

Wetbud Surface Water Components in the Basic Model

Presenters:

Tess Thompson

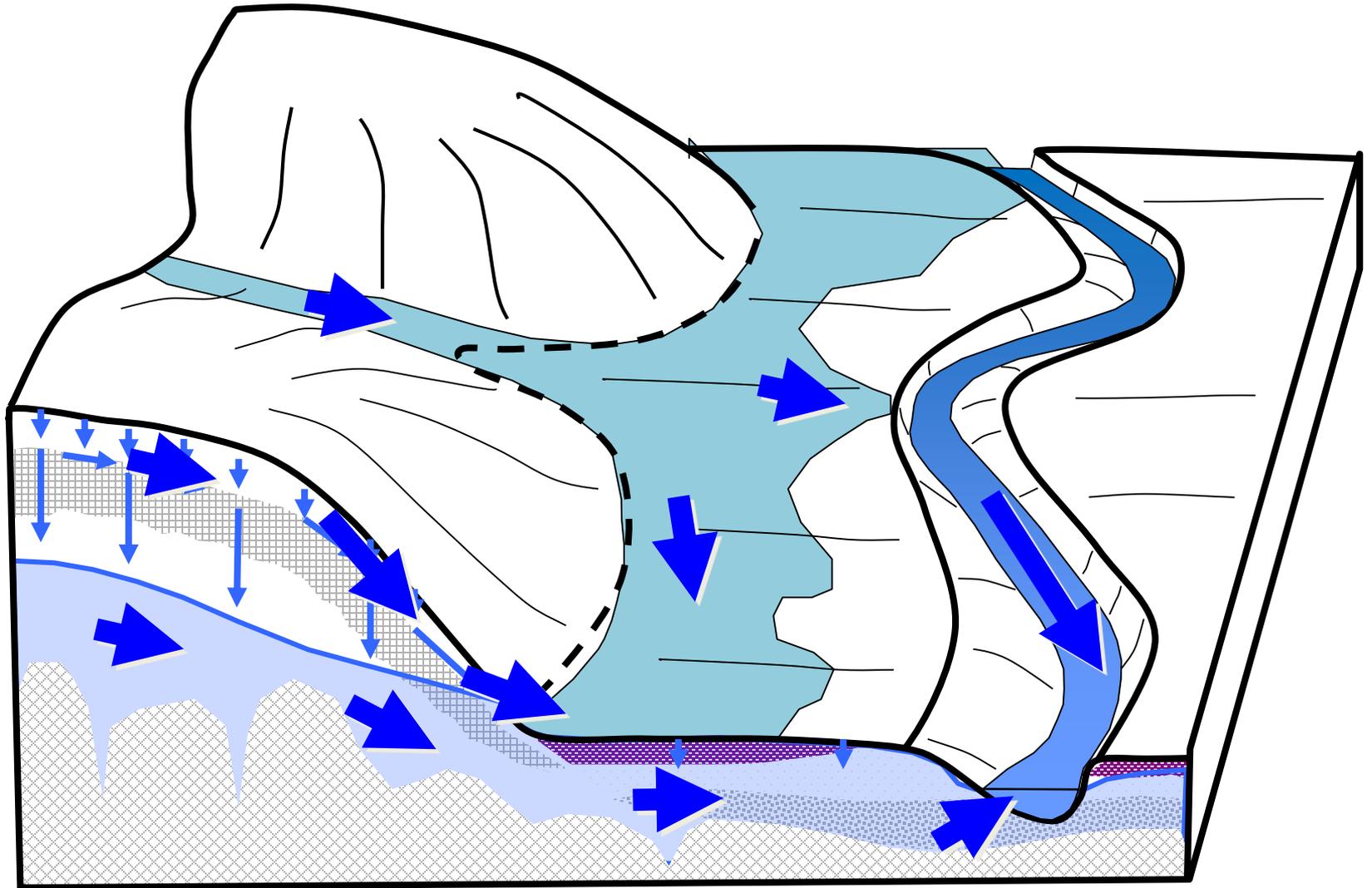
Virginia Tech

Zach Agioutantis

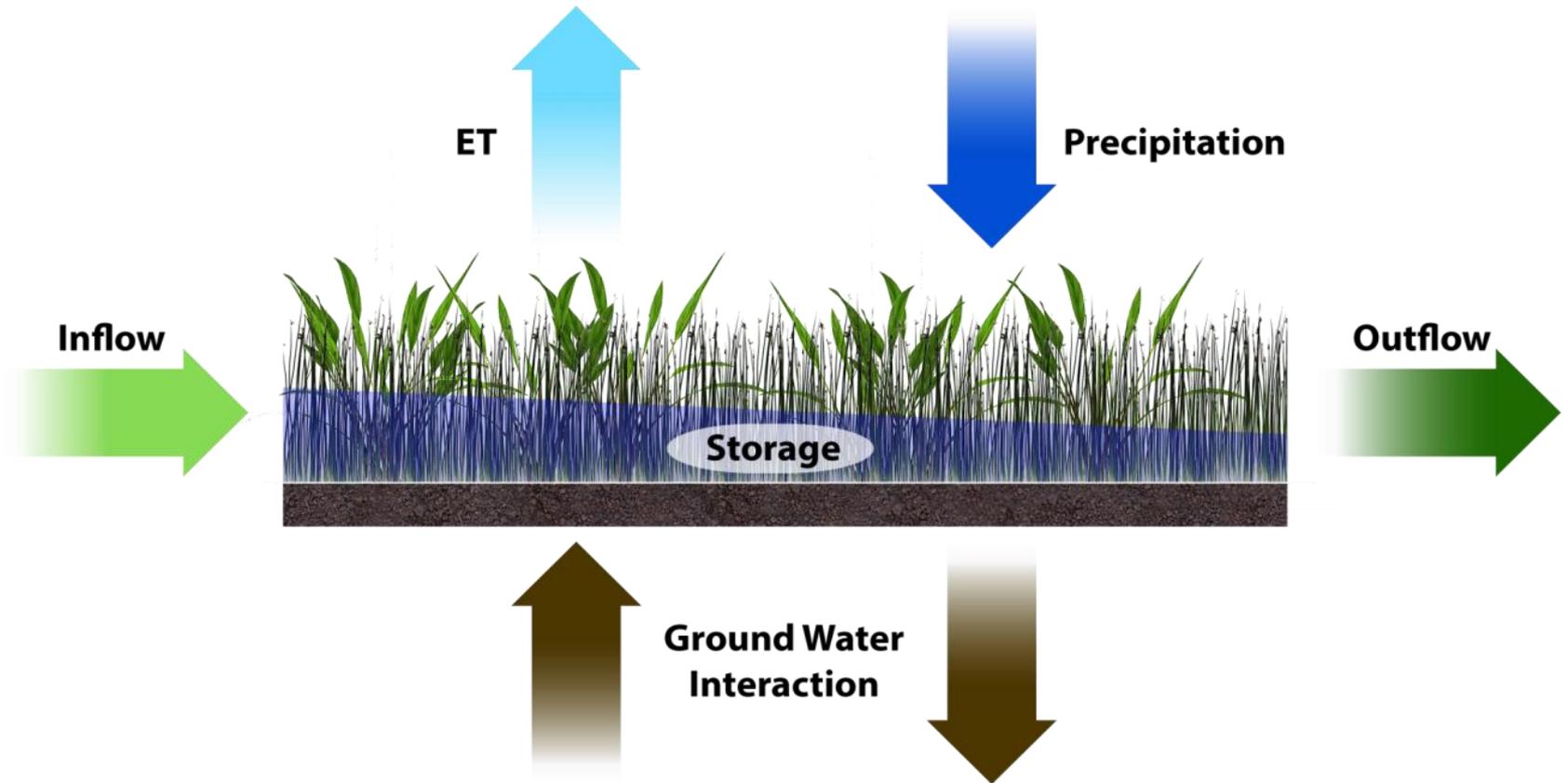
University of Kentucky

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

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

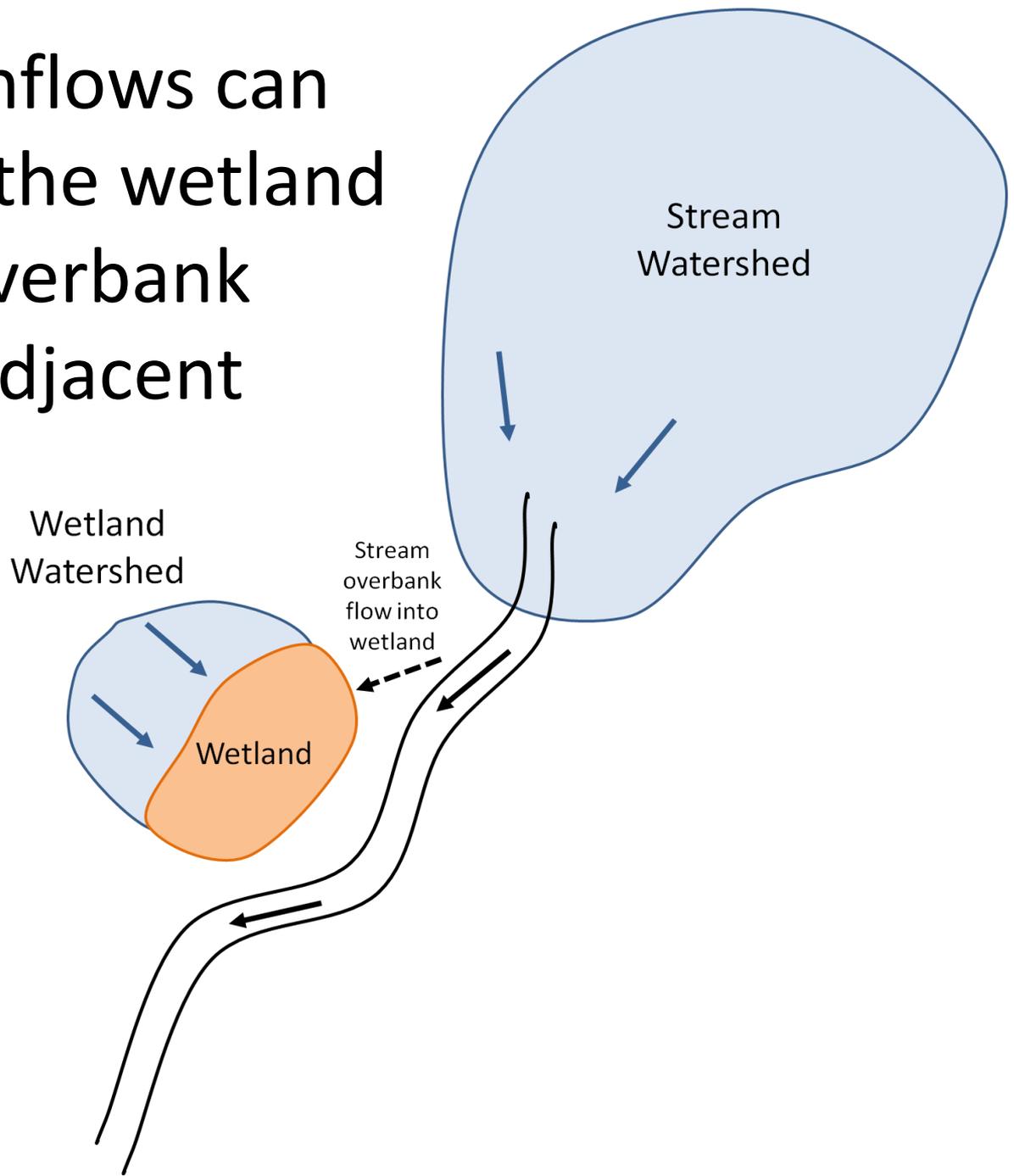


Water Inflows and Outflows



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

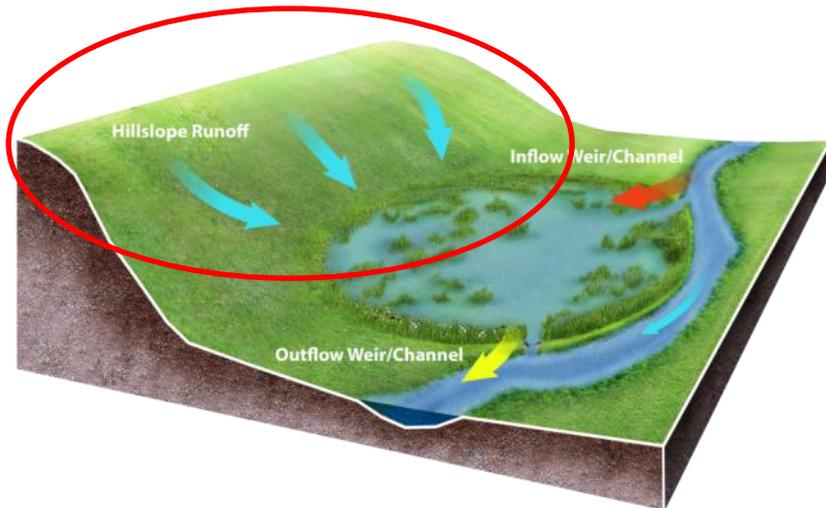
Surface water inflows can be runoff from the wetland watershed or overbank flows from an adjacent stream.



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)

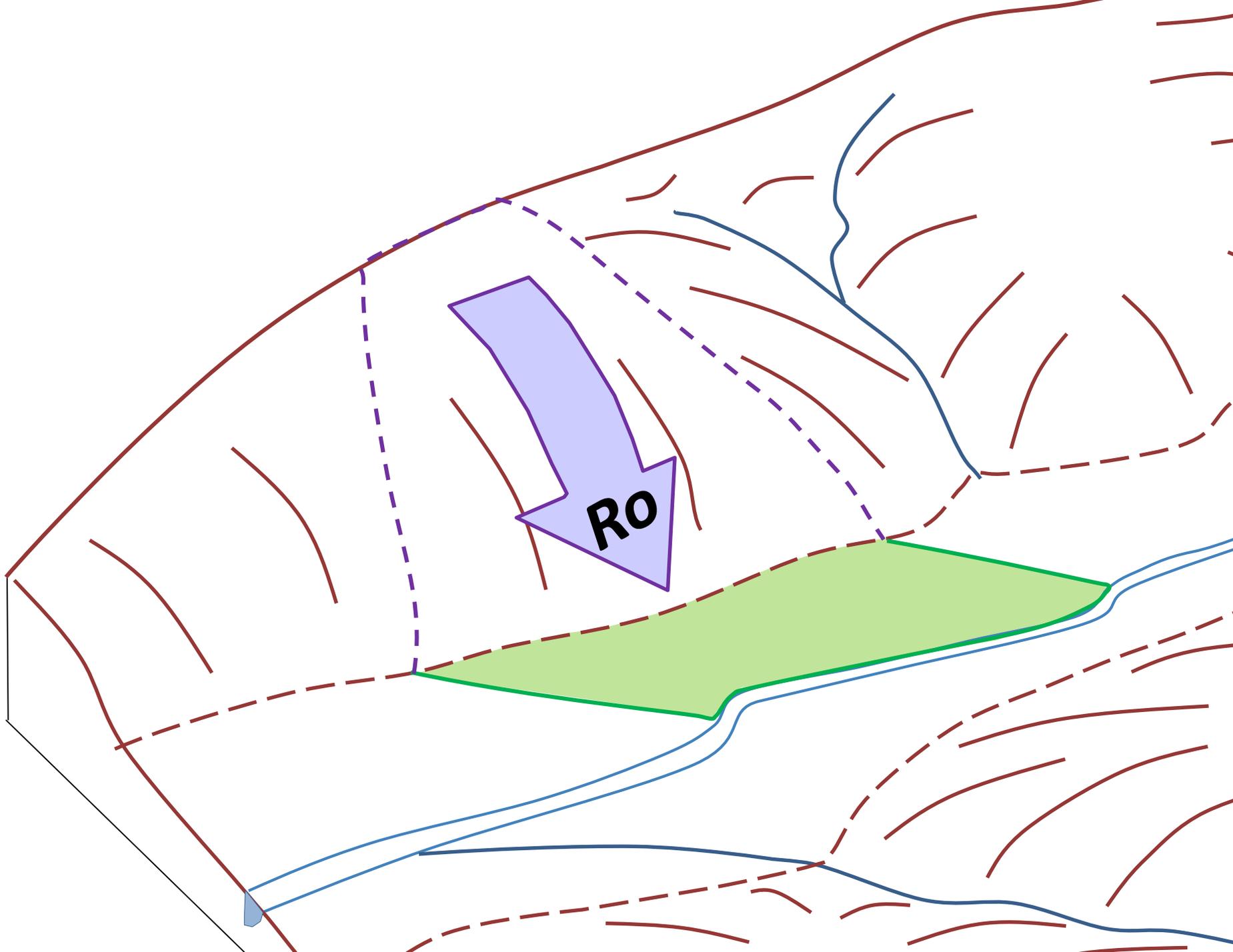
P = actual rainfall (inches)

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)

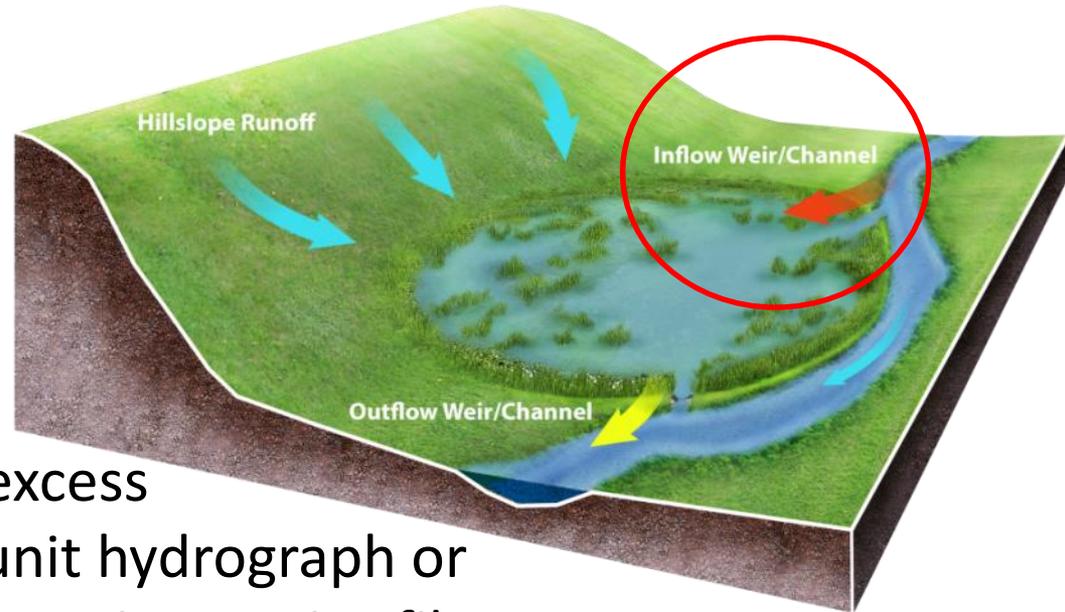
CN = runoff curve number

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.



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



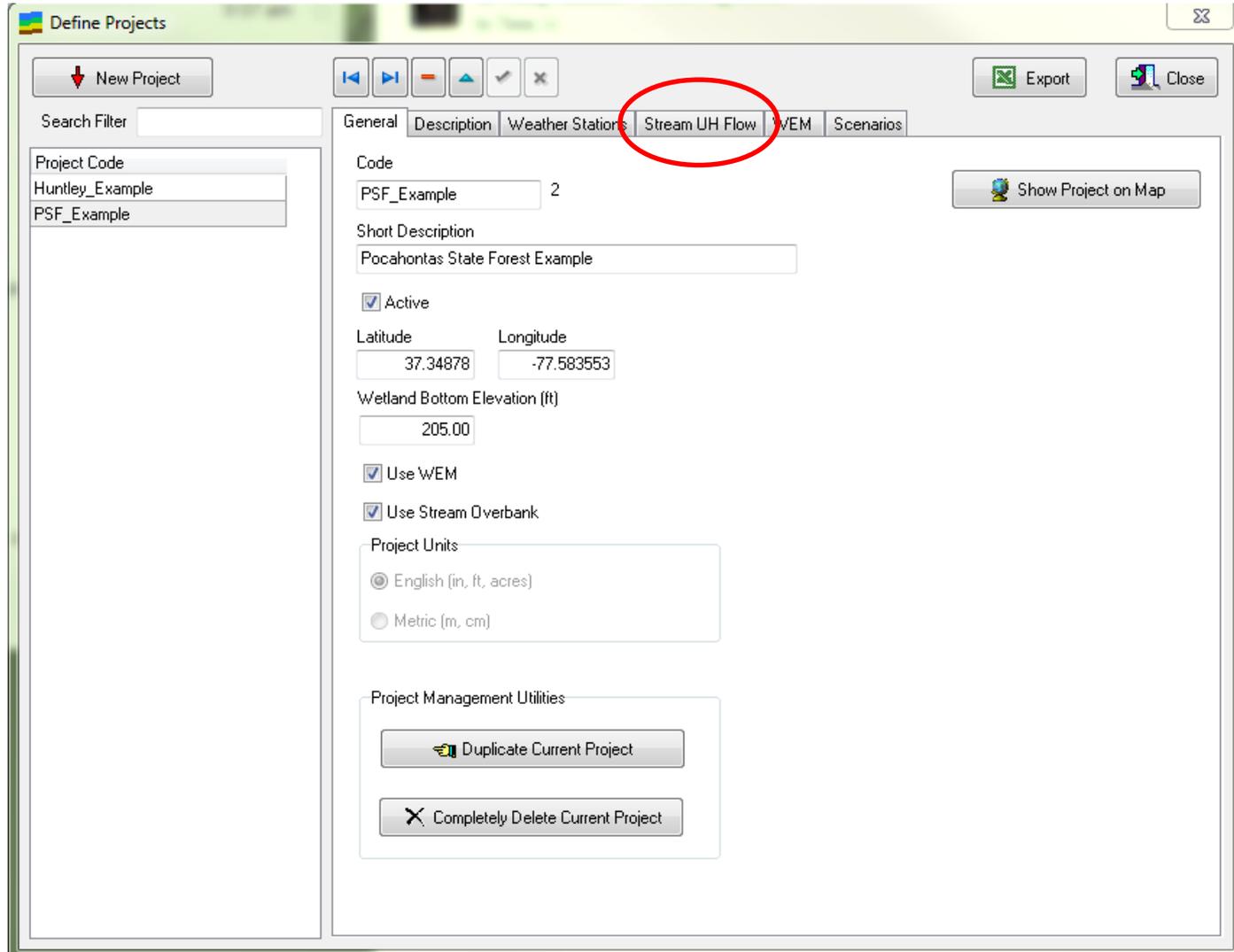
Overbank Step 1: Calculate stream flows

The screenshot shows the 'Define Projects' window with the following configuration:

- Project Code:** PSF_Example
- Code:** 2
- Short Description:** Pocahontas State Forest Example
- Active
- Latitude:** 37.34878
- Longitude:** -77.583553
- Wetland Bottom Elevation (ft):** 205.00
- Use WEM
- Use Stream Overbank (highlighted with a red circle)
- Project Units:** English (in, ft, acres) (selected)
- Metric (m, cm)

Buttons visible include: New Project, Export, Close, Show Project on Map, Duplicate Current Project, and Completely Delete Current Project.

Overbank Step 1: Calculate stream flows



Overbank Step 1: Calculate stream flows

Define Projects

New Project

Search Filter

Project Code
Huntley_Example
PSF_Example

General Description Weather Stations Stream UH Flow WEM Scenarios

Sheet Flow (A to B)

Manning's n 0.400 Manning's n

Flow Length (ft) 100.00

Land Slope (ft/ft) 0.0500

2-yr 24h Precip (in) 3.38 NOAA Site

Travel Time (h) 0.241

Shallow Concentrated Flow (B to C)

Surface Condition Unpaved

Flow Length (ft) 650.00

Watercourse Slope (ft/ft) 0.0150

Average Velocity (ft/s) 2.490

Travel Time (h) 0.073

Open Channel Flow (C to D)

Manning's n Manning's n 0.035

Flow Length (ft) 5150.00

Channel Bottom Width (ft) 10.00

Channel Side Slope (z:1) 1.00

Channel Depth (ft) 3.00

Channel Cross Sectional Area (ft²) 39.00

Channel Wetted Perimeter (ft) 18.49

Hydraulic Radius (ft) 2.11

Channel Slope (ft/ft) 0.0107

Average Velocity (ft/s) 7.244

Travel Time (h) 0.197

Watershed Data (for Stream)

Watershed Area (acres) 383.0

NRCS Curve Number 66

Time of Concentration (h) 0.511

Peaking Factor (100-600) 484

Time to Peak Flow (h) 0.34

625

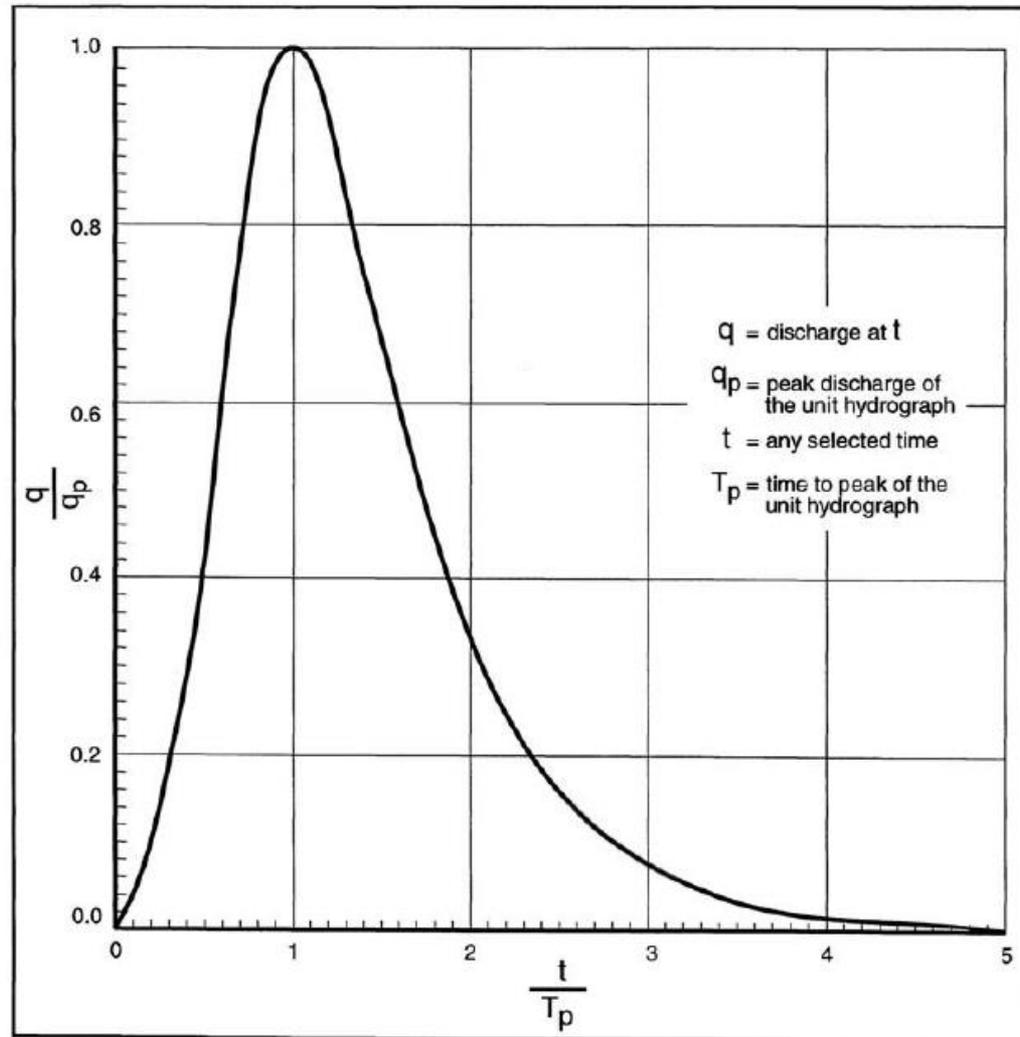
qp for Unit Runoff (cfs) 850

Data are used to construct the Discharge Unit Hydrograph (UH) for the watershed of the stream which is the source of overbank flow. The user can generate a discharge hydrograph for a given 24 hr precipitation depth (i.e., 3.2 inches/24 hrs.). When overbank flow is calculated, daily precipitation data will be used to calculate the stream discharge hydrograph for that precipitation depth.

Automatic Calculation

Calculate Chart Discharge Unit Hydrograph

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

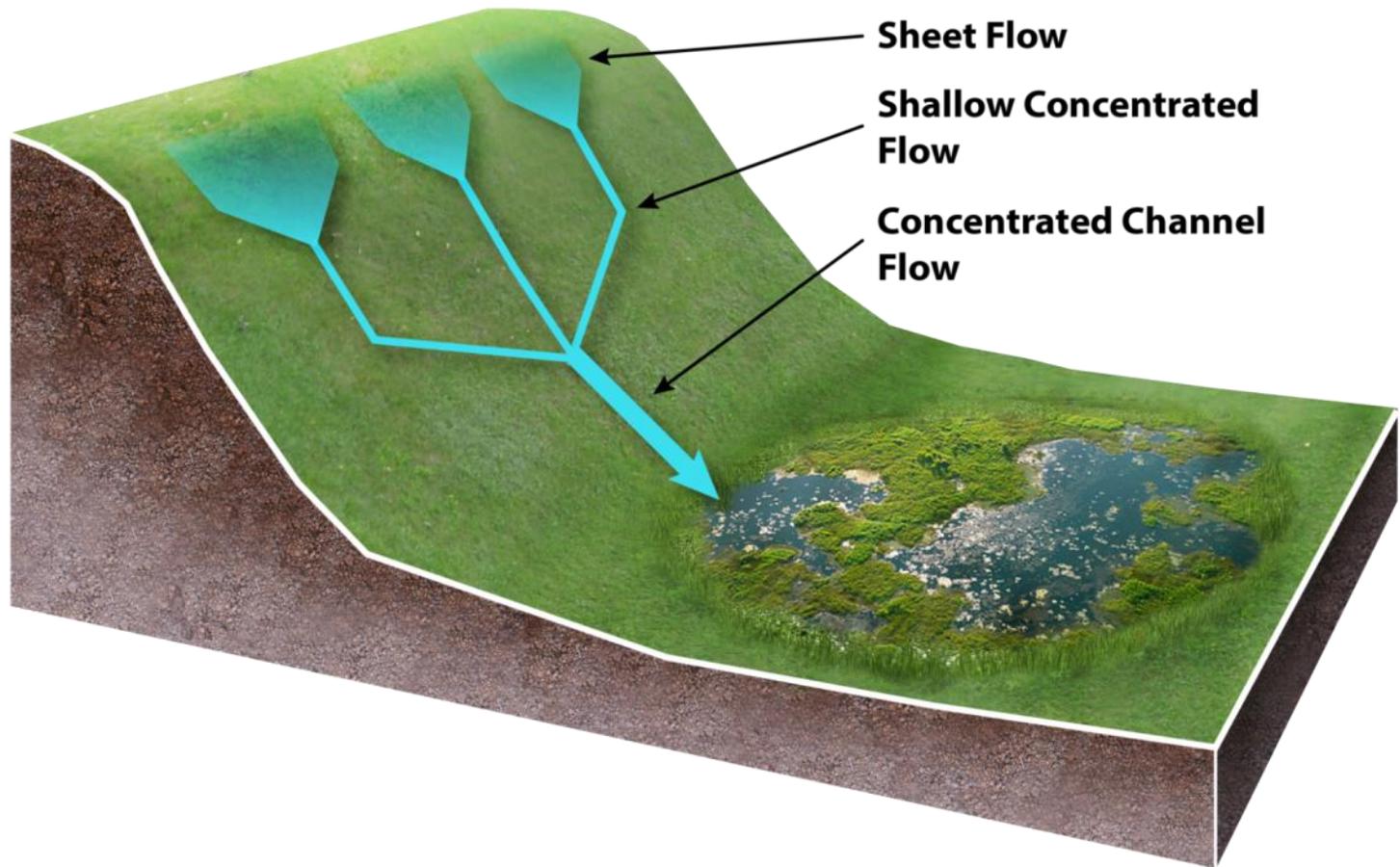


Overbank Step 1: Calculate stream watershed time to peak (T_p) and unit peak runoff (q_p , 1 in./day) as part of the overall project

The screenshot displays the 'Define Projects' software interface, specifically the 'Stream UH Flow' tab. The interface is divided into several sections for inputting hydrology data:

- Project Code:** A list on the left shows 'Huntley_Example' and 'PSF_Example'.
- Navigation:** Buttons for back, forward, home, and search are located at the top.
- General Tab:** The active tab, containing the following sections:
 - Sheet Flow (A to B):** Manning's n (0.400), Flow Length (ft) (100.00), Land Slope (ft/ft) (0.0500), 2-yr 24h Precip (in) (3.38), and Travel Time (h) (0.241).
 - Open Channel Flow (C to D):** Manning's n (0.035), Flow Length (ft) (5150.00), Channel Bottom Width (ft) (10.00), Channel Side Slope (z:1) (1.00), Channel Depth (ft) (3.00), Channel Cross Sectional Area (ft²) (39.00), Channel Wetted Perimeter (ft) (18.49), Hydraulic Radius (ft) (2.11), Channel Slope (ft/ft) (0.0107), Average Velocity (ft/s) (7.244), and Travel Time (h) (0.197).
 - Automatic Calculation:** A checkbox at the bottom left.
- Shallow Concentrated Flow (B to C):** Surface Condition (Unpaved), Flow Length (ft) (650.00), Watercourse Slope (ft/ft) (0.0150), Average Velocity (ft/s) (2.490), and Travel Time (h) (0.073).
- Watershed Data (for Stream):** Watershed Area (acres) (383.0), NRCS Curve Number (66), Time of Concentration (h) (0.511), Peaking Factor (100-600) (484), Time to Peak Flow (h) (0.34), and qp for Unit Runoff (cfs) (625).
- Notes:** A text box at the bottom right explains that the data is used to construct the Discharge Unit Hydrograph (UH) for the watershed of the stream.
- Buttons:** 'Calculate' and 'Chart Discharge Unit Hydrograph' buttons are located at the bottom right.

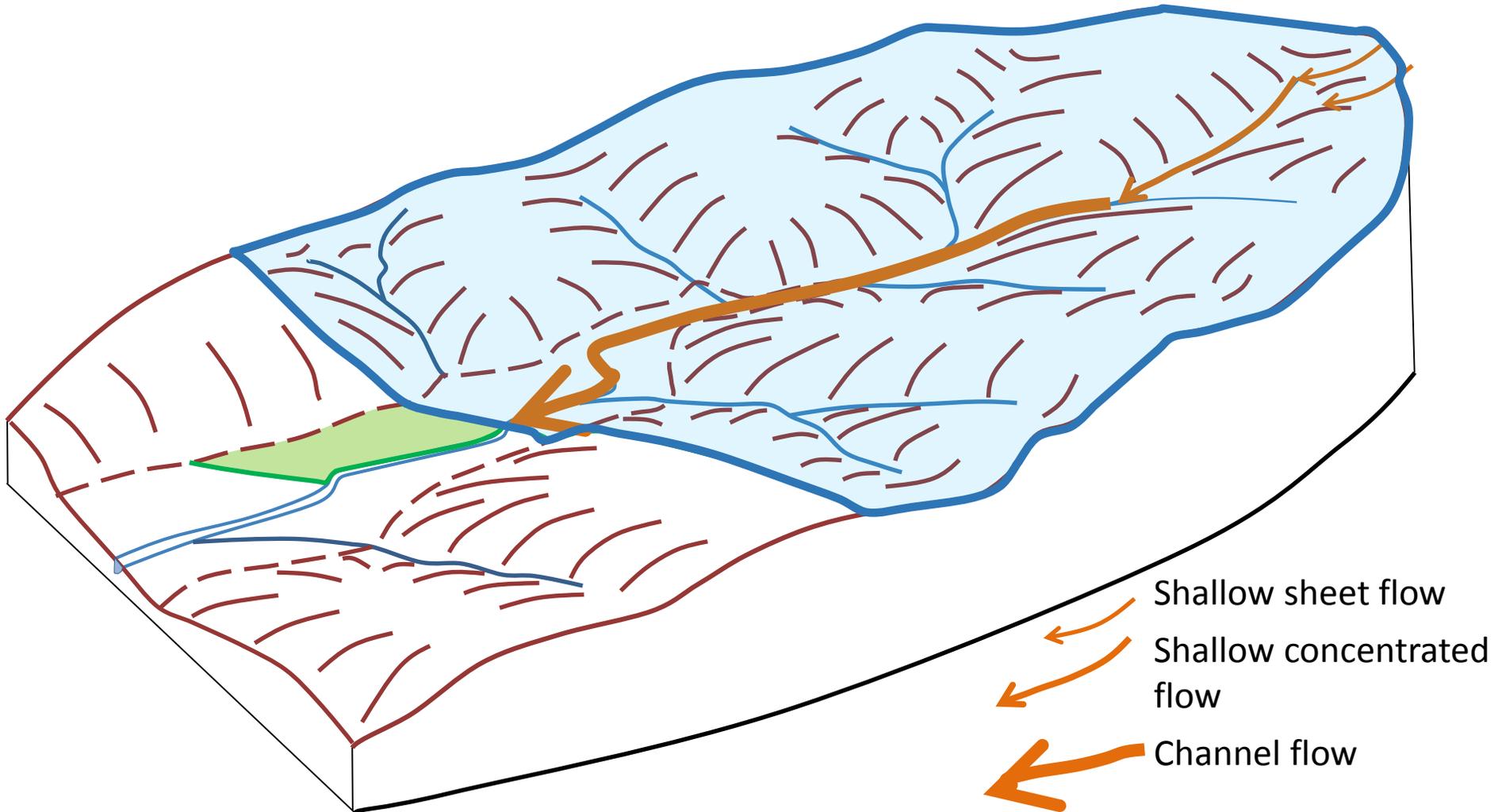
Time to peak is the sum of the travel times as sheet flow, shallow concentrated flow, and concentrated channel flow



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

Define Projects

New Project

Search Filter

Project Code
Huntley_Example
PSF_Example

General Description Weather Stations Stream UH Flow WEM Scenarios

Sheet Flow (A to B)

Manning's n 0.400 Manning's n

Flow Length (ft) 100.00

Land Slope (ft/ft) 0.0500

2-yr 24h Precip (in) 3.38 NOAA Site

Travel Time (h) 0.241

Shallow Concentrated Flow (B to C)

Surface Condition Unpaved

Flow Length (ft) 650.00

Watercourse Slope (ft/ft) 0.0150

Average Velocity (ft/s) 2.490

Travel Time (h) 0.073

Open Channel Flow (C to D)

Manning's n Manning's n 0.035

Flow Length (ft) 5150.00

Channel Bottom Width (ft) 10.00

Channel Side Slope (z:1) 1.00

Channel Depth (ft) 3.00

Channel Cross Sectional Area (ft²) 39.00

Channel Wetted Perimeter (ft) 18.49

Hydraulic Radius (ft) 2.11

Channel Slope (ft/ft) 0.0107

Average Velocity (ft/s) 7.244

Travel Time (h) 0.197

Watershed Data (for Stream)

Watershed Area (acres) 383.0

NRCS Curve Number 66

Time of Concentration (h) 0.511

Peaking Factor (100-600) 484

Time to Peak Flow (h) 0.34

625

qp for Unit Runoff (cfs) 850

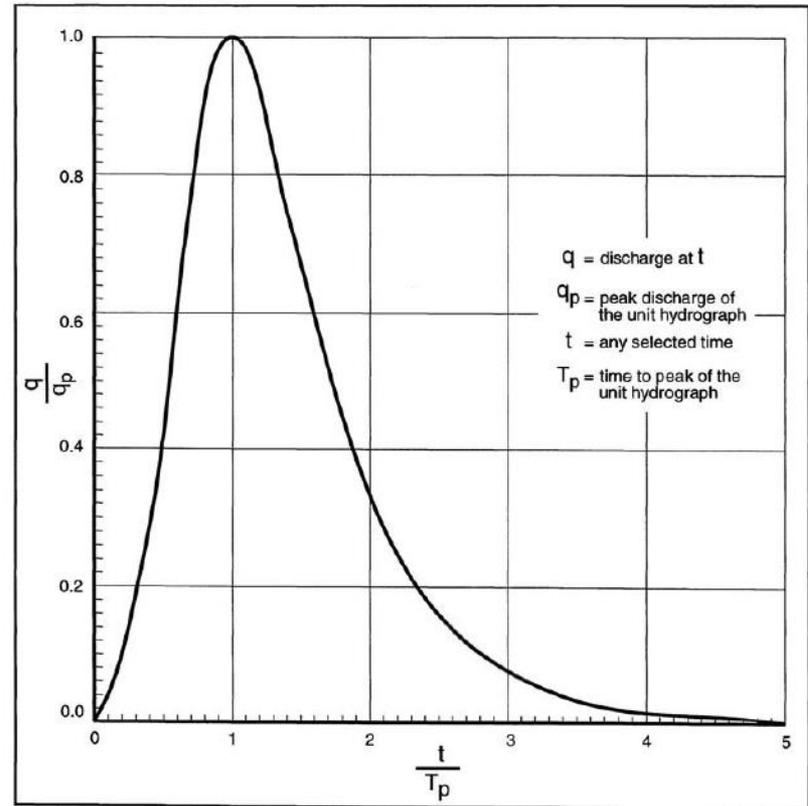
Data are used to construct the Discharge Unit Hydrograph (UH) for the watershed of the stream which is the source of overbank flow. The user can generate a discharge hydrograph for a given 24 hr precipitation depth (i.e., 3.2 inches/24 hrs.). When overbank flow is calculated, daily precipitation data will be used to calculate the stream discharge hydrograph for that precipitation depth.

Automatic Calculation

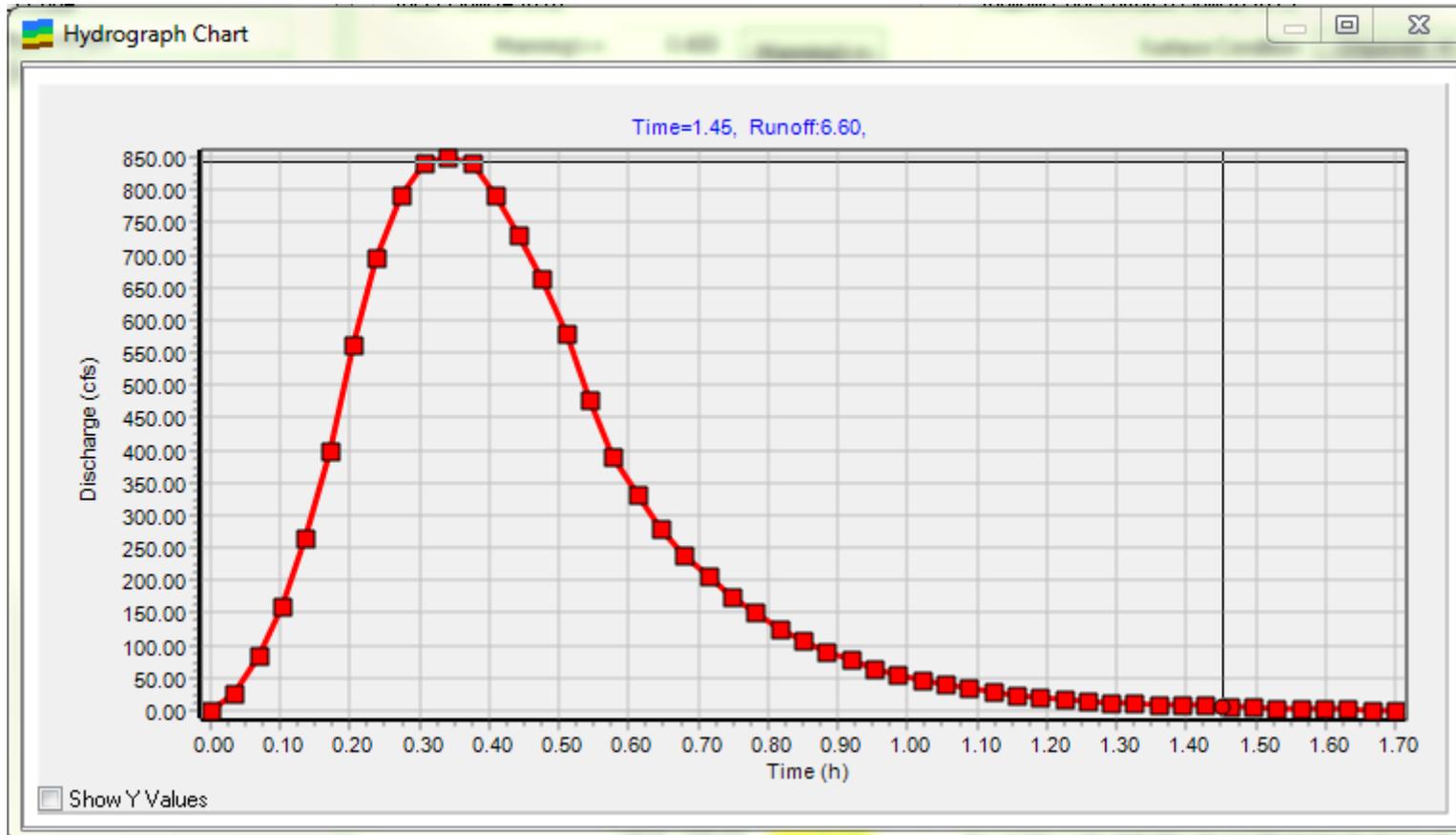
Calculate Chart Discharge Unit Hydrograph

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);

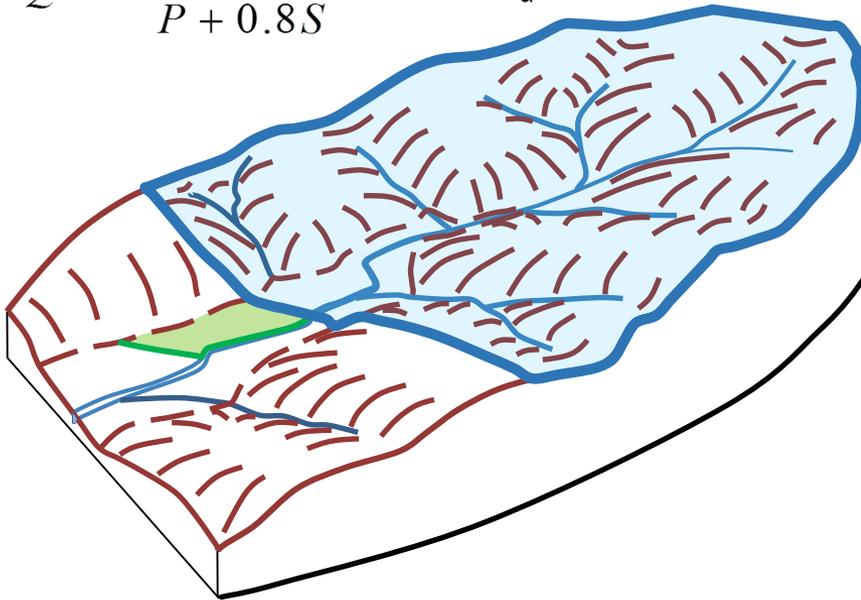
I_a = initial abstraction = interception plus infiltration during early parts of the storm plus surface depression storage = 0.2S (inches)

CN = runoff curve number

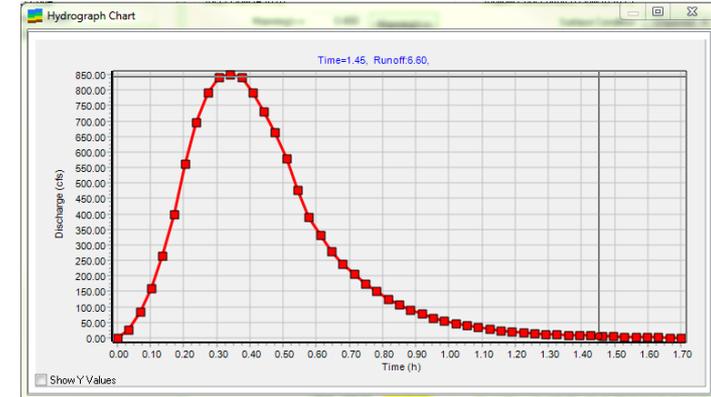
Wetbud assumes all of the “precipitation excess” enters the wetland each day – there is no flow routing or hydrograph generation for inflows from the wetland watershed.

Overbank Step 1: Calculate stream flows for each day

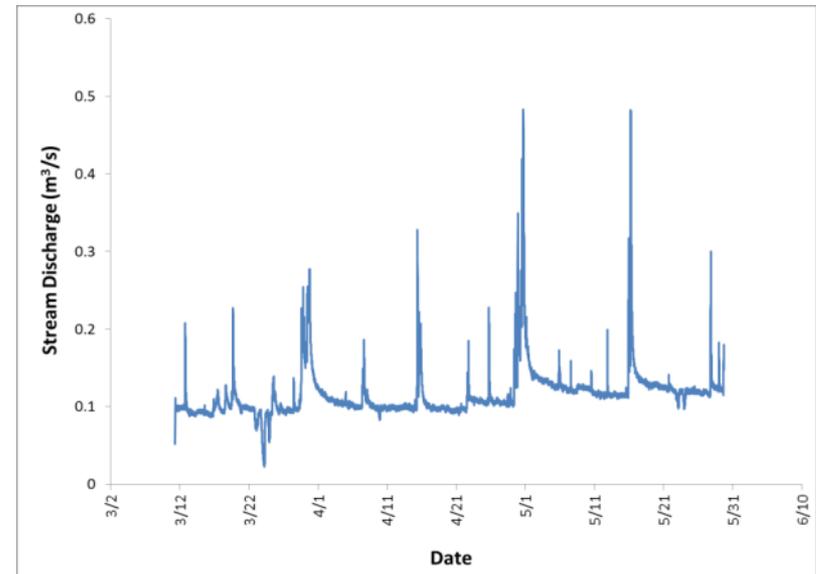
$$Q = \frac{(P - 0.2S_a)^2}{P + 0.8S} \text{ for } P > I_a$$



*



=



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

Basic Scenarios for Project: PSF_Example

New Basic Scenario

Search

Code	Description
PptROStm	Inputs from precipitz

General | Wetland Watershed | Inputs and Outputs | Management and Options

Scenario Code: PptROStm 1

Description: Inputs from precipitation, run off, and stream OB

Reference Weather Station: 724010

Active

Standard Analysis Years

Dry Year Specification: User Specified (1995), Default Year for Station, Partial Year

Normal Year Specification: User Specified (1990), Default Year for Station, Partial Year

Wet Year Specification: User Specified (1984), Default Year for Station, Partial Year

Project Units: English (in, ft, acres), Metric (m, cm)

Custom Analysis Range: Use Custom Range (yyyy-mm)

From yyyy-mm: 2011-06, To yyyy-mm: 2012-08

Project Information

Project Latitude: 37.34878

Project Longitude: -77.583553

Wetland Bottom Elevation (ft): 205.00

Comment

Overbank Step 2: Calculate water surface elevation in the stream

Basic Scenarios for Project: PSF_Example

New Basic Scenario

Search

Code	Description
PptROStm	Inputs from precipite

1 General Wetland Watershed Inputs and Outputs Management and Options

Water Inputs Water Outputs Site Parameters Stream Overbank Flow

Water Inputs

Initial Fill Depth

Dry Year 3.00 (in)

Normal Year 3.00 (in)

Wet Year 3.00 (in)

Custom Period 0.00 (in)

Precipitation

Direct Surface Runoff into Wetland

Groundwater IN Options

No Groundwater IN

Constant Rate

Calculated by Wetbud using wcm

User Time Series

Stream Overbank Flow

No Overbank Flow

Calculated by Wetbud based on NRCS DUH

User Time Series (MONTHLY Wetland Depth)

User Time Series (DAILY Stream Elevation)

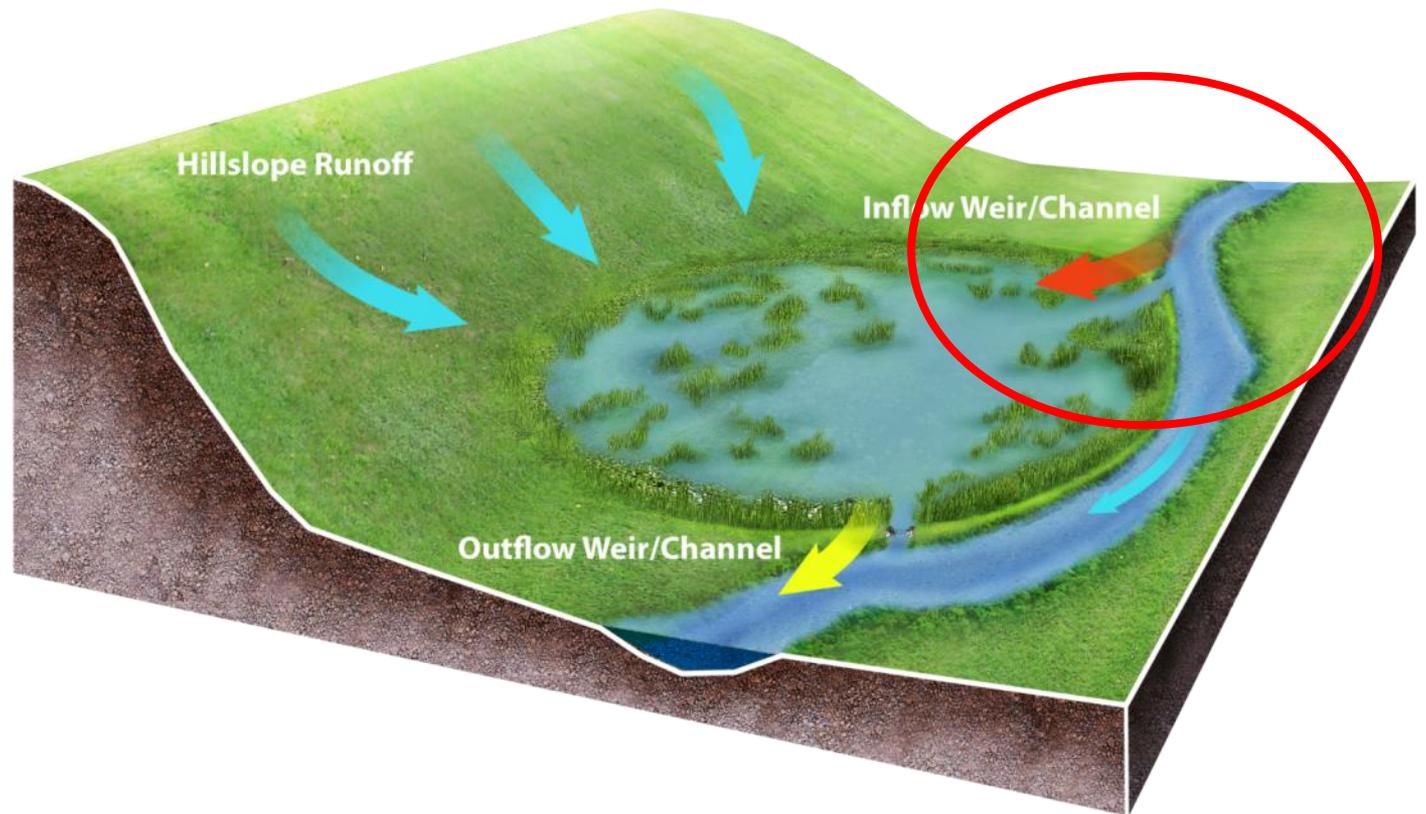
User Water IN

Select Series

Stream Overbank Data

User IN Data

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

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

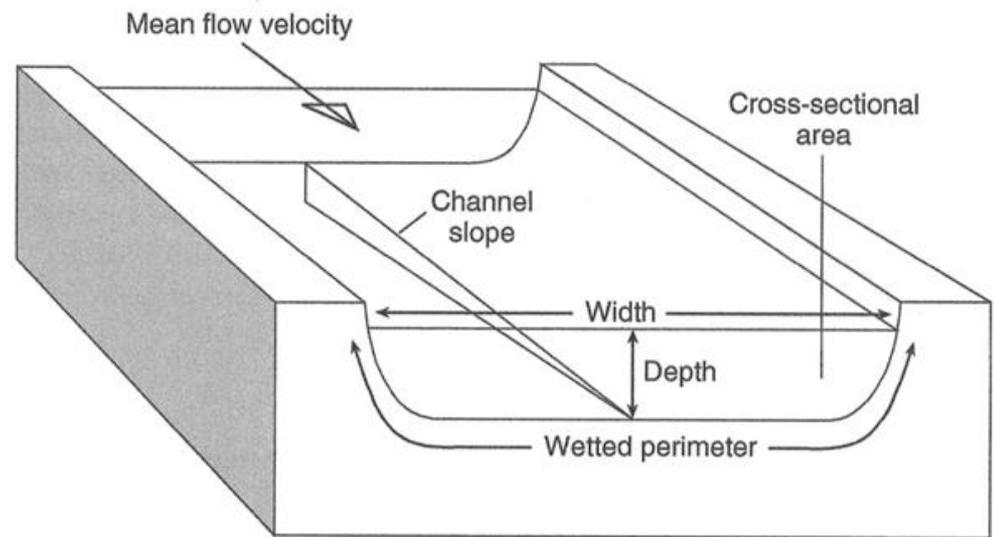
q = flow (ft/s)

n = roughness coefficient

A = cross-sectional area (ft²)

P = wetted perimeter (ft)

S = hydraulic gradient (ft/ft)



Discharge = Cross-sectional area x Mean flow velocity
Hydraulic radius = Cross-sectional area/wetted perimeter

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

Basic Scenarios for Project: PSF_Example

New Basic Scenario

Search

Code Description

PptROStm Inputs from precipite

General Wetland Watershed Inputs and Outputs Management and Options

Water Inputs Water Outputs Site Parameters Stream Overbank Flow

Stream Channel Data

Manning's n Manning's n 0.040

Channel Bottom Width (ft) 10.00

Channel Side Slope (x:1) 1.00

Channel Slope (ft/ft) 0.0050

Stream Base Flow (cfs) 5

Type of Inflow Structure

Cipoletti Weir

Trapezoidal Inflow Channel

Broad Crest Weir

Trapezoidal Inflow Channel

Manning's n Manning's n 0.050

Channel Bottom Width (ft) 10.00

Channel Side Slope (x:1) 2.00

Channel Slope 0.0010

Elevations Related to the Inflow Structure

Elevation of Stream Bed at Inflow Structure (ft) 205.00

Elevation of Inflow Invert (ft) 208.00

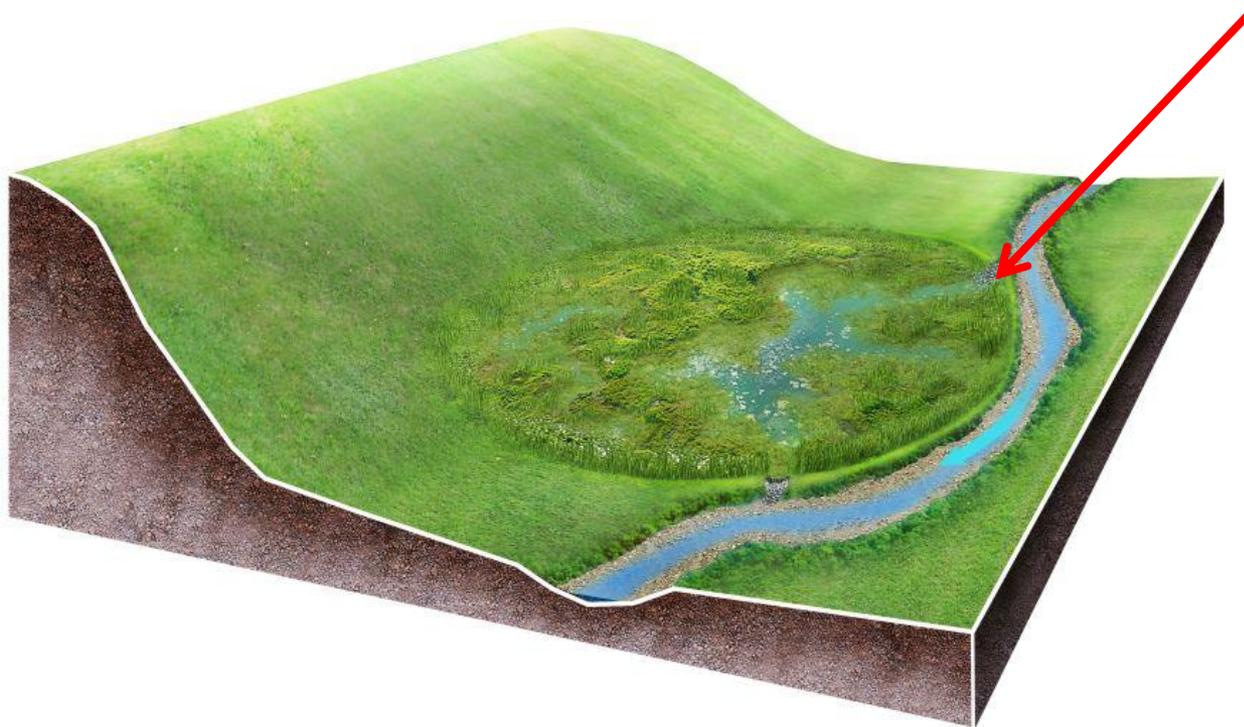
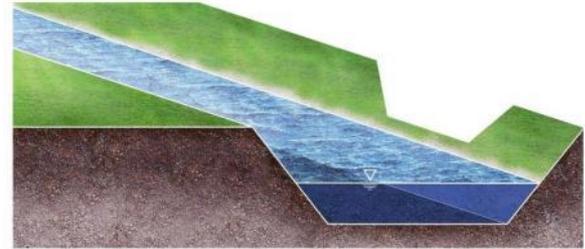
Elevation (Top) of Wetland Berm (ft) 208.00

Wetland Bottom Elevation (ft) 205.00

Chart Stream Hydrograph for Unit Runoff

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



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

Basic Scenarios for Project: PSF_Example

New Basic Scenario

Search

Code Description

PptROStm	Inputs from precipit
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General Wetland Watershed Inputs and Outputs Management and Options

Water Inputs Water Outputs Site Parameters Stream Overbank Flow

Stream Channel Data

Manning's n Manning's n 0.040

Channel Bottom Width (ft) 10.00

Channel Side Slope (x:1) 1.00

Channel Slope (ft/ft) 0.0050

Stream Base Flow (cfs) 5

Chart Stream Hydrograph for Unit Runoff

Type of Inflow Structure

Cipolletti Weir

Trapezoidal Inflow Channel

Broad Crest Weir

Trapezoidal Inflow Channel

Manning's n Manning's n 0.050

Channel Bottom Width (ft) 10.00

Channel Side Slope (x:1) 2.00

Channel Slope 0.0010

Elevations Related to the Inflow Structure

Elevation of Stream Bed at Inflow Structure (ft) 205.00

Elevation of Inflow Invert (ft) 208.00

Elevation (Top) of Wetland Berm (ft) 208.00

Wetland Bottom Elevation (ft) 205.00

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

The screenshot shows the 'Basic Scenarios' software interface. The 'Stream Channel Data' section includes the following parameters:

Parameter	Value
Manning's n	0.039
Channel Bottom Width (ft)	5.00
Channel Side Slope (x:1)	1.00
Channel Slope (ft/ft)	0.0050
Stream Base Flow (cfs)	0

The 'Type of Inflow Structure' section has 'Cipoletti Weir' selected. The 'Cipoletti Weir' section includes:

Parameter	Value
Weir Length (ft)	10.00

The 'Elevations Related to the Inflow Structure' section includes:

Parameter	Value
Elevation of Stream Bed at Inflow Structure (ft)	203.00
Elevation of Inflow Invert (ft)	205.00
Elevation (Top) of Wetland Berm (ft)	206.00
Wetland Bottom Elevation (ft)	205.00

Red arrows point from the text on the left to the 'Manning's n' field (a), the 'Elevation of Stream Bed at Inflow Structure' field (b), and the 'Elevation of Inflow Invert' field (c).

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

The screenshot shows the 'Basic Scenarios' software interface. The 'Stream Overbank Flow' tab is active, displaying various parameters for stream channel data and inflow structure. A red circle highlights the 'Type of Inflow Structure' section, where 'Cipoletti Weir' is selected. A red box highlights the 'Elevation (Top) of Wetland Berm (ft)' field, which is set to 206.00.

Code	Description
PptRO	PptRO
PptROStWem	Precip Runoff Strea
PptROStm	Ppt RO and Stream

Stream Channel Data

- Manning's n: 0.039
- Channel Bottom Width (ft): 5.00
- Channel Side Slope (x:1): 1.00
- Channel Slope (ft/ft): 0.0050
- Stream Base Flow (cfs): 0

Type of Inflow Structure

- Cipoletti Weir
- Trapezoidal Inflow Channel
- Broad Crest Weir

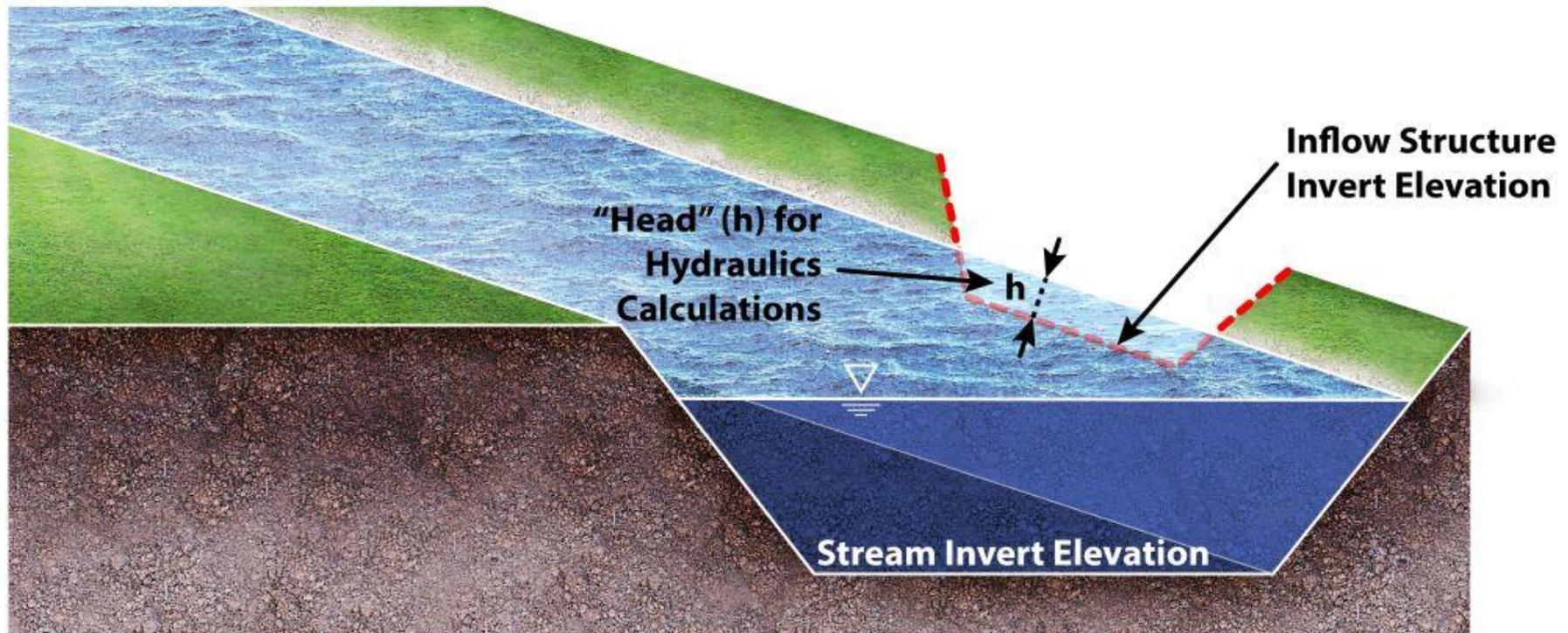
Cipoletti Weir

- Weir Length (ft): 10.00

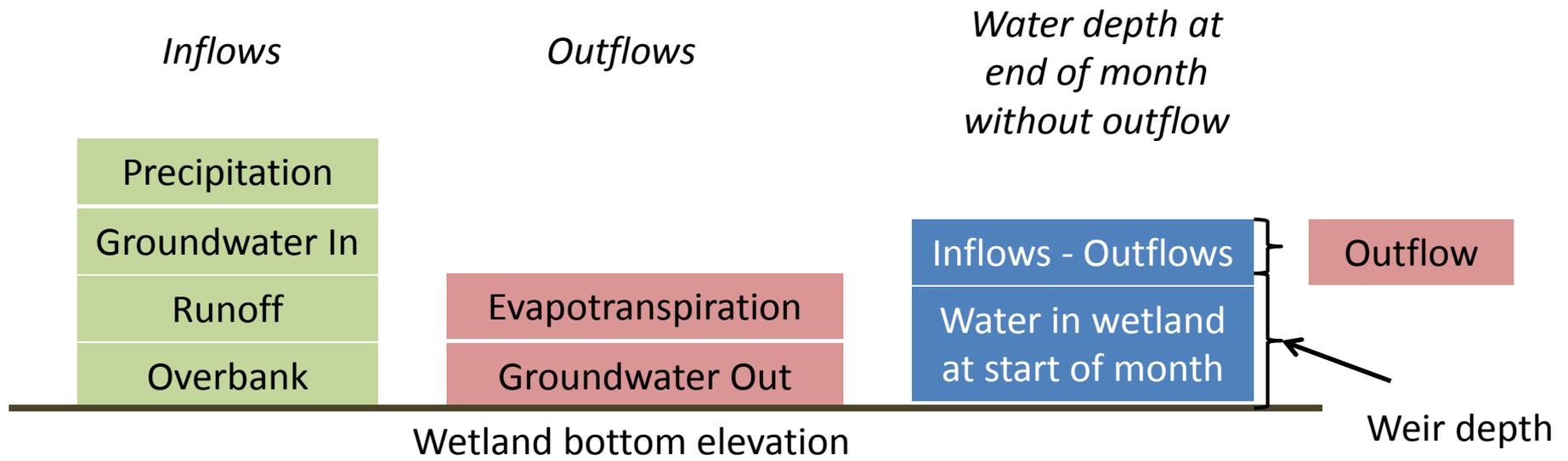
Elevations Related to the Inflow Structure

- Elevation of Stream Bed at Inflow Structure (ft): 203.00
- Elevation of Inflow Invert (ft): 205.00
- Elevation (Top) of Wetland Berm (ft): 206.00**
- Wetland Bottom Elevation (ft): 205.00

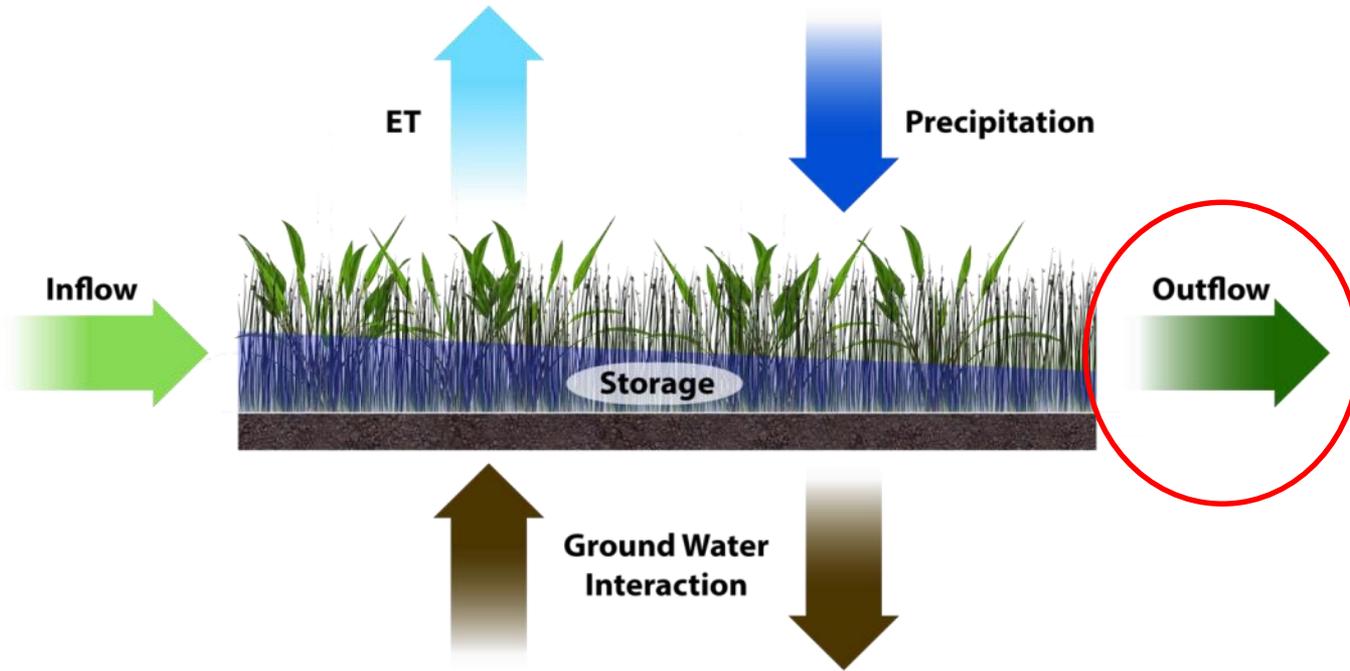
The depth of water above the inflow structure (hydraulic head, h) determines the inflow rate to calculate monthly overbank volume.

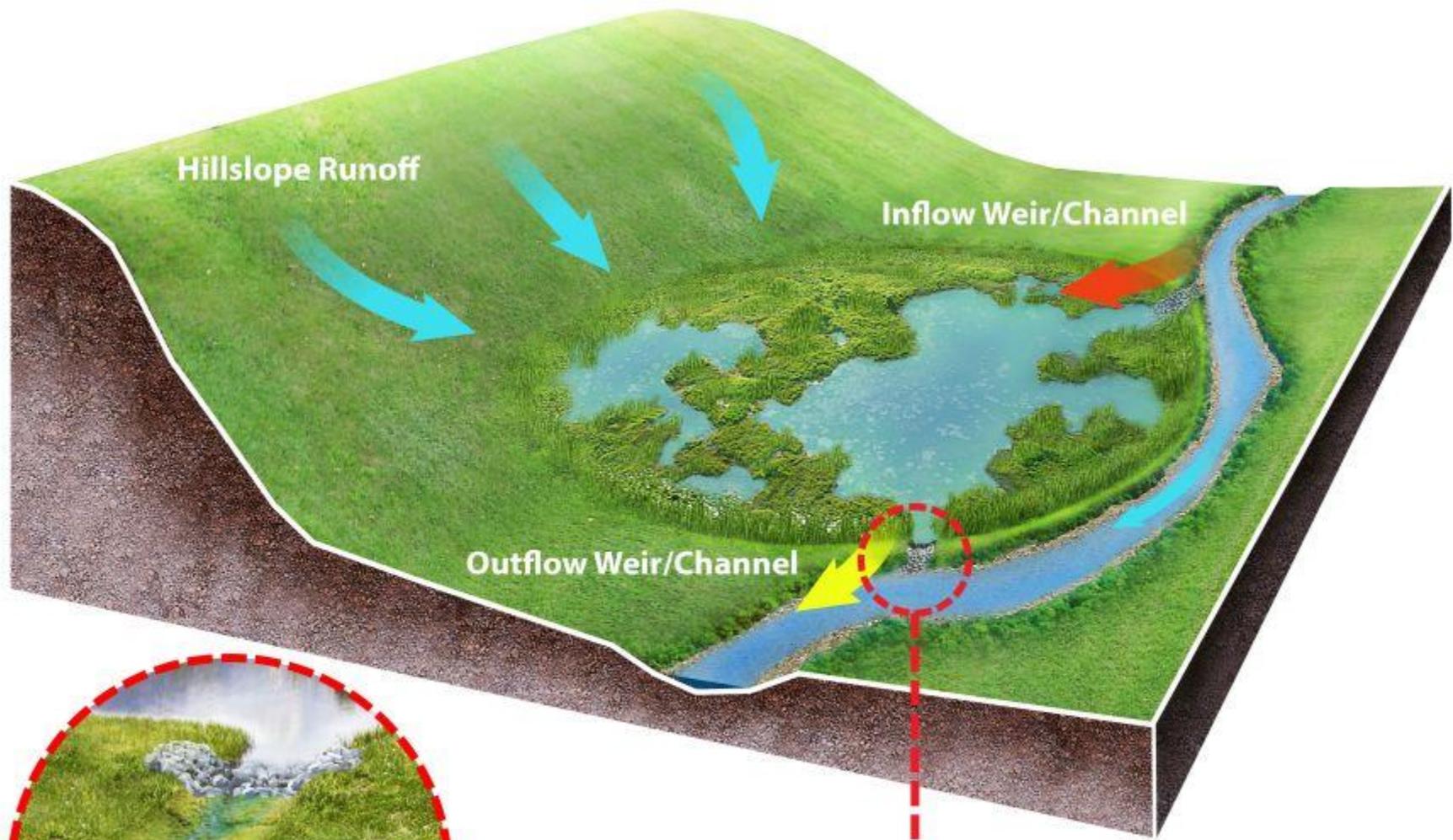


In the Basic Model, water greater than the “weir depth” is lost from the wetland as outflow each month.



Outflow assumed to occur through a weir





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

The screenshot shows the 'Basic Scenarios' software interface. The window title is 'Basic Scenarios'. At the top, there are buttons for 'New Basic Scenario', navigation controls (back, forward, home, search, check, close), 'Export', and 'Exit'. Below the title bar, there are tabs for 'General', 'Wetland Watershed', 'Inputs and Outputs', and 'Management and Options'. The 'Inputs and Outputs' tab is active, and within it, the 'Site Parameters' sub-tab is selected. On the left side, there is a search bar and a table with the following content:

Code	Description
Scenario1	Scenario1

The 'Site Parameters' section contains two main areas: 'Storage Factors' and 'Outlet Weir'. Under 'Storage Factors', there are two input fields: 'Soil Storage Factor (0-1)' with a value of 0.250, and 'Surface Storage Factor (0-1)' with a value of 1.000. Under 'Outlet Weir', there are two radio buttons: 'Constant Depth' (which is selected) and 'User Time Series'. To the right of these radio buttons is a 'Weir Depth' section with an input field labeled 'Weir Depth (in)' containing the value 3.00.



Questions?