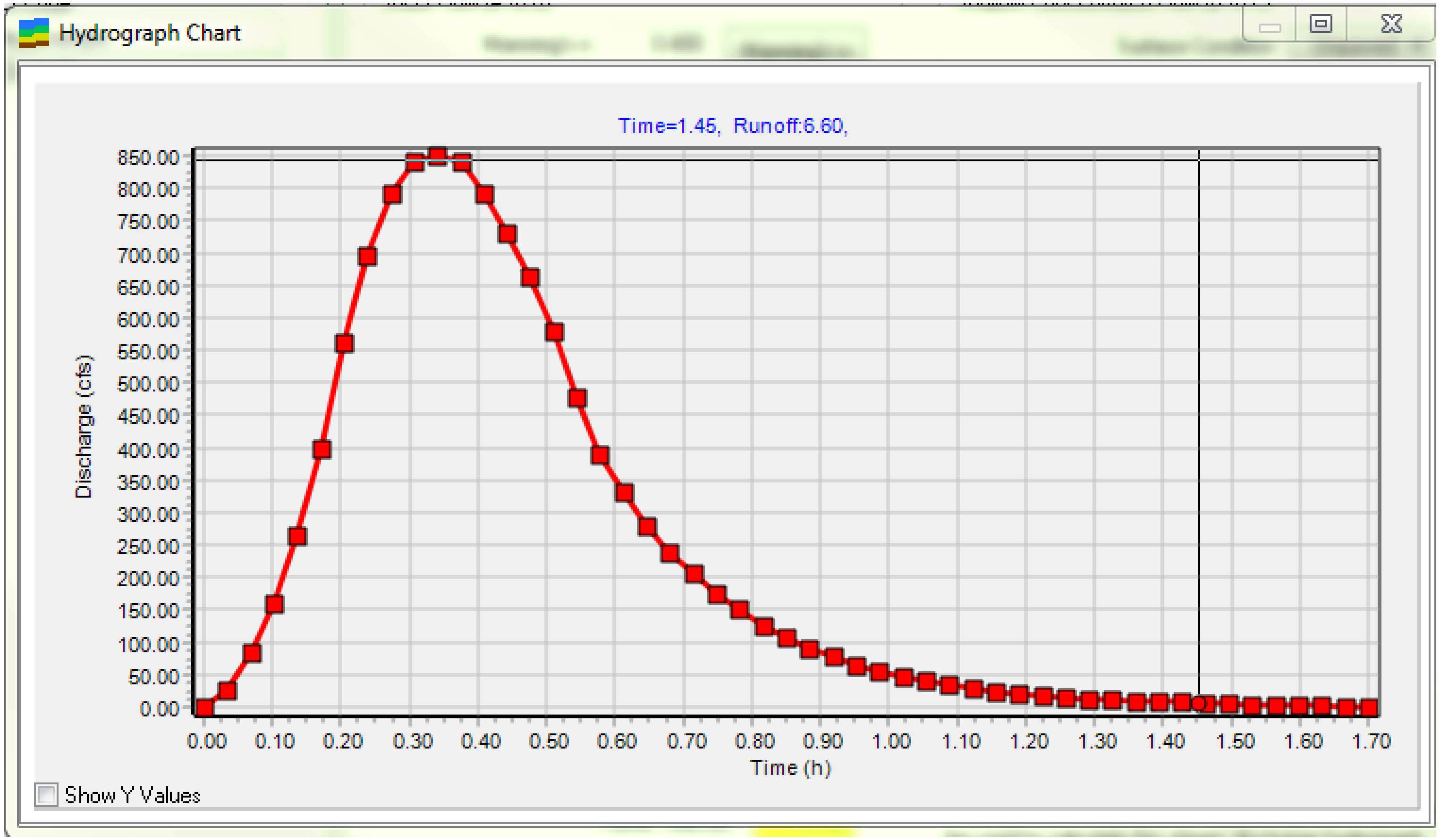


Overbank Step 1: Multiply DUH by watershed T_p and q_p resulting from 1 inch of precipitation excess, to determine the stream watershed unit hydrograph

Then, to develop a hydrograph for each day, multiple the unit hydrograph flow (resulting from 1 in. of precipitation excess) by the total precipitation excess for that day.



Stream discharge unit hydrograph for Pocahontas example



This graph shows the response of the stream to 1 inch of surface runoff ("precipitation excess") .

Calculate precipitation excess for stream watershed

$$Q = \frac{(P - 0.2S_a)^2}{P + 0.8S} \quad \text{for } P > I_a$$

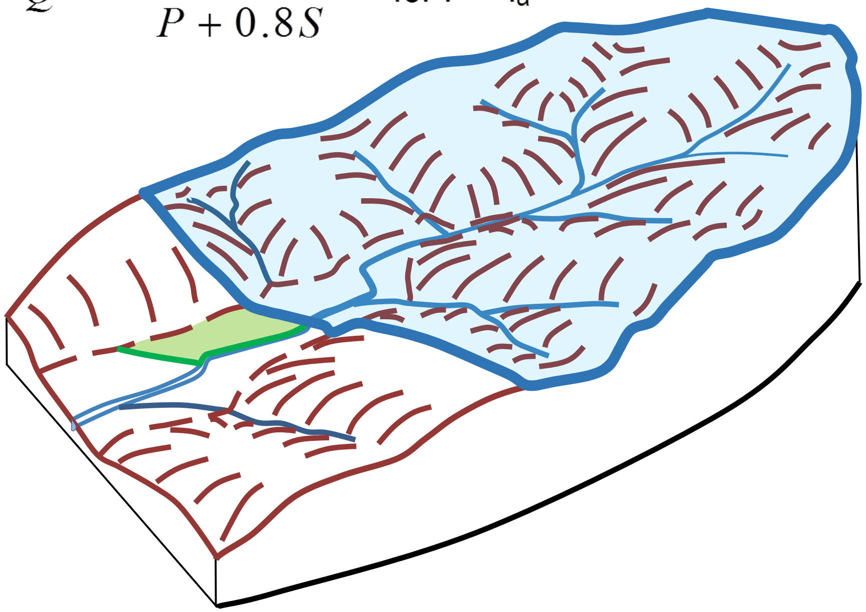
$$S = \frac{1000}{CN} - 10$$

where Q = actual runoff, aka "precipitation excess" (inches)
P = actual rainfall (inches)
S = potential maximum retention after runoff begins (inches);
I_a = initial abstraction = interception plus infiltration during early parts of the storm plus surface depression storage = 0.2S (inches)
CN = runoff curve number

Wetbud assumes all of the "precipitation excess" enters the wetland each day – there is no flow routing or hydrograph generation for inflows from the wetland watershed.

Overbank Step 1: Calculate stream flows for each day

$$Q = \frac{(P - 0.2S_a)^2}{P + 0.8S} \quad \text{for } P > I_a$$



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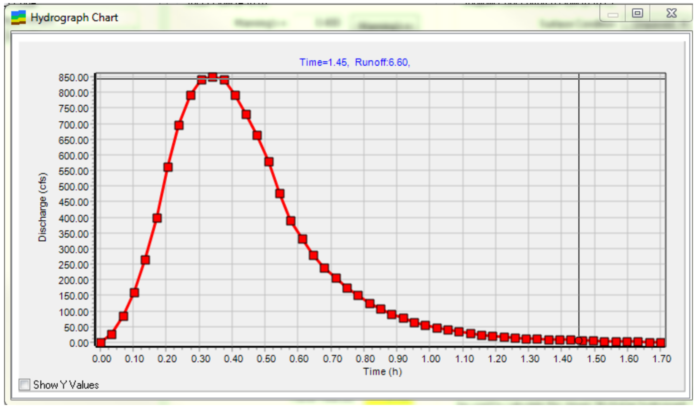

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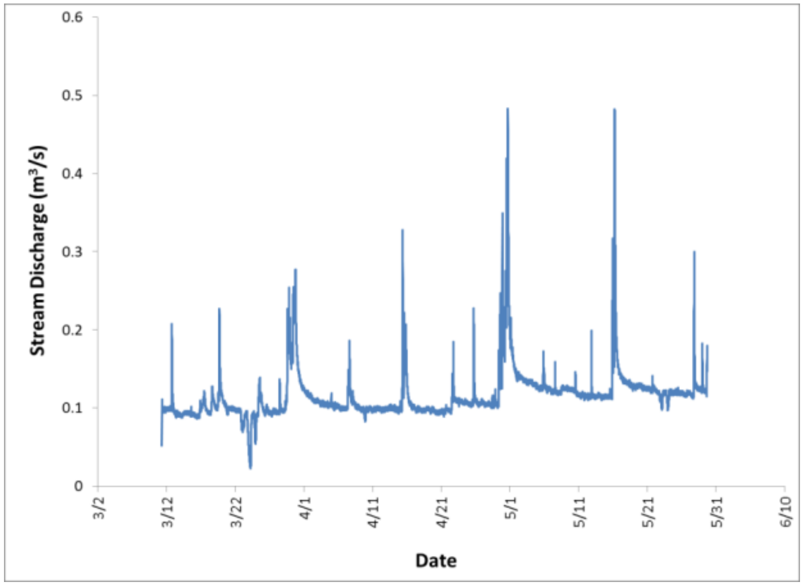
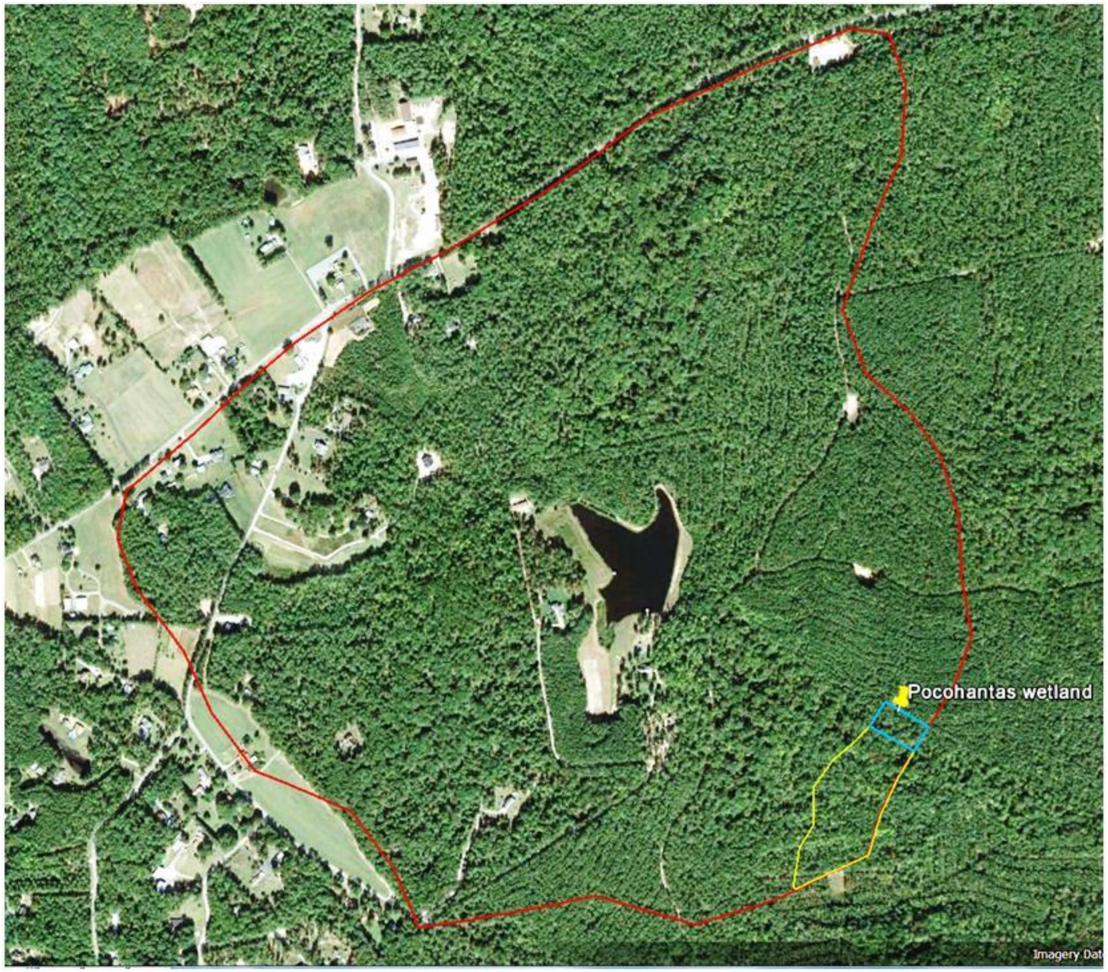


Cautions with having Wetbud calculate stream flows!!

- Only simulates one small watershed (< ? acres)
- Cannot have multiple sub-watersheds
- Does not route flow
- Does not simulate structures, such as ponds

For large, complex watersheds, compute continuous streamflow time series outside of Wetbud (e.g. HEC-RAS, SWMM, SWAT) and then import into Wetbud.

Caution: The overbank flow routine includes only a single watershed and NO STRUCTURES

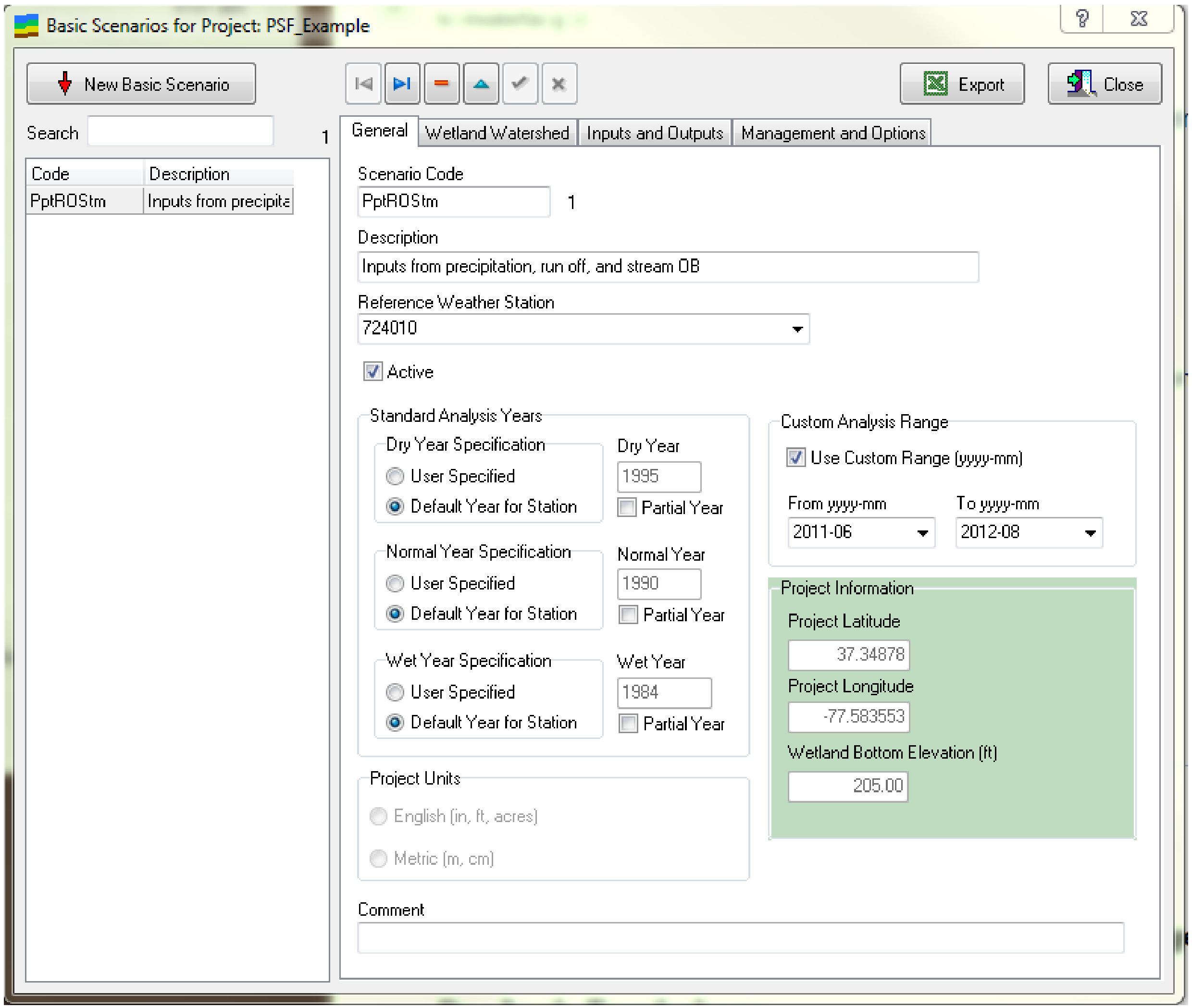


If the stream watershed is more than a few hundred acres or if there are significant structures in the watershed, use HEC-HMS or similar program and import stream discharge.

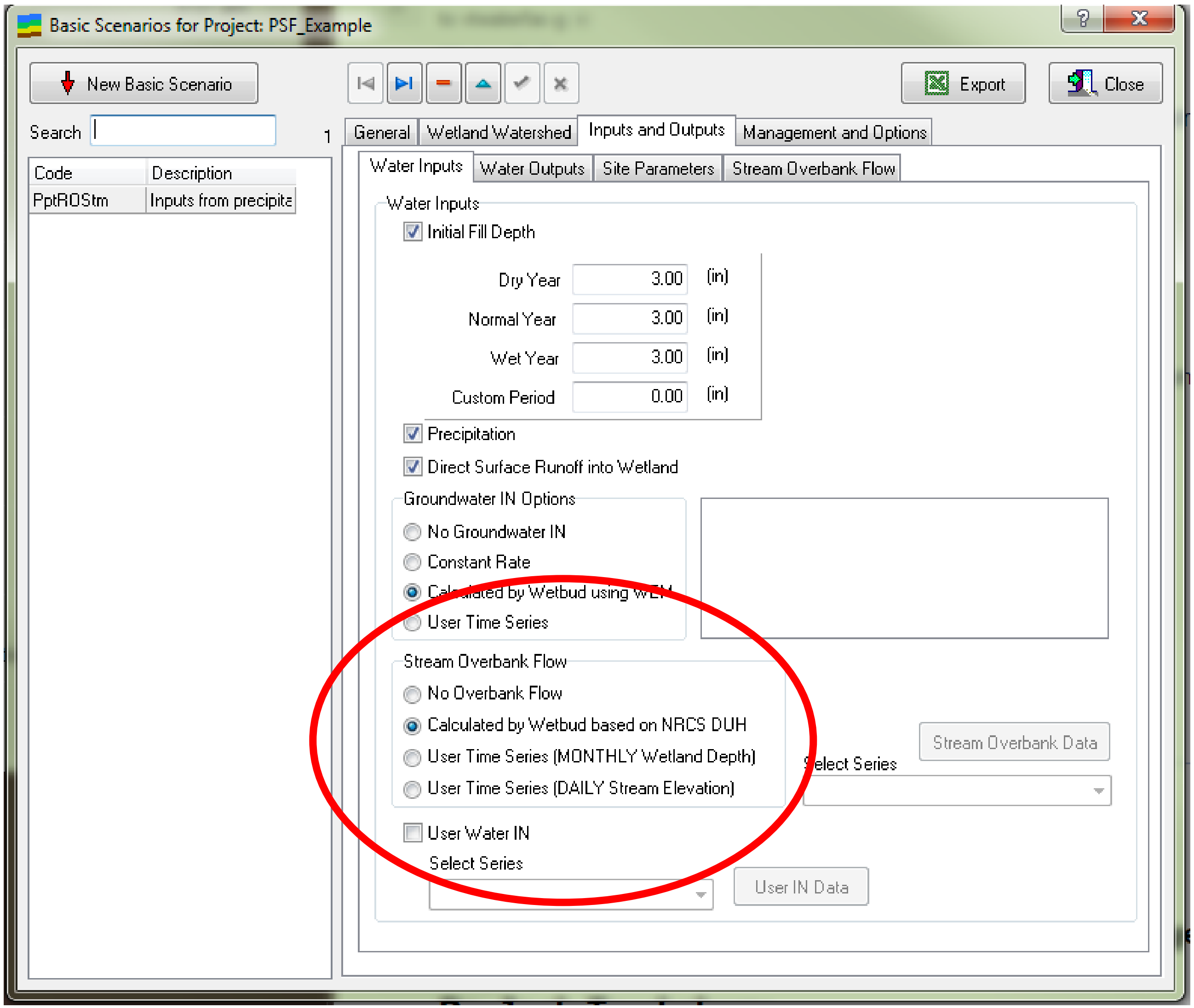
This is the end of the Project-Level surface flow inputs (i.e. you can't change these through your design).

The rest of the calculations are at the Scenario-Level (because they can be changed through wetland design).

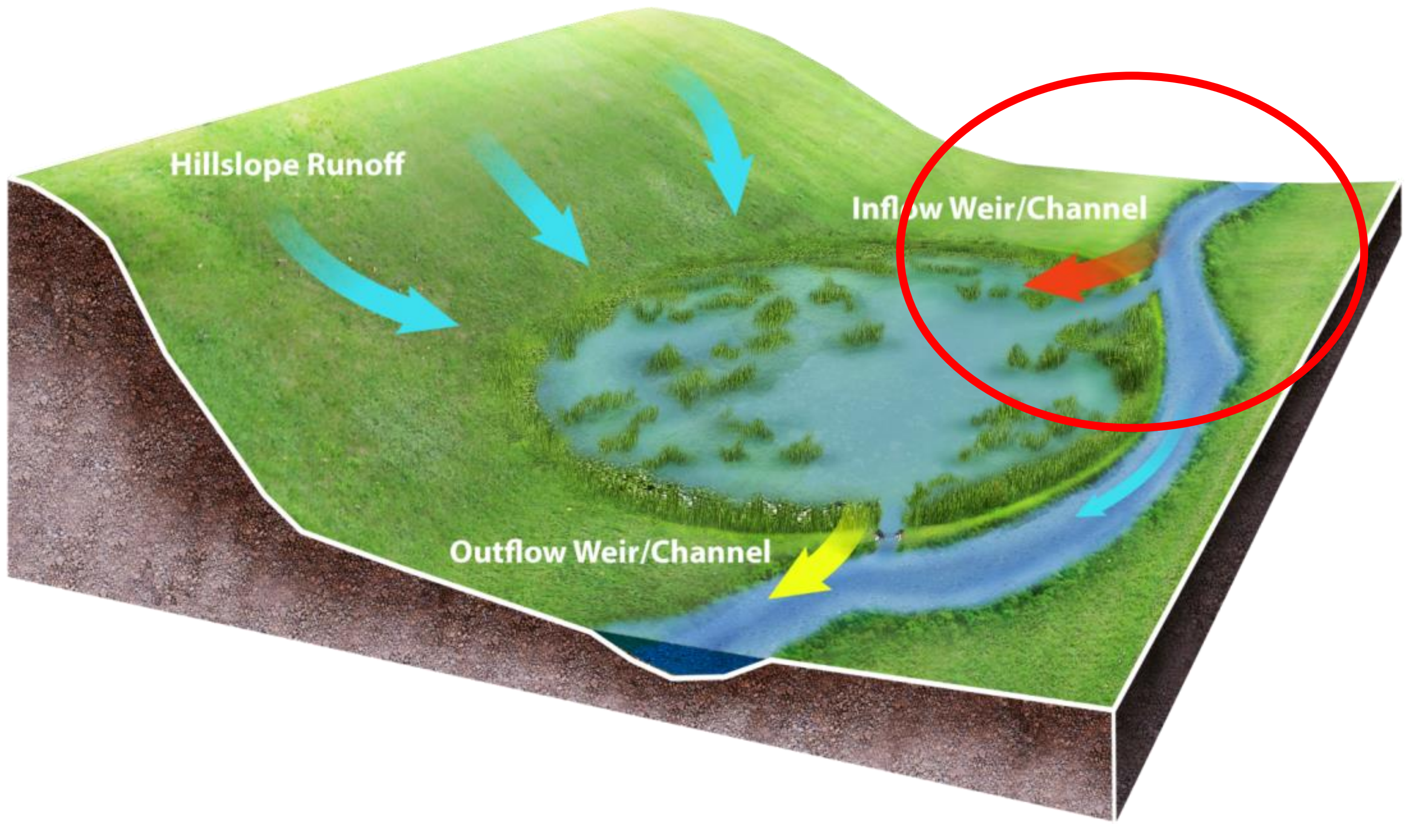
Overbank Step 2: Calculate water surface elevation in the stream



Overbank Step 2: Calculate water surface elevation in the stream



The stream overbank flow routine assumes there is an inflow weir or channel constructed in the wetland berm.



If there is no inflow structure, the entire berm can be modeled as a broad-crested weir.

Overbank Step 2: Calculate water surface elevation in the stream

$$q = \frac{1.49}{n} \frac{A^{5/3}}{P^{2/3}} S^{1/2}$$

q = flow (ft/s)
n = roughness coefficient
A = cross-sectional area (ft^2)
P = wetted perimeter (ft)
S = hydraulic gradient (ft/ft)

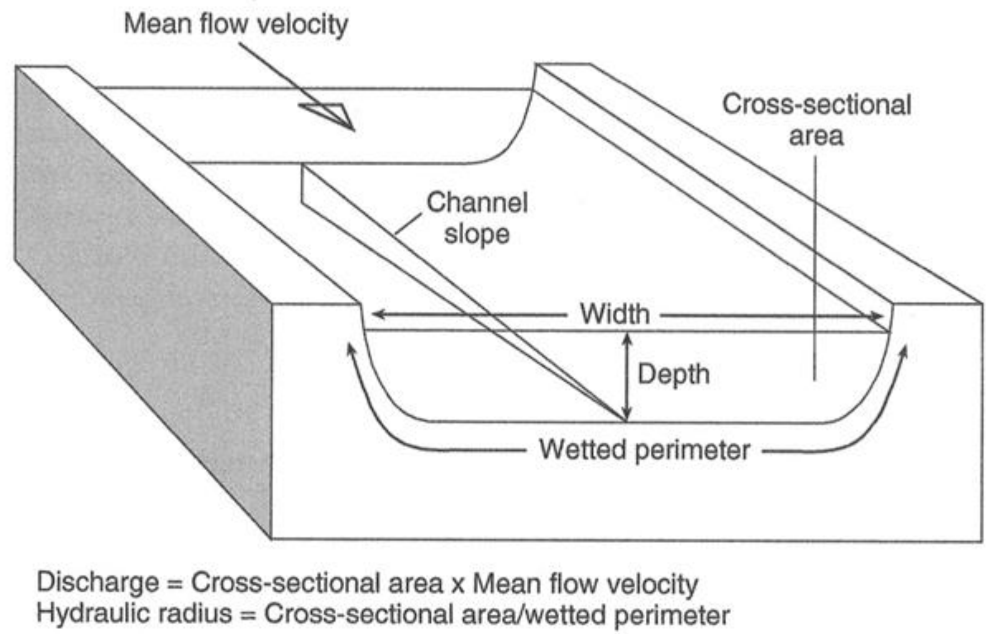
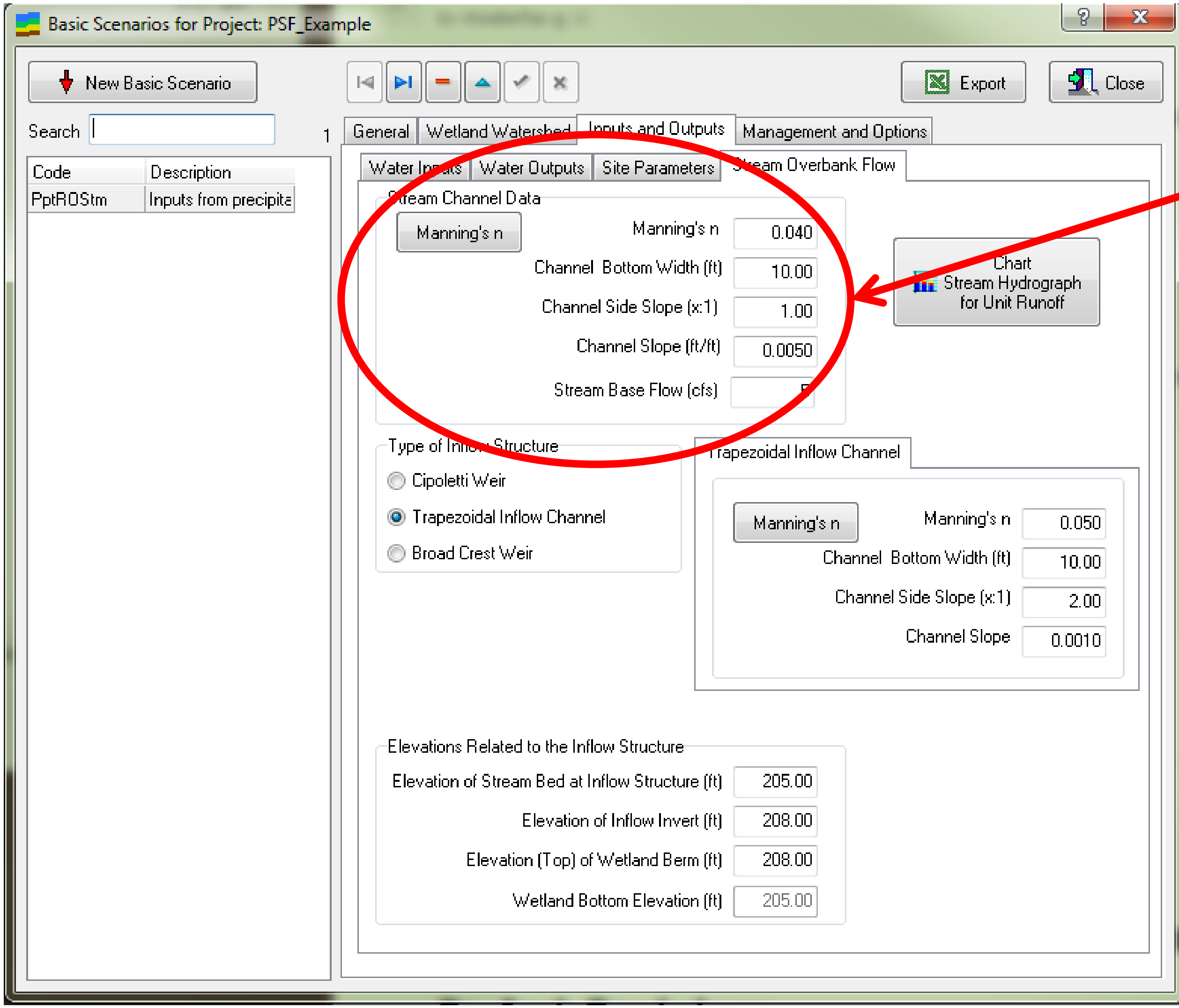


Figure 6.1 Basic channel parameters. After Summerfield (1991).

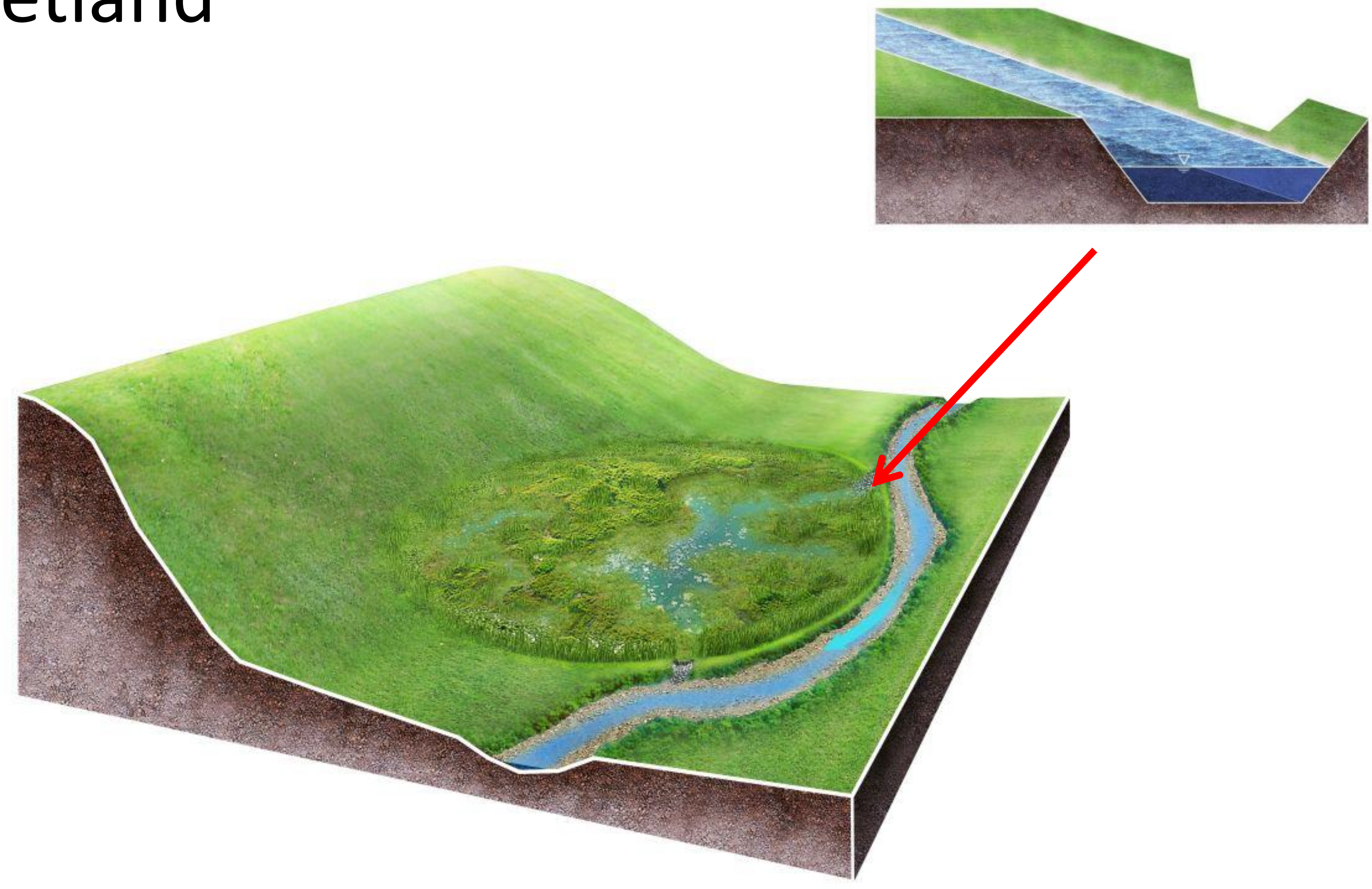
Depth is included in A and P: knowing q, n, S and width, we can solve for depth.

Overbank Step 2: Calculate water surface elevation in the stream



For stream restoration design, can change channel dimensions and roughness here.

Overbank Step 2: Check to see if water in the stream is high enough to overflow into the wetland



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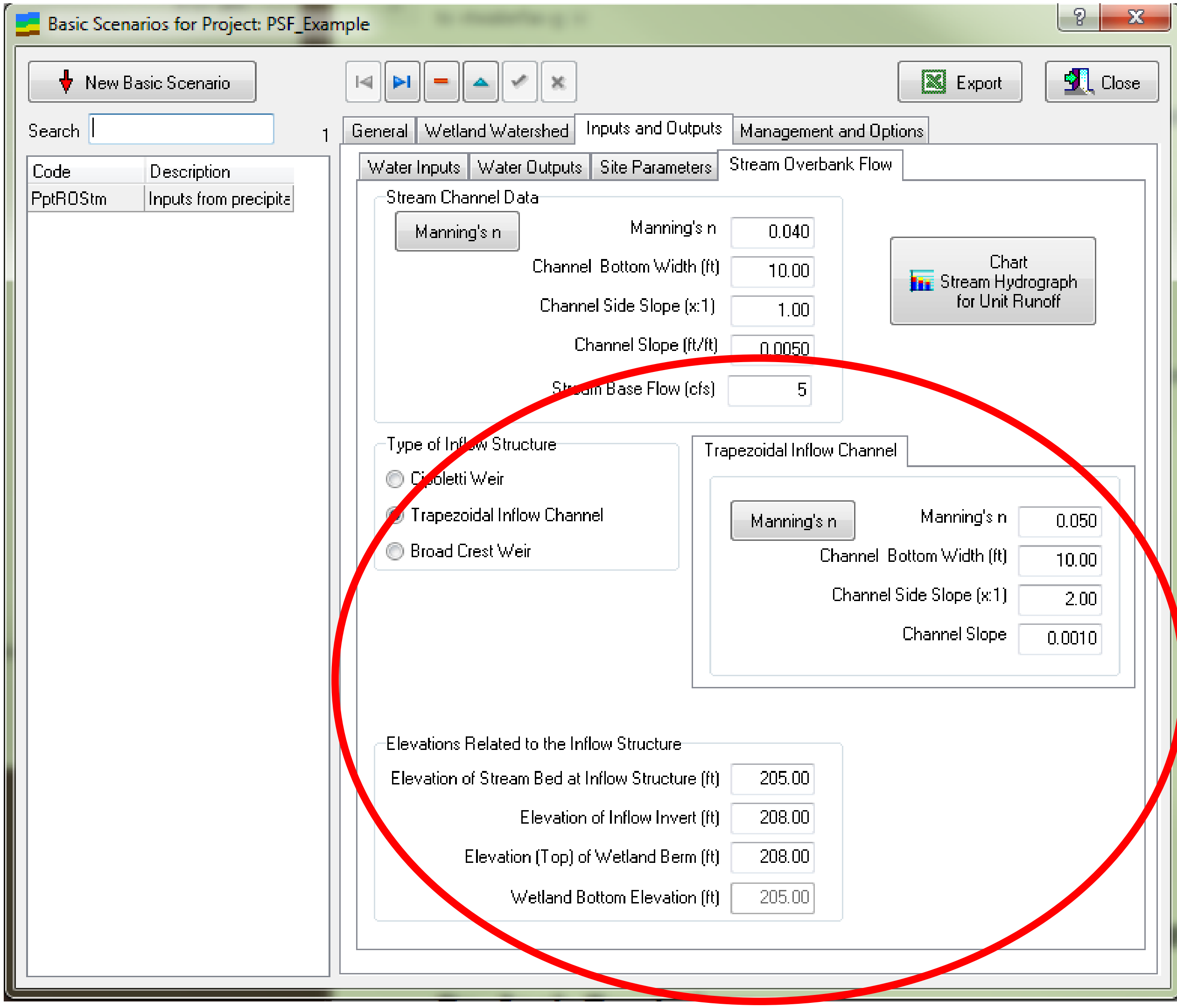


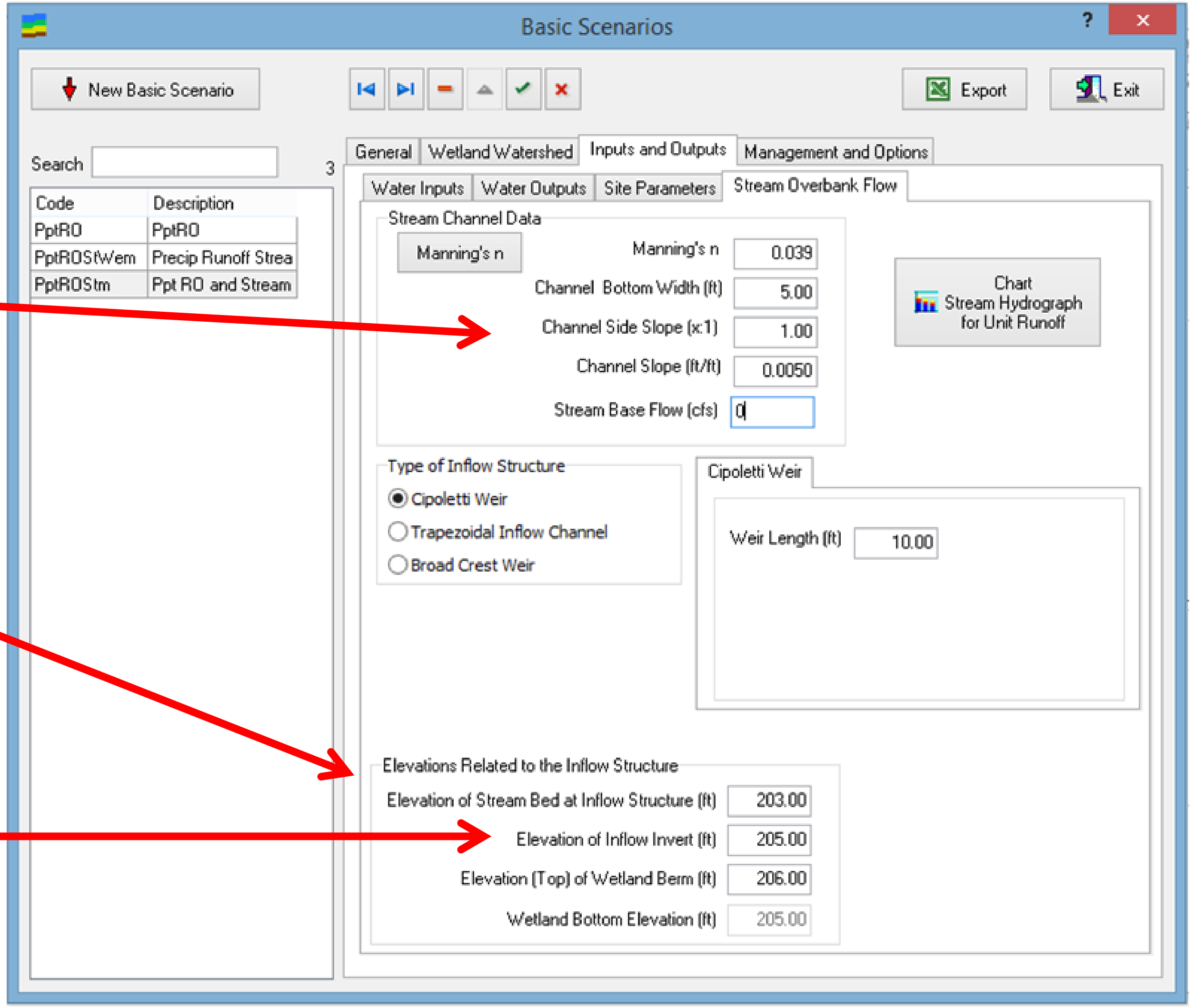
Design inflow structure here

Overbank Step 2: Check to see if water in the stream is high enough to overflow into the wetland

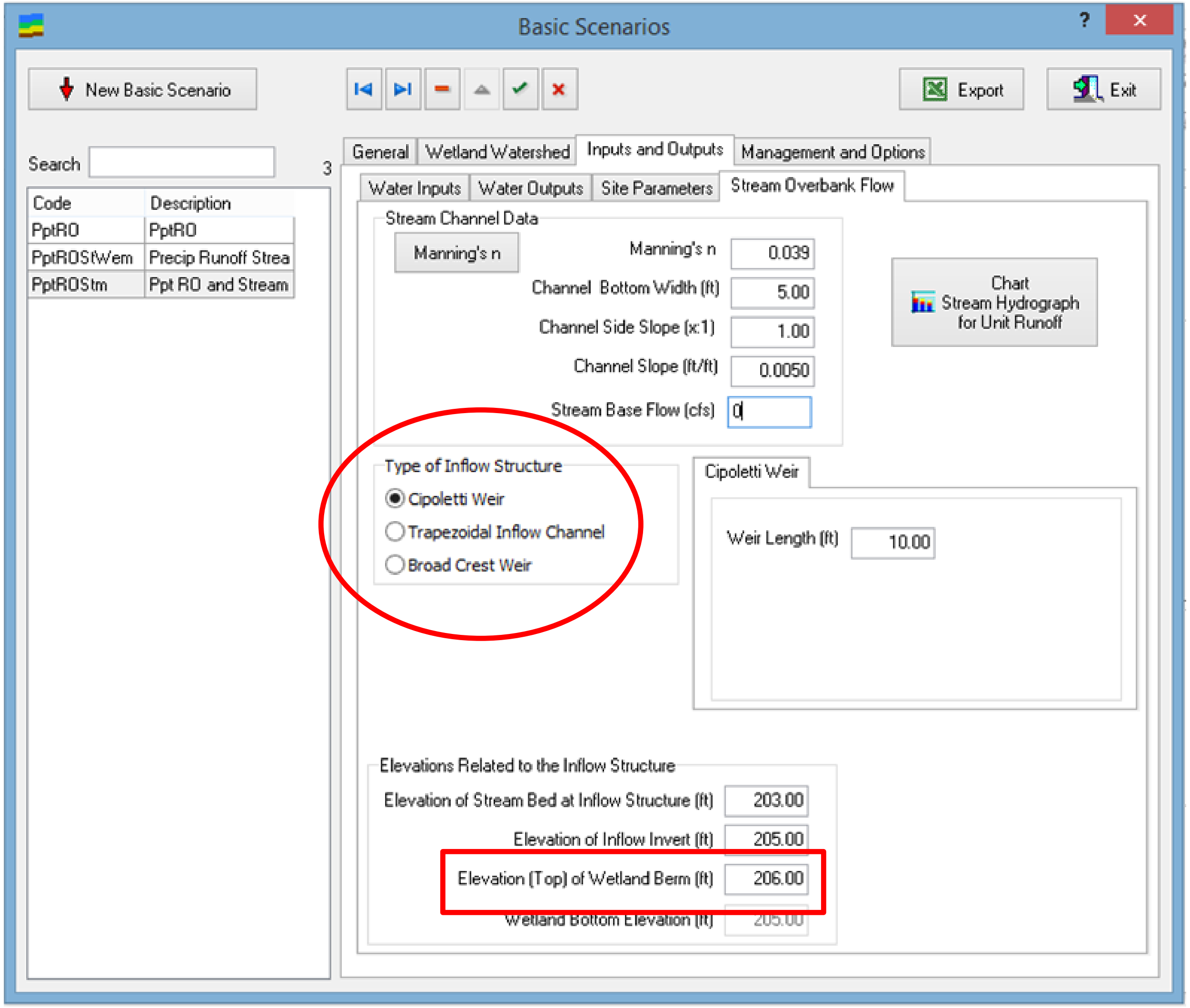
a. Calculate water depth in stream

b. Add water depth to stream bed elevation

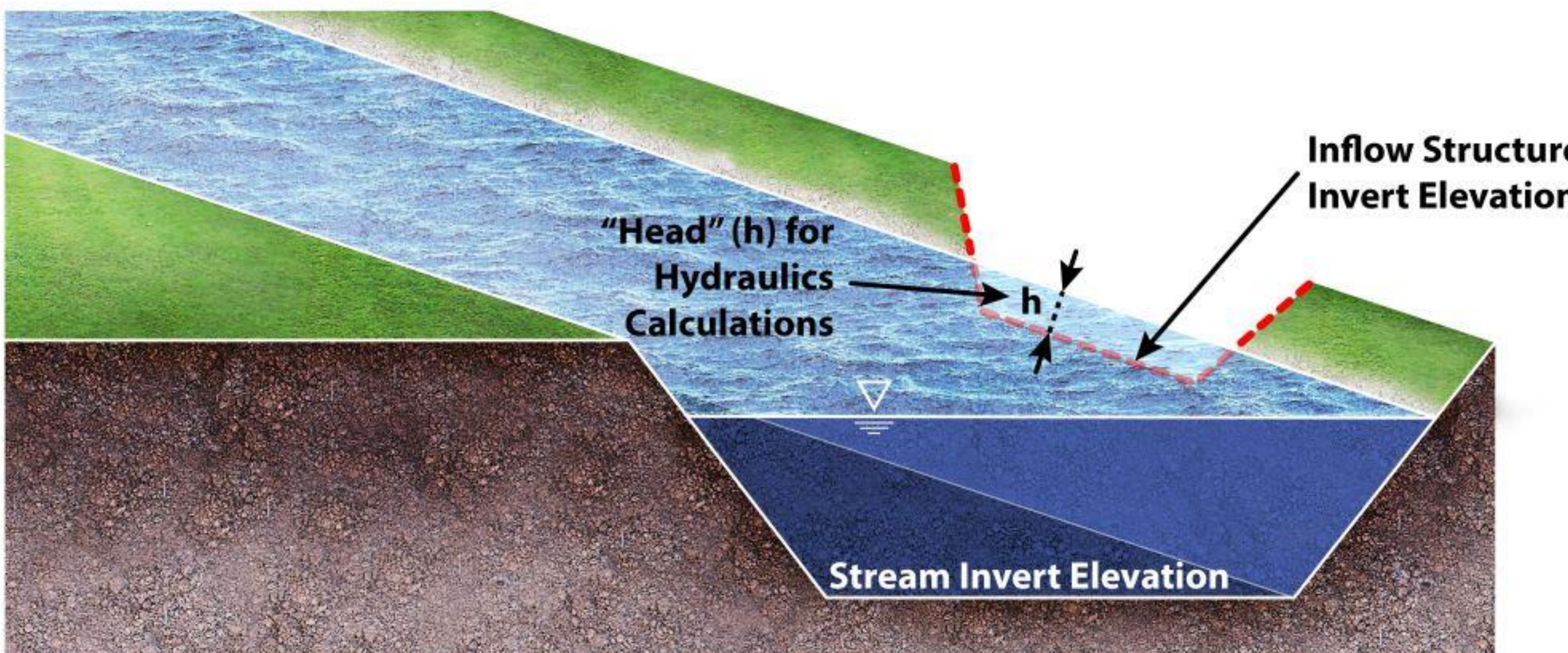
c. Compare water depth to inflow structure elevation



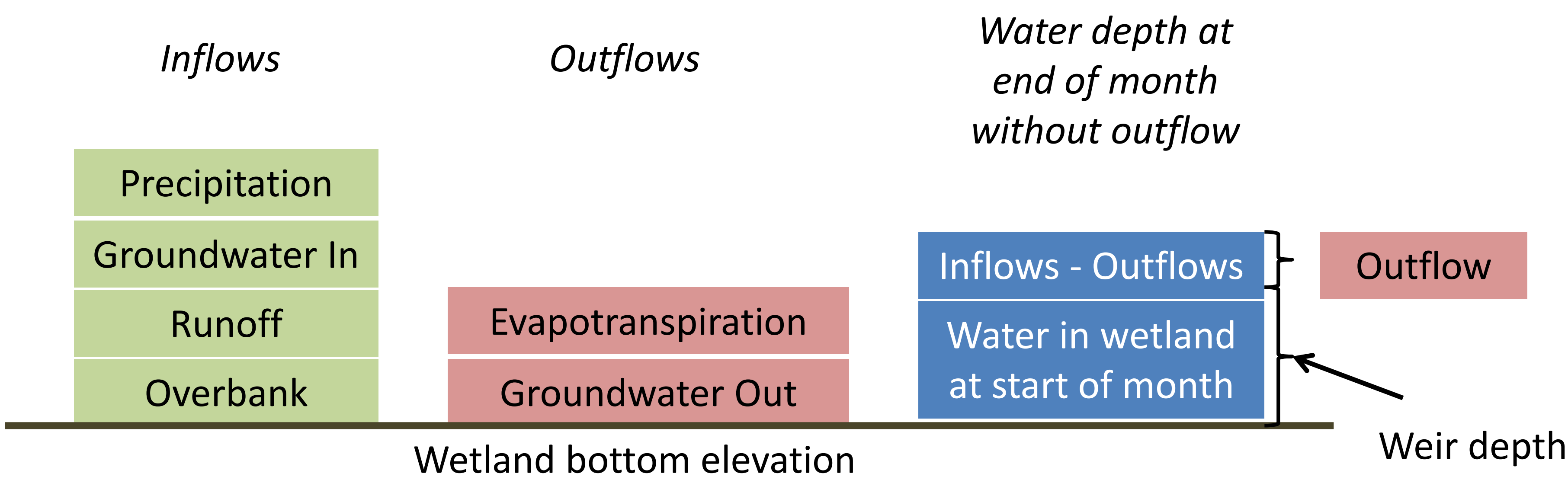
Overbank Step 3: Calculate amount of water that enters wetland from that 24-hr storm event



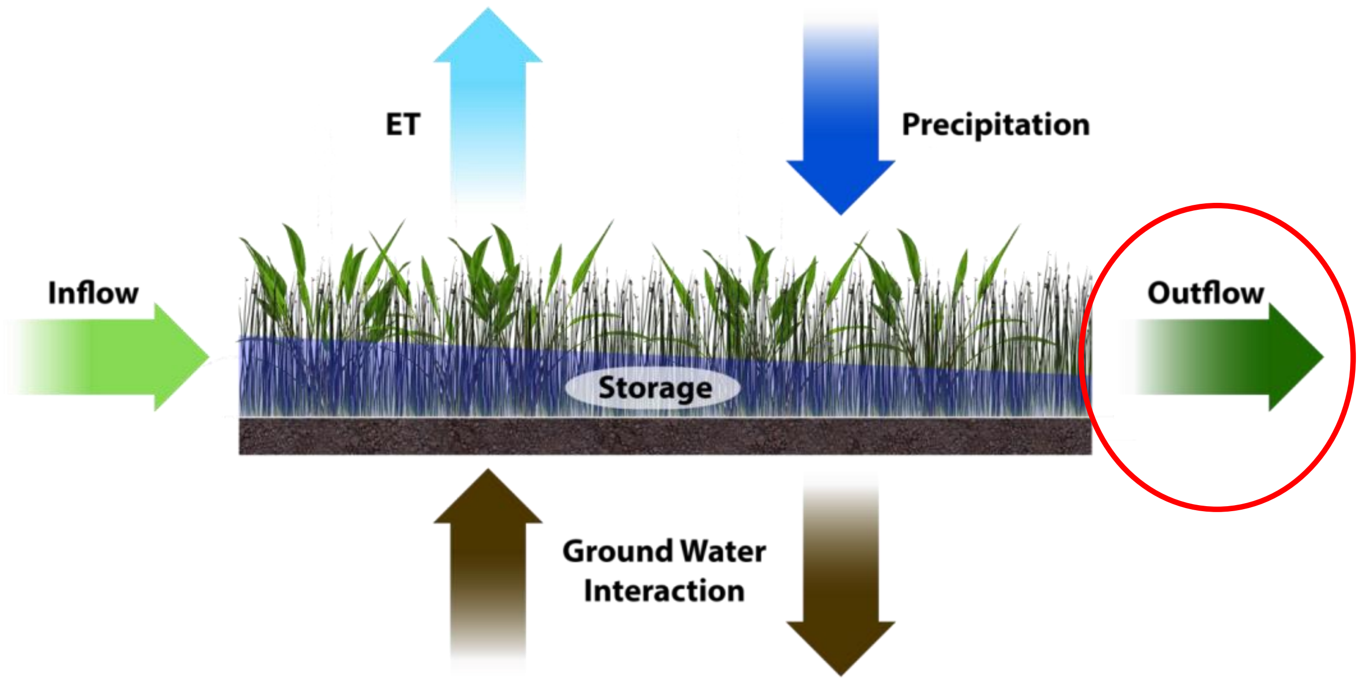
The depth of water above the inflow structure (hydraulic head, h) determines the inflow rate to calculate monthly overbank volume.

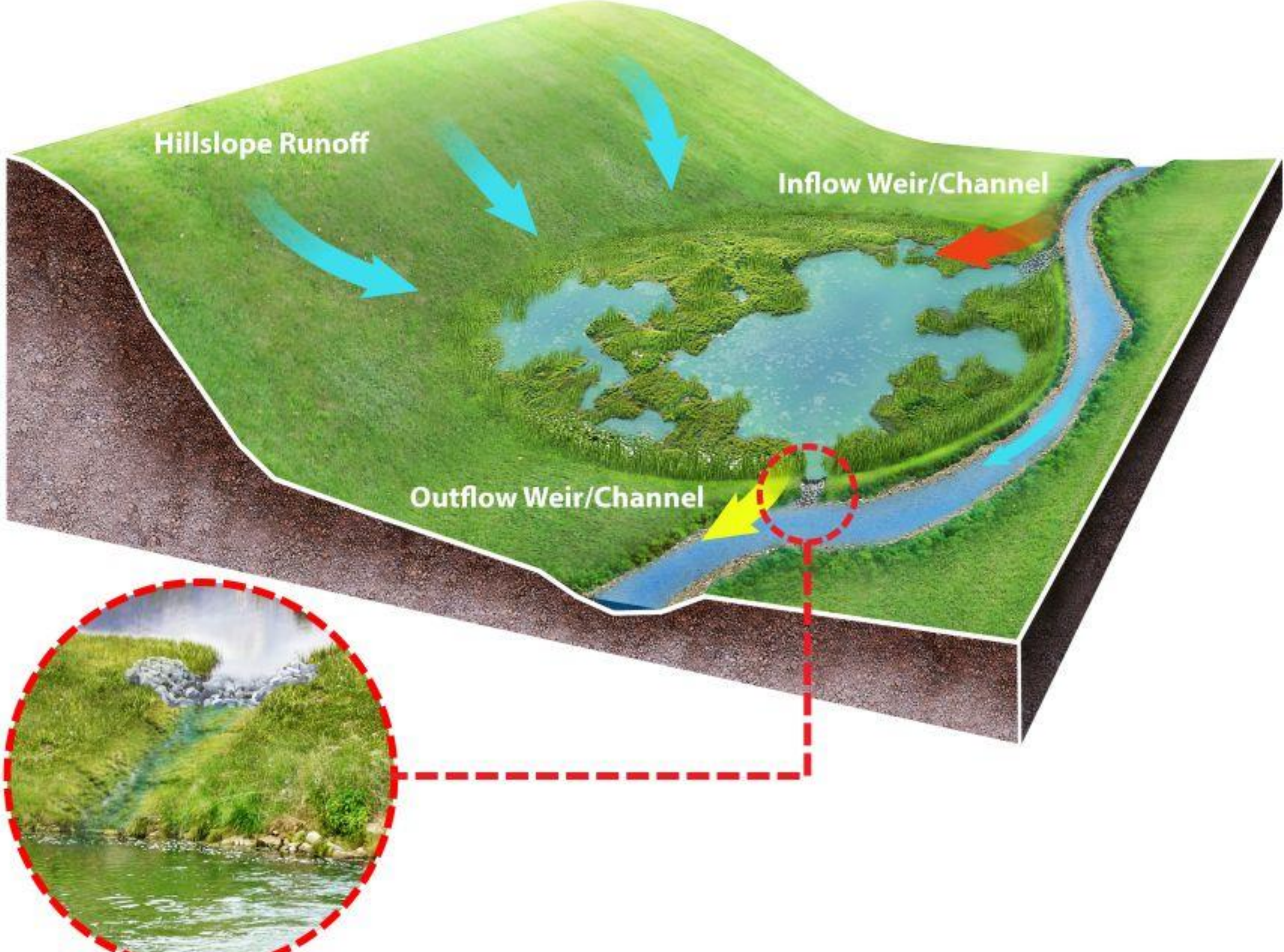


In the Basic Model, water greater than the "weir depth" is lost from the wetland as outflow each month.

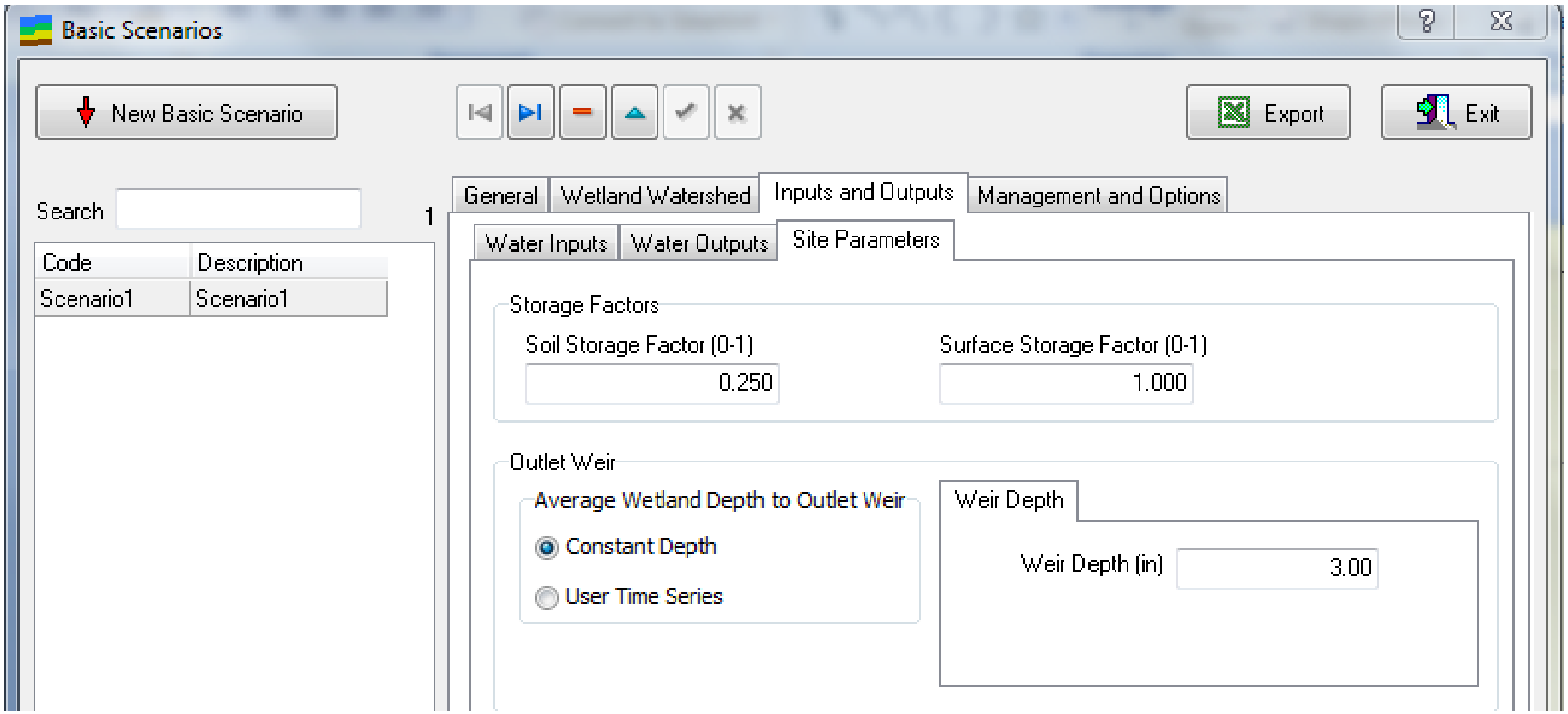


Outflow assumed to occur through a weir




Hillslope Runoff
Inflow Weir/Channel
Outflow Weir/Channel

In the Basic Model, water greater than the "weir depth" is lost from the wetland as outflow each month.




Questions?