Regulatory Review Webinar Series

Lesson 2
Hydraulics, Part 1

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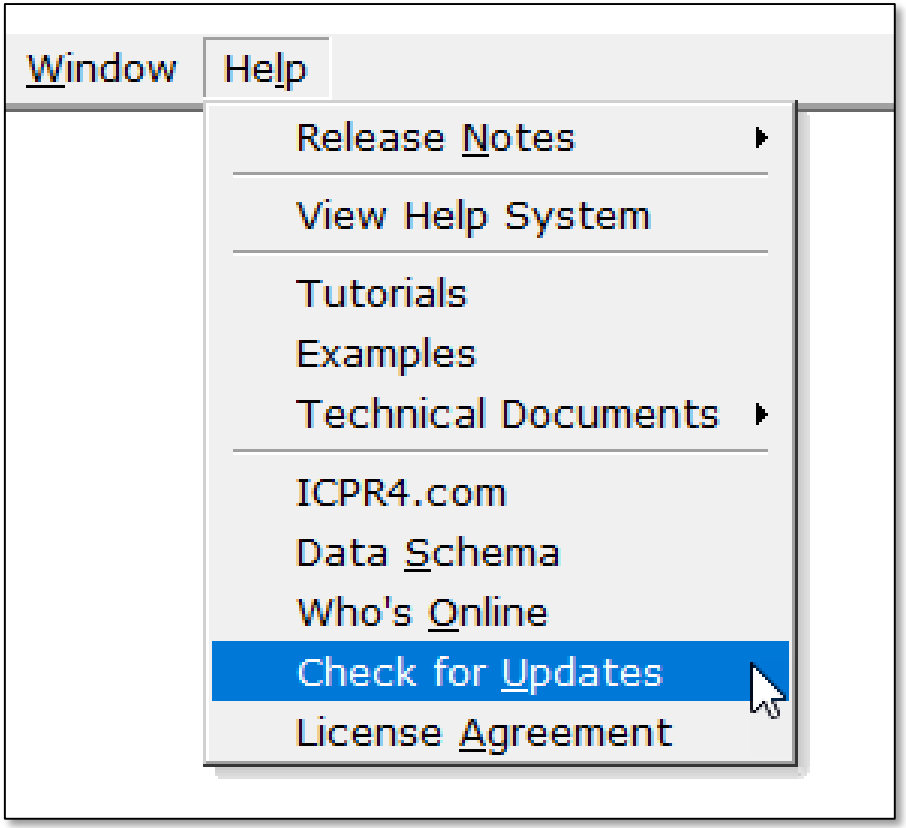
Streamline Technologies, Inc.

Wednesday – October 23, 2019

Next Webinar – Lesson 3: Hydraulics, Part 2

Tuesday October 29, 2019
11:30 – 1:30 (EDT)



We will try to post a recording of this webinar and/or the presentation material as soon as we can.

To find them:
"Check for Updates"
sometime tomorrow.

support@icpr4.com

Objectives of the Regulatory Review Webinar Series

- Learn details of ICPR4 computational methods
- Learn about input data requirements
- Learn about ICPR4's reporting system

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What's not included:

- 2D overland flow
- 2D groundwater
- Details of the graphical user interface
- Importing/drawing background images, map layers and surfaces

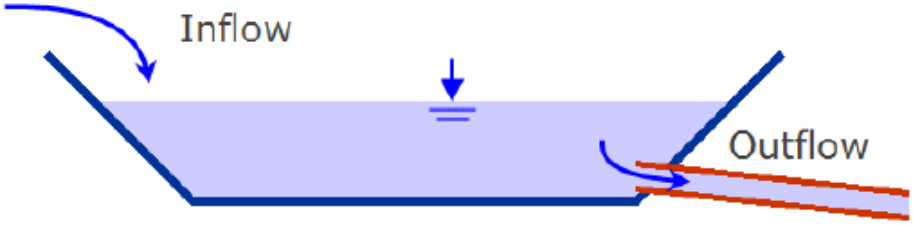
Lesson 2 Topics

- Nodes
  - Mass Balance Equation
  - Node Types
- Links
  - General
  - Pipes
  - Channels
- Examples
  - Highway Cross Drain & Channel
  - Integrated Storm Sewer Hydraulics and Pond Routing for a Commercial Site

Nodes

Mass Balance Equation

$$dz = dt\,(Q_{in} - Q_{out}) / A_{surface}$$



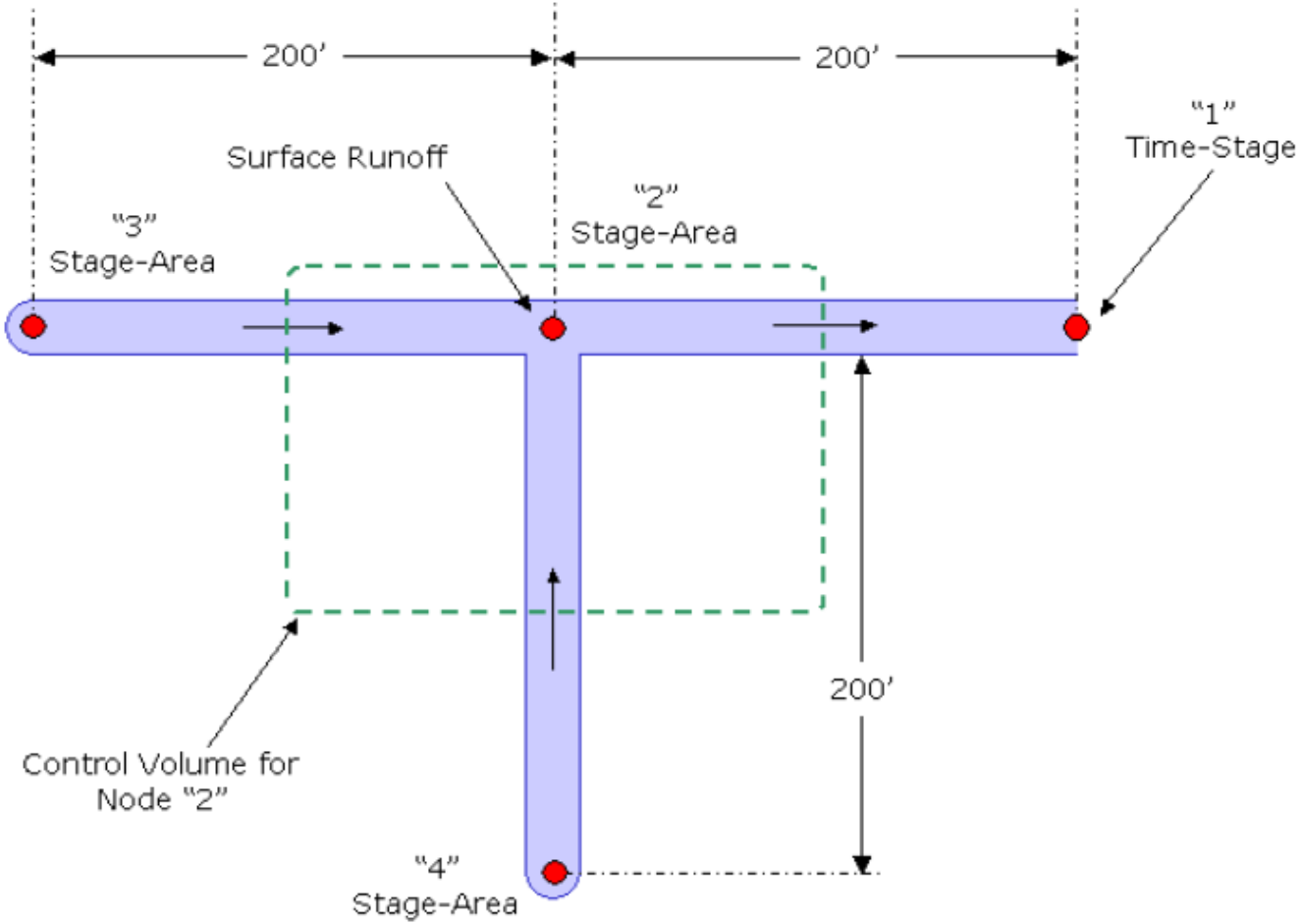
where,

dz	change in stage
dt	change in time, or simply, the time increment
Q_{in}	combined or total inflow rate
Q_{out}	combined or total outflow rate
$A_{surface}$	surface area associated with the node

$$Z^1 = Z^o + dz$$

Nodes

Mass Balance Equation



Nodes

Mass Balance Equation

$$dz = dt\,(Q_{in} - Q_{out}) / A_{surface}$$

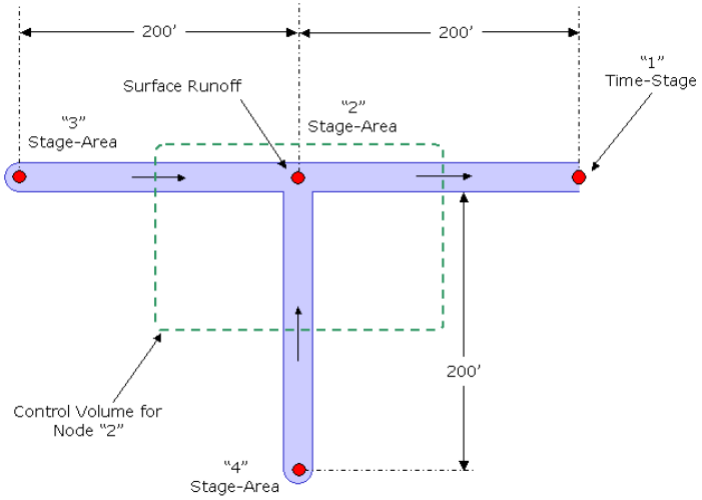
$$= dt\,(Q_{runoff} + Q_{3\text{-}2} + Q_{4\text{-}2} - Q_{2\text{-}1}) / A_{surface}$$

$$A_{3\text{-}2} = 0.5 \times (T^{ds}_{3\text{-}2} + T^{mid}_{3\text{-}2}) \times (200' / 2)$$

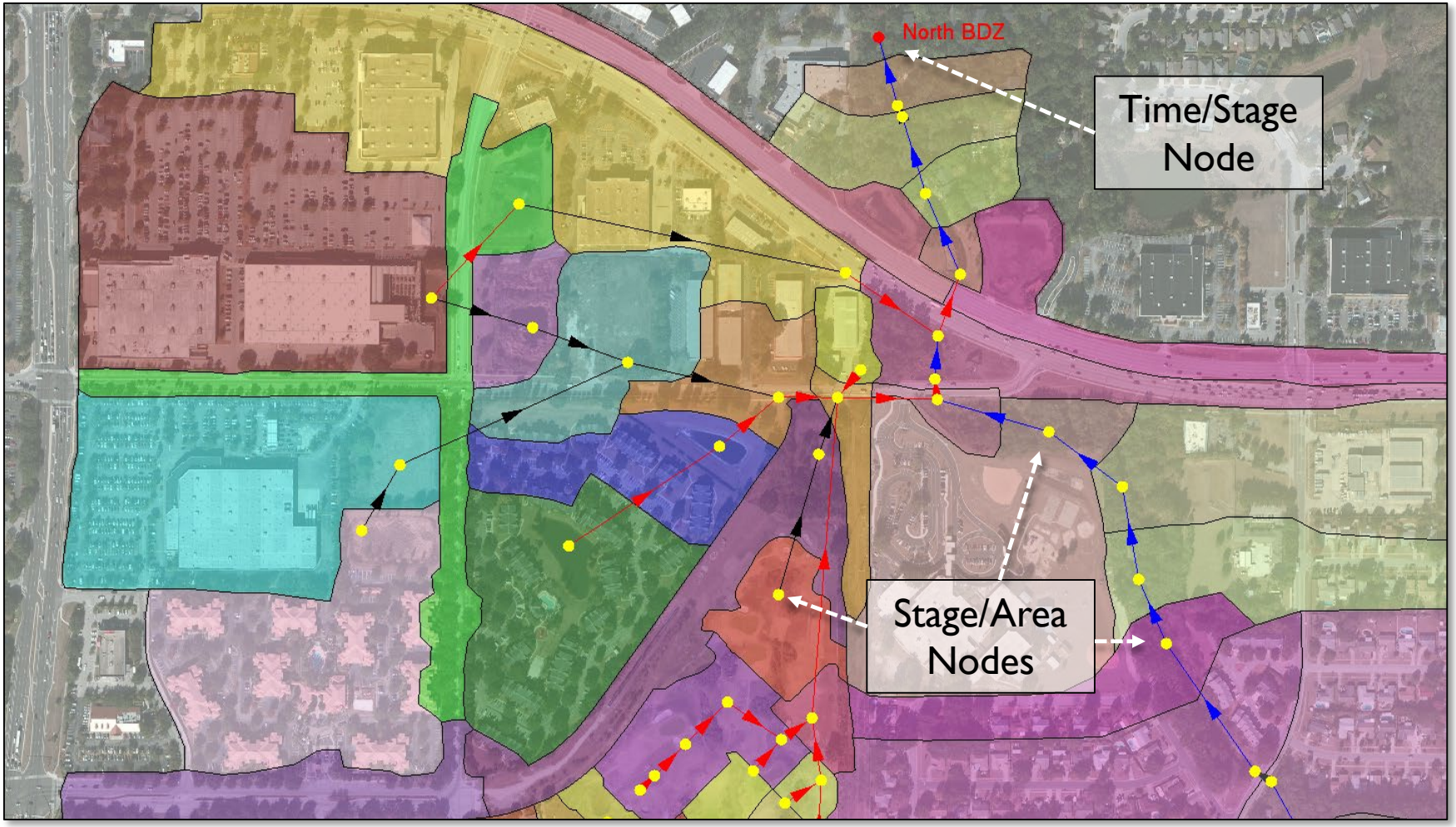
$$A_{4\text{-}2} = 0.5 \times (T^{ds}_{4\text{-}2} + T^{mid}_{4\text{-}2}) \times (200' / 2)$$

$$A_{2\text{-}1} = 0.5 \times (T^{us}_{2\text{-}1} + T^{mid}_{2\text{-}1}) \times (200' / 2)$$

$$A_{surface} = A_{3\text{-}2} + A_{4\text{-}2} + A_{2\text{-}1}$$



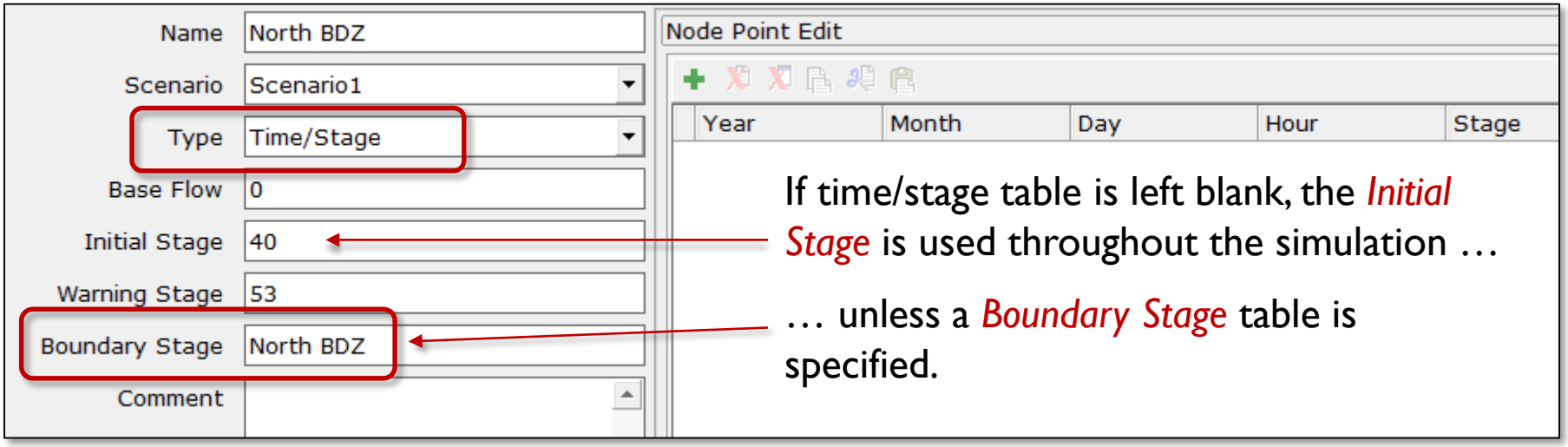
Nodes



Nodes

Time/Stage Nodes

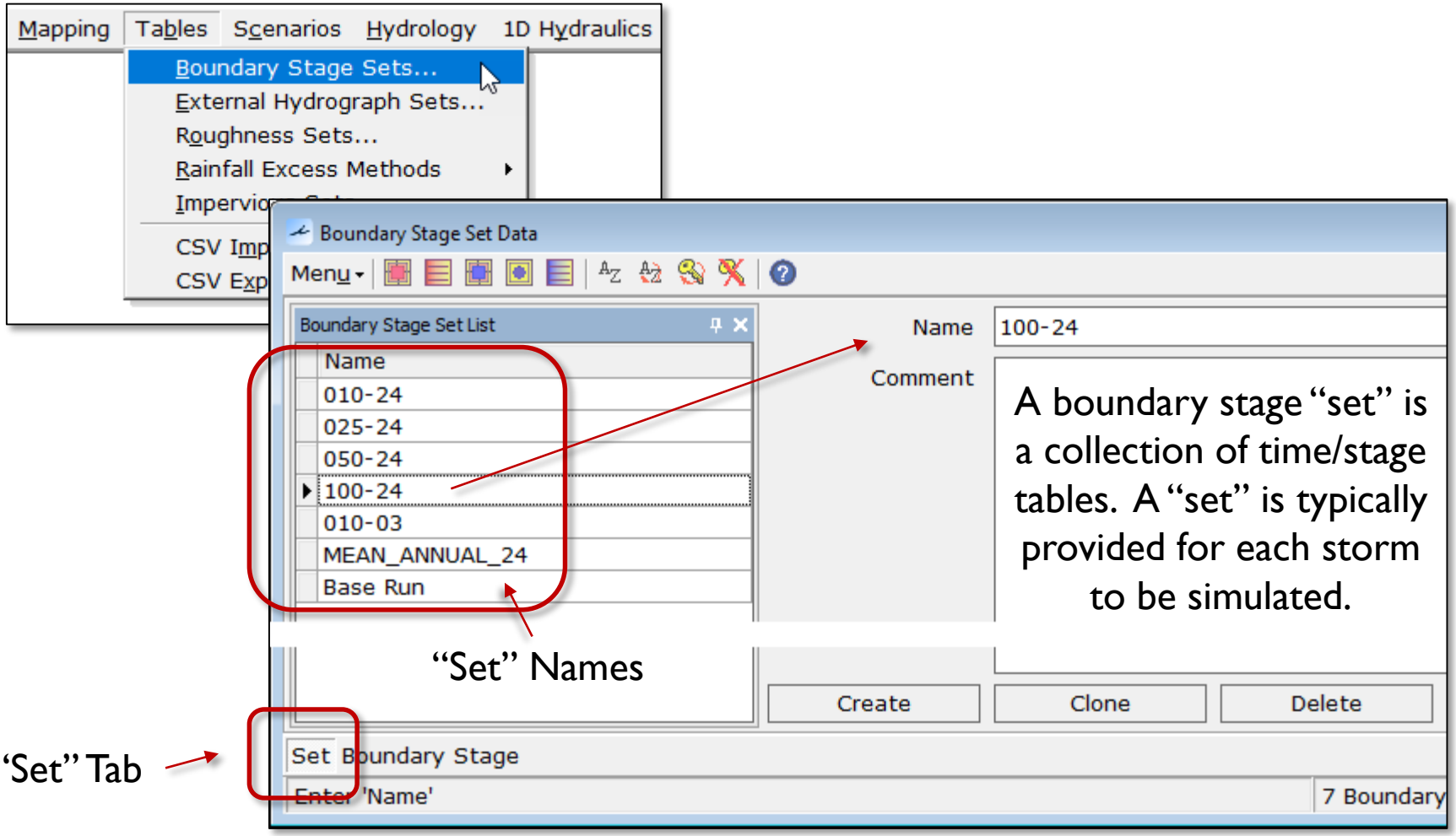
Time/Stage nodes serve as outlets for the surface water system. Instead of calculating stage from the mass balance equation, stage is forced from a time versus stage table.



Node Data Form

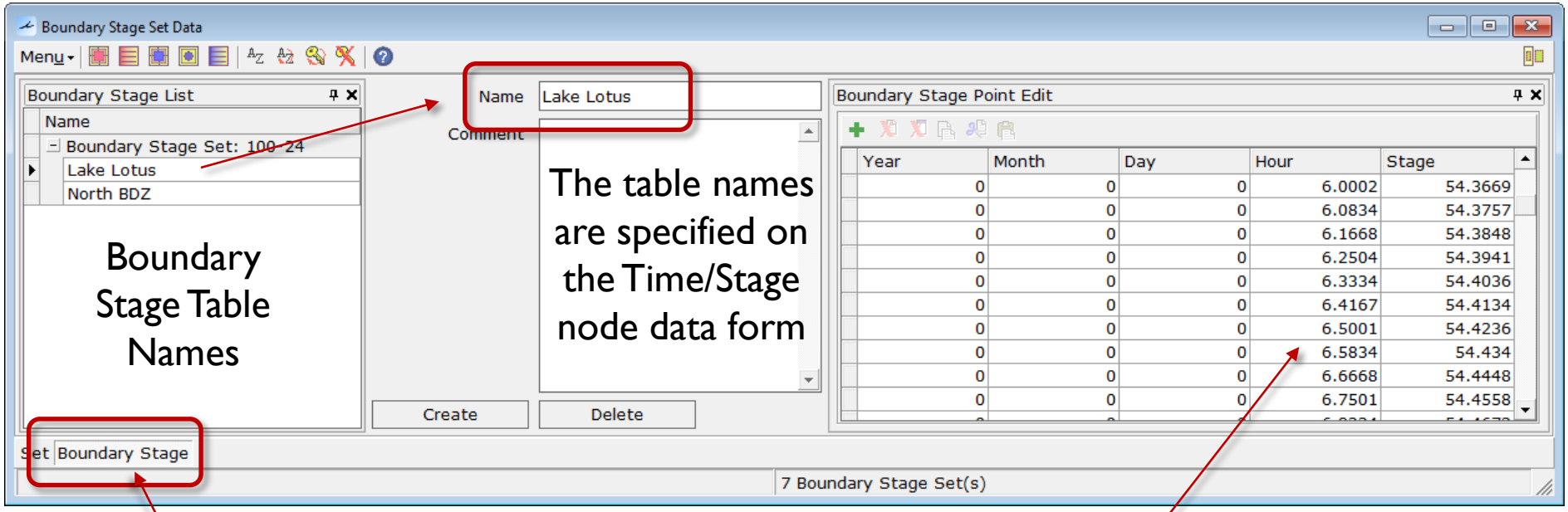
Nodes

Boundary Stage Tables



Nodes

Boundary Stage Tables

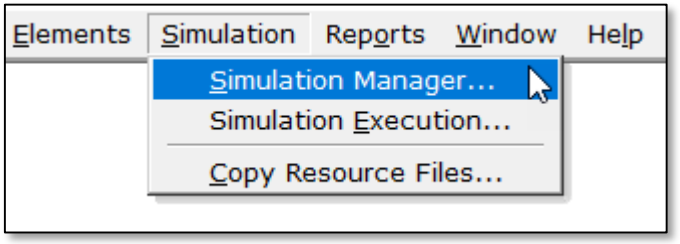


"Boundary Stage" Tab

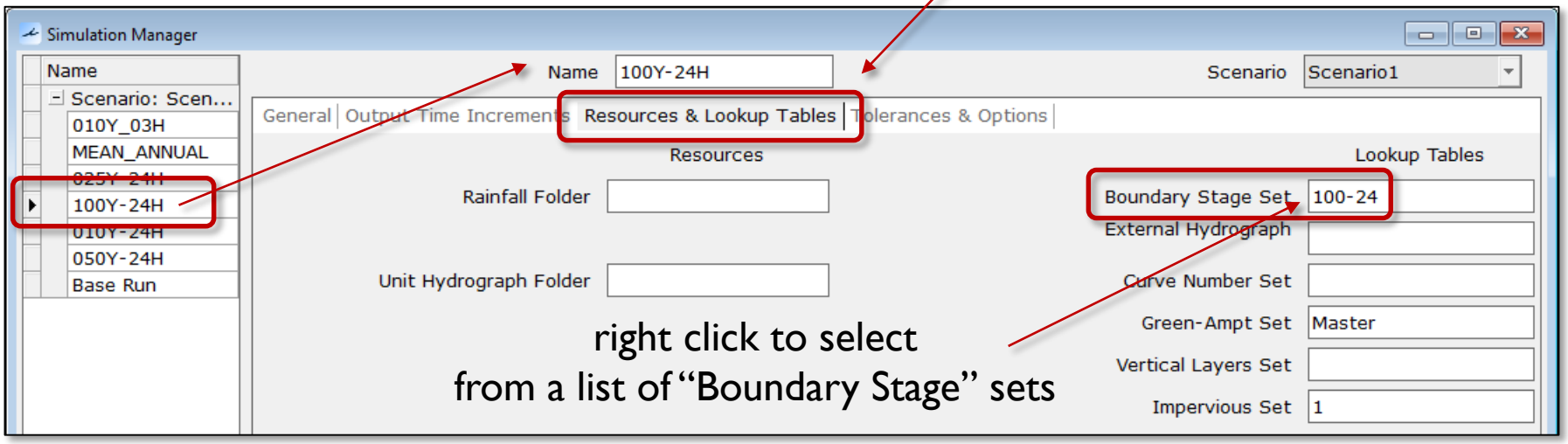
Time/Stage data obtained from a larger watershed model

Nodes

Boundary Stage Tables



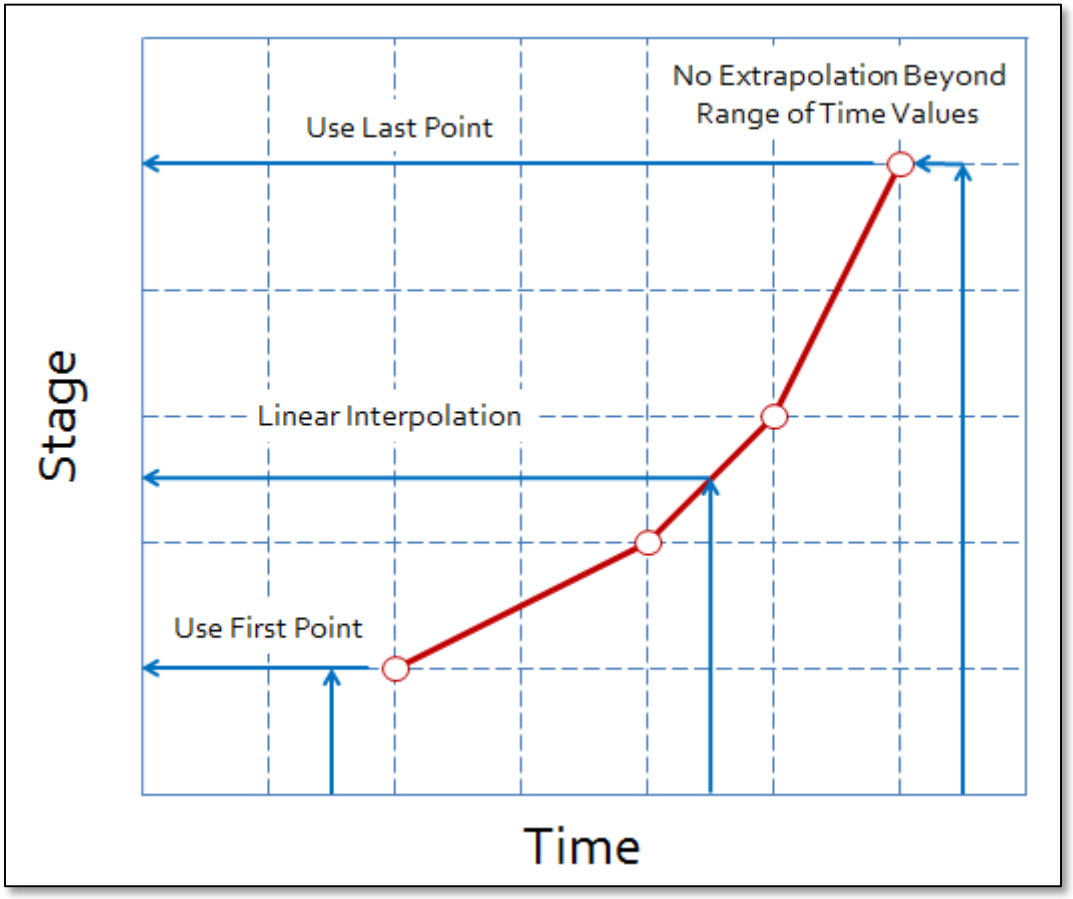
Simulation Manager
"Resources & Lookup Tables" Tab



right click to select
from a list of "Boundary Stage" sets

Nodes

Time/Stage Table Interpolation



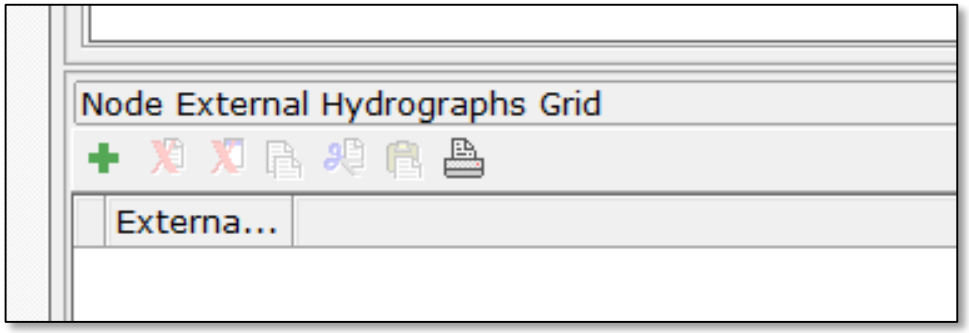
Nodes

Time/Stage Precedence

- The initial stage on the node data form is used for the entire simulation if a time/stage table is not provided.
- If a time/stage table is provided on the node data form, it overrides the initial stage.
- If a boundary stage table is specified for the node, it overrides the initial stage and the stage/area table on the node data form.

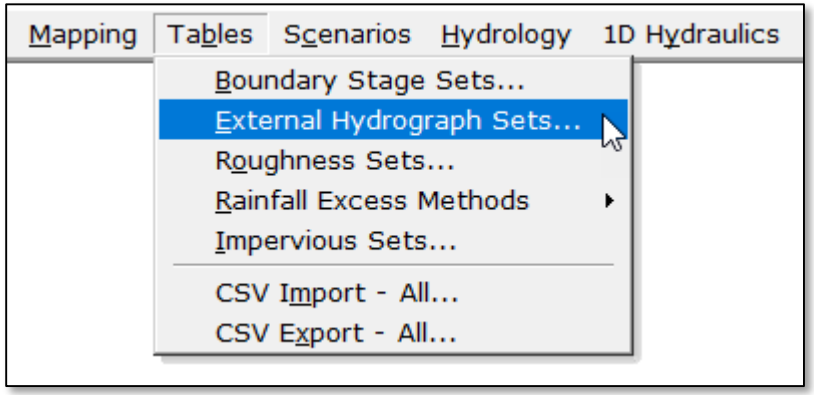
Nodes

External Hydrographs



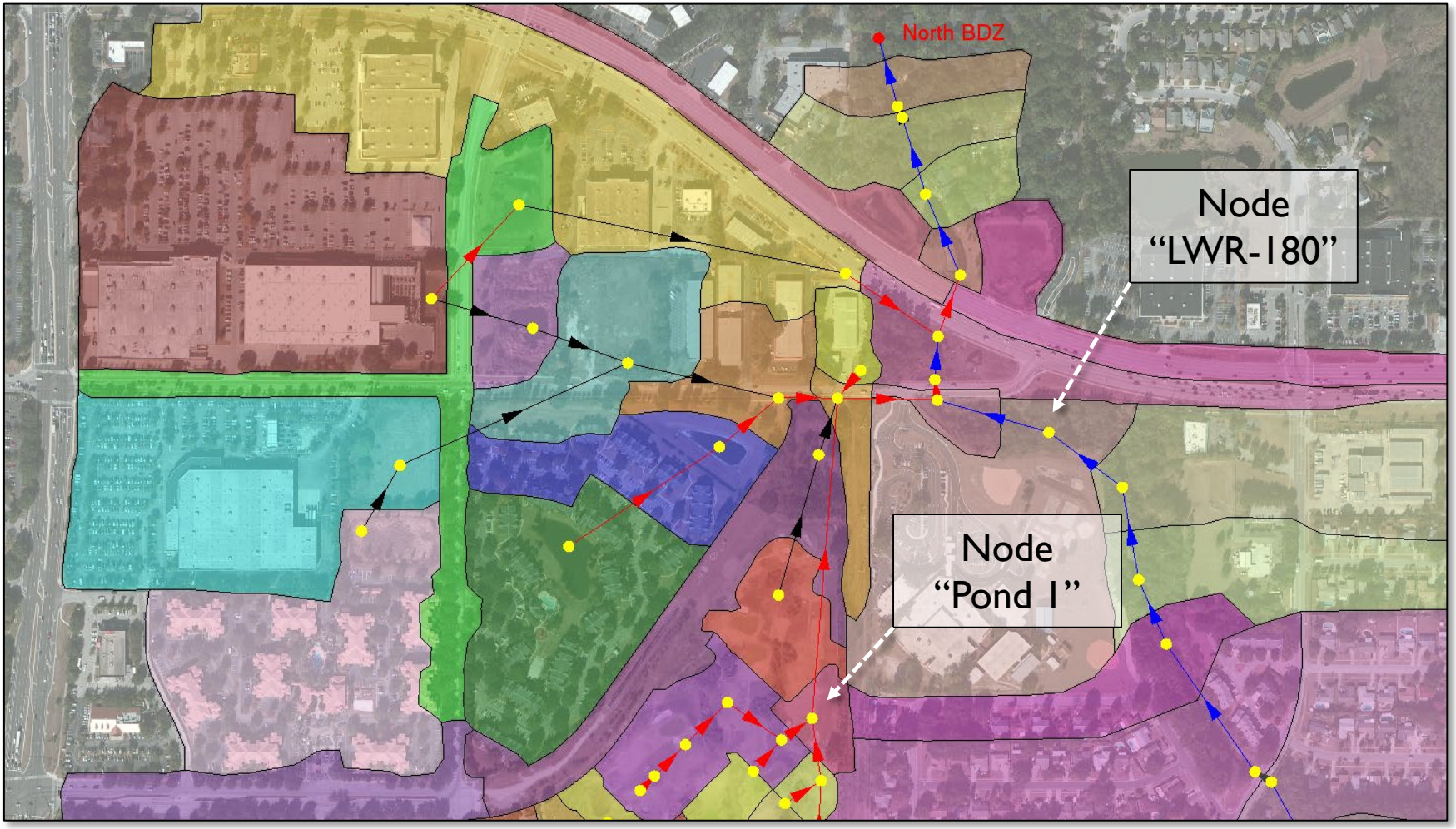
Node Data Form

- "External Hydrographs" are similar to "Boundary Stage" tables, except instead of forcing stages, flows are added to the node.
- They can be assigned to any node type.
- External hydrographs are optional.
- There is no limit as to the number of external hydrographs that can be assigned to a given node.



Nodes

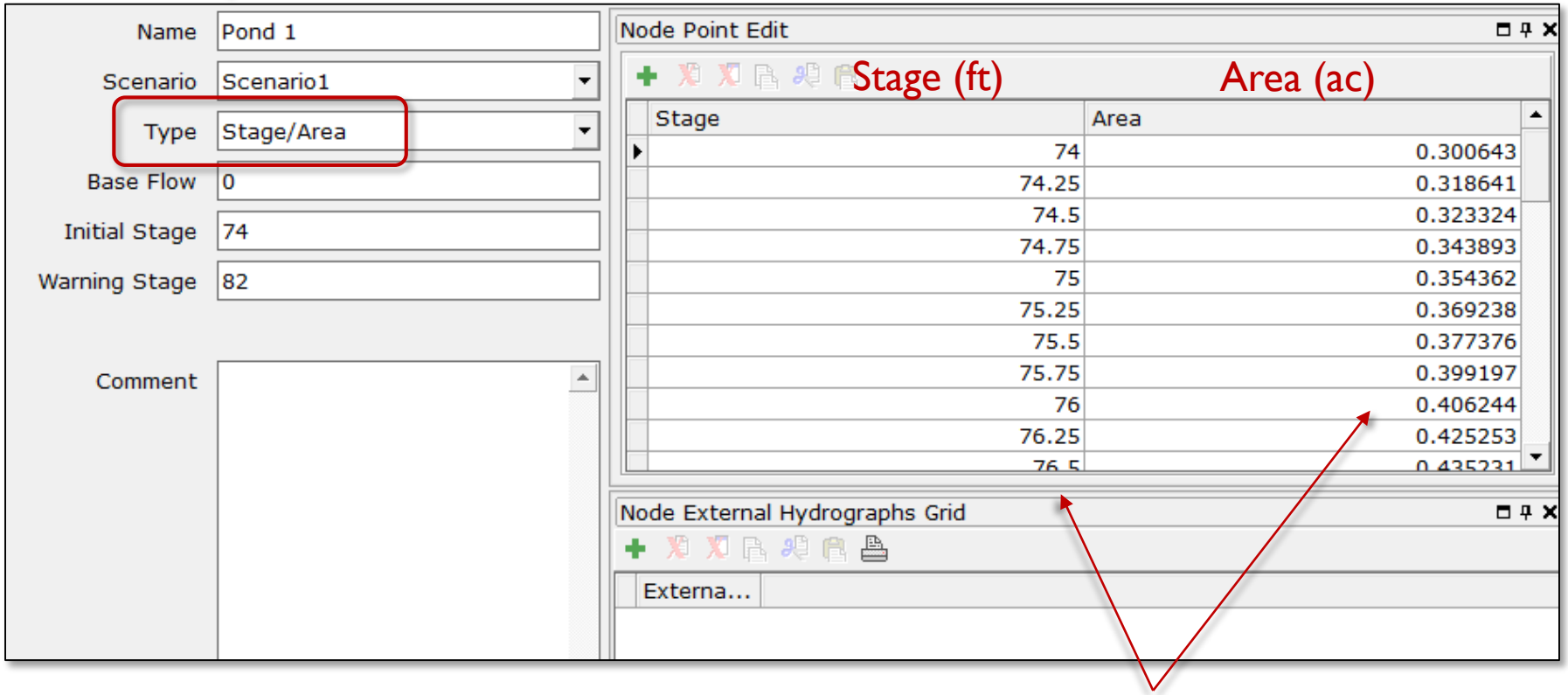
Stage/Area Nodes



Nodes

Stage/Area Nodes

Node "Pond 1"



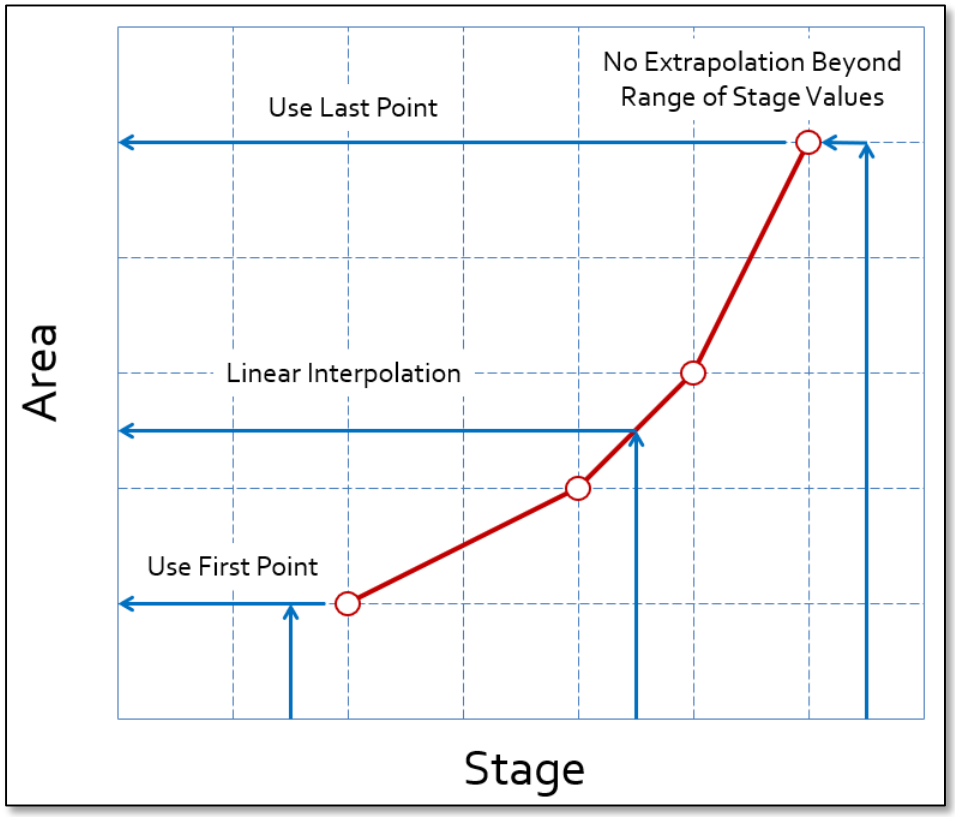
Stage versus area table usually provided for nodes that represent ponds, lakes and depressions

Nodes

Stage/Area Table Interpolation

If a channel link and/or a pipe link is attached to a node and the water level drops below the first data point in the stage/area table, the surface area for the node is derived completely from the links.

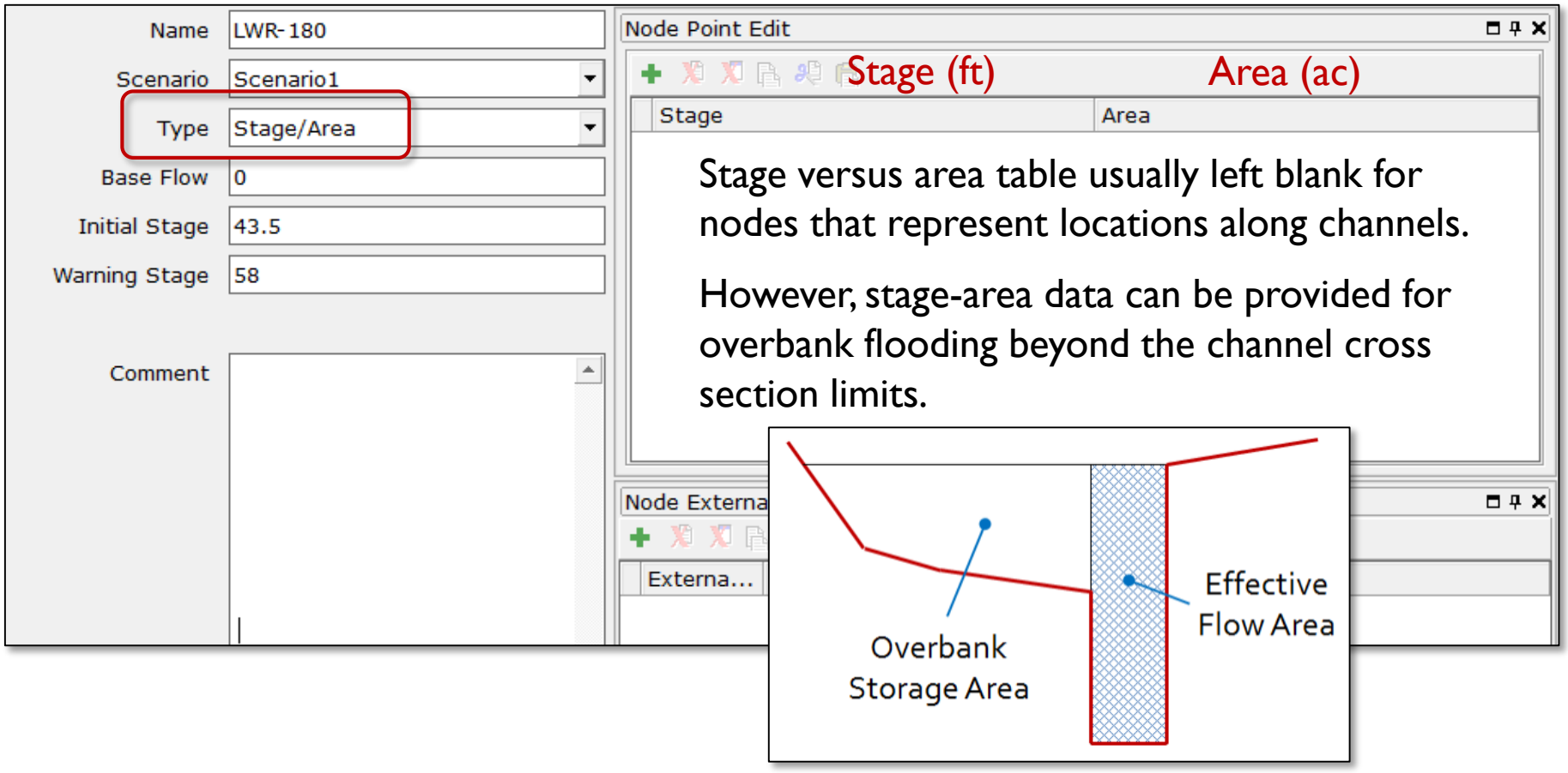
Otherwise, ICPR uses the area specified for the first data point.



Nodes

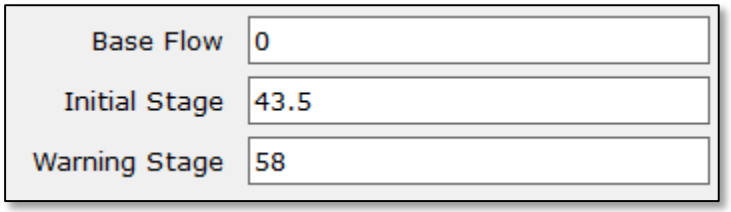
Stage/Area Nodes

Node "LWR-180"



Nodes

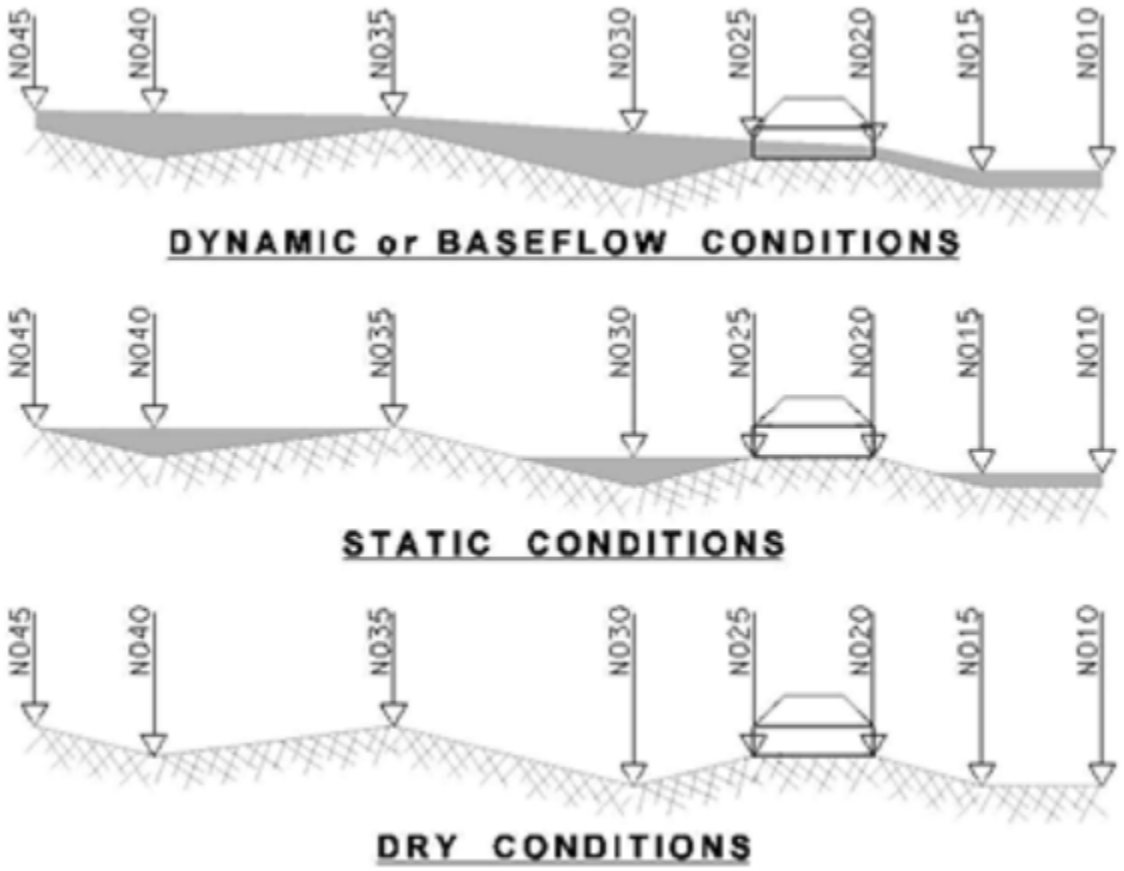
Base Flow, Initial Stage, Warning Stage



- Base Flow – a constant (steady-state) flow rate. Positive value for inflow, negative value for outflow.
- Initial Stage – water surface elevations used at the start of a simulation. Initial link flows are calculated based on initial stages. Time-stage tables override the initial stage.
- Warning Stage – an optional parameter used to identify potential problems such as street flooding or out-of-bank flooding. Warning stages are not used for hydraulic computations but do appear in various reports and charts.

Nodes

Initial Stage



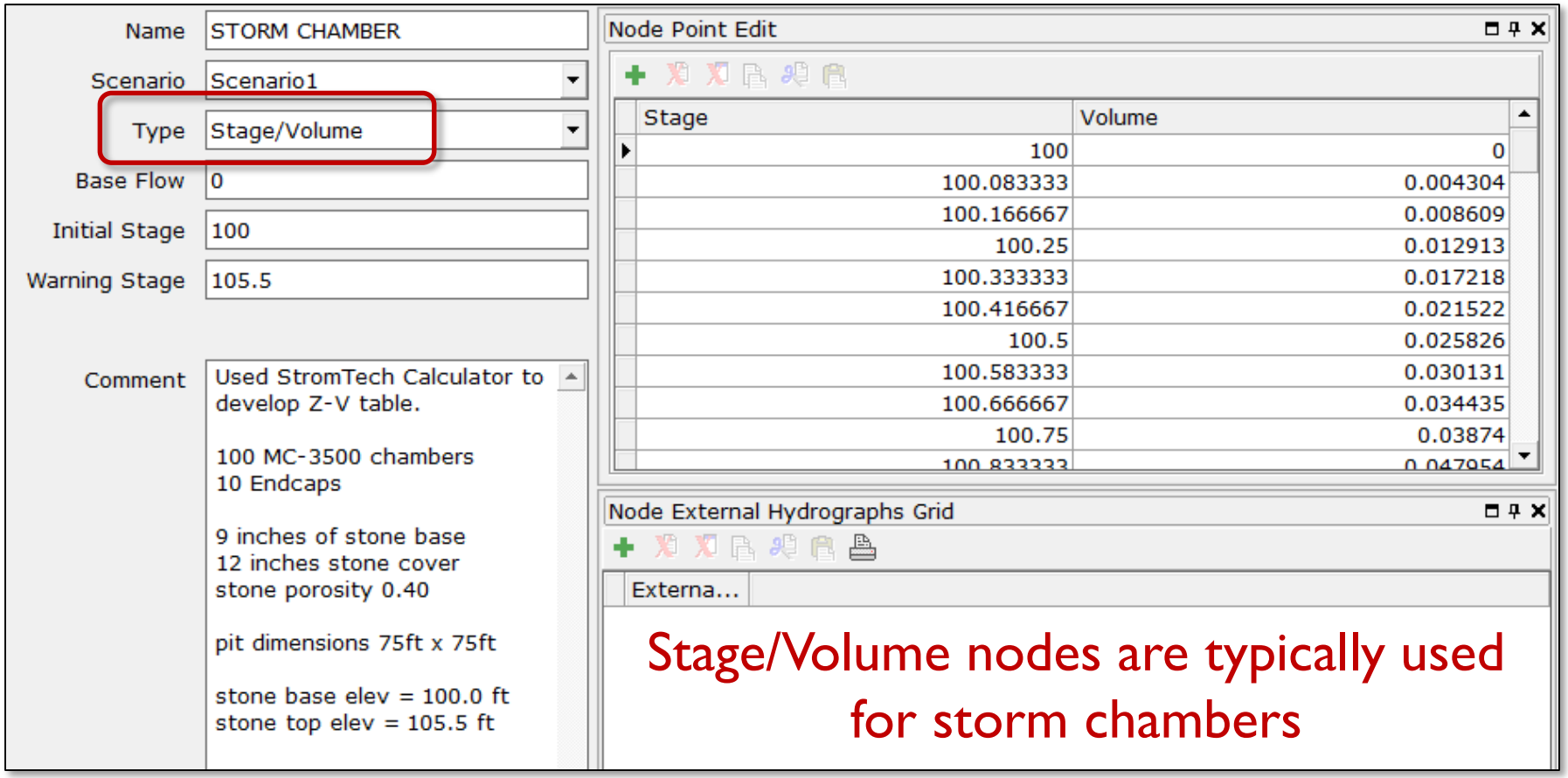
Nodes

Stage/Volume Nodes

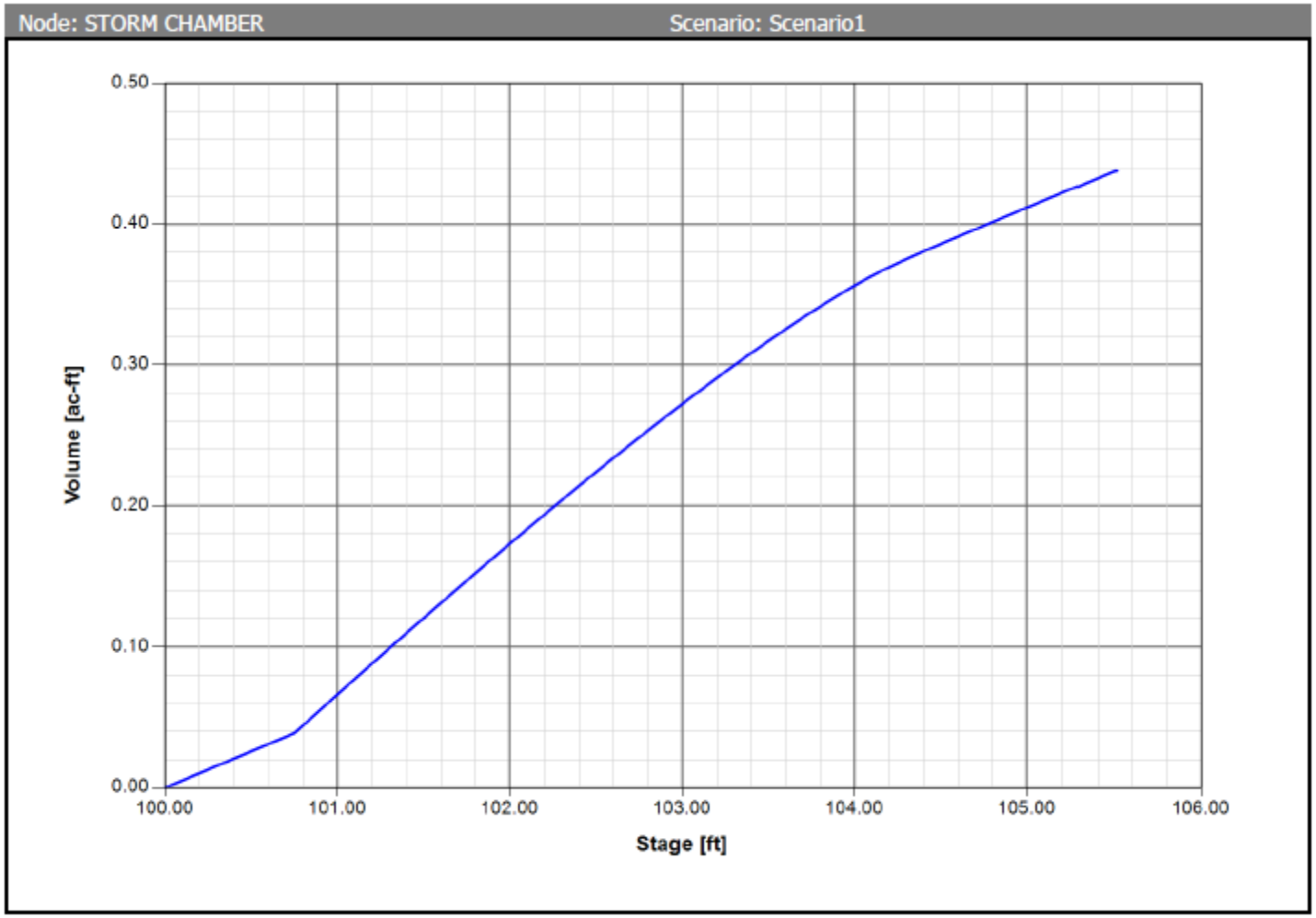
- Stage/volume nodes are converted to stage/area nodes at runtime using a reverse average-end-area method.
- At least 3 points are needed for the conversion.
- The accuracy of the conversion from stage/volume to stage/area improves with more points.

Nodes

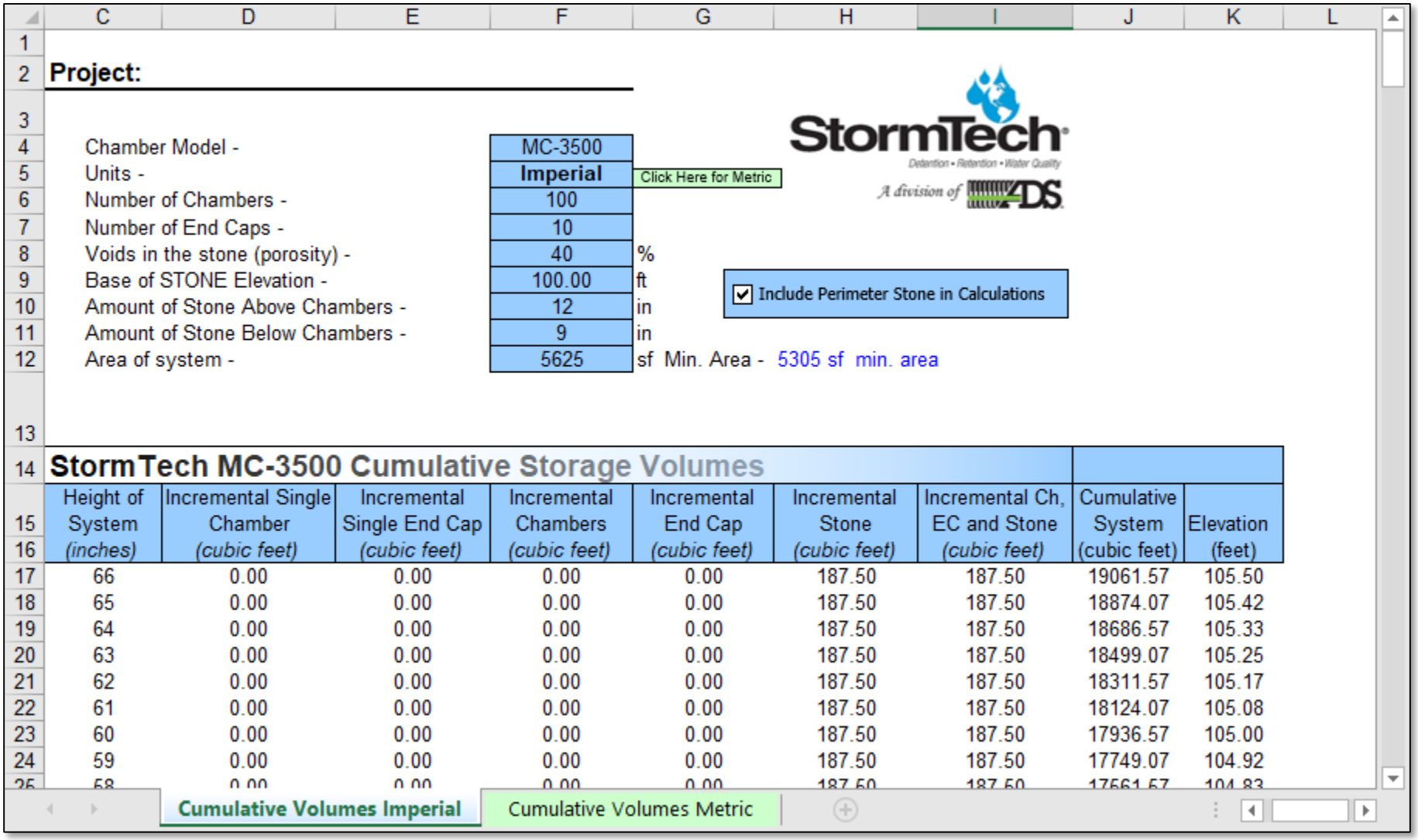
Storm Chambers



Nodes



StormTech Calculator



Project:

Chamber Model -	MC-3500	
Units -	**Imperial**	Click Here for Metric
Number of Chambers -	100	
Number of End Caps -	10	
Voids in the stone (porosity) -	40	%
Base of STONE Elevation -	100.00	ft
Amount of Stone Above Chambers -	12	in
Amount of Stone Below Chambers -	9	in
Area of system -	5625	sf Min. Area - 5305 sf min. area

StormTech Detention • Retention • Water Quality
A division of ADS

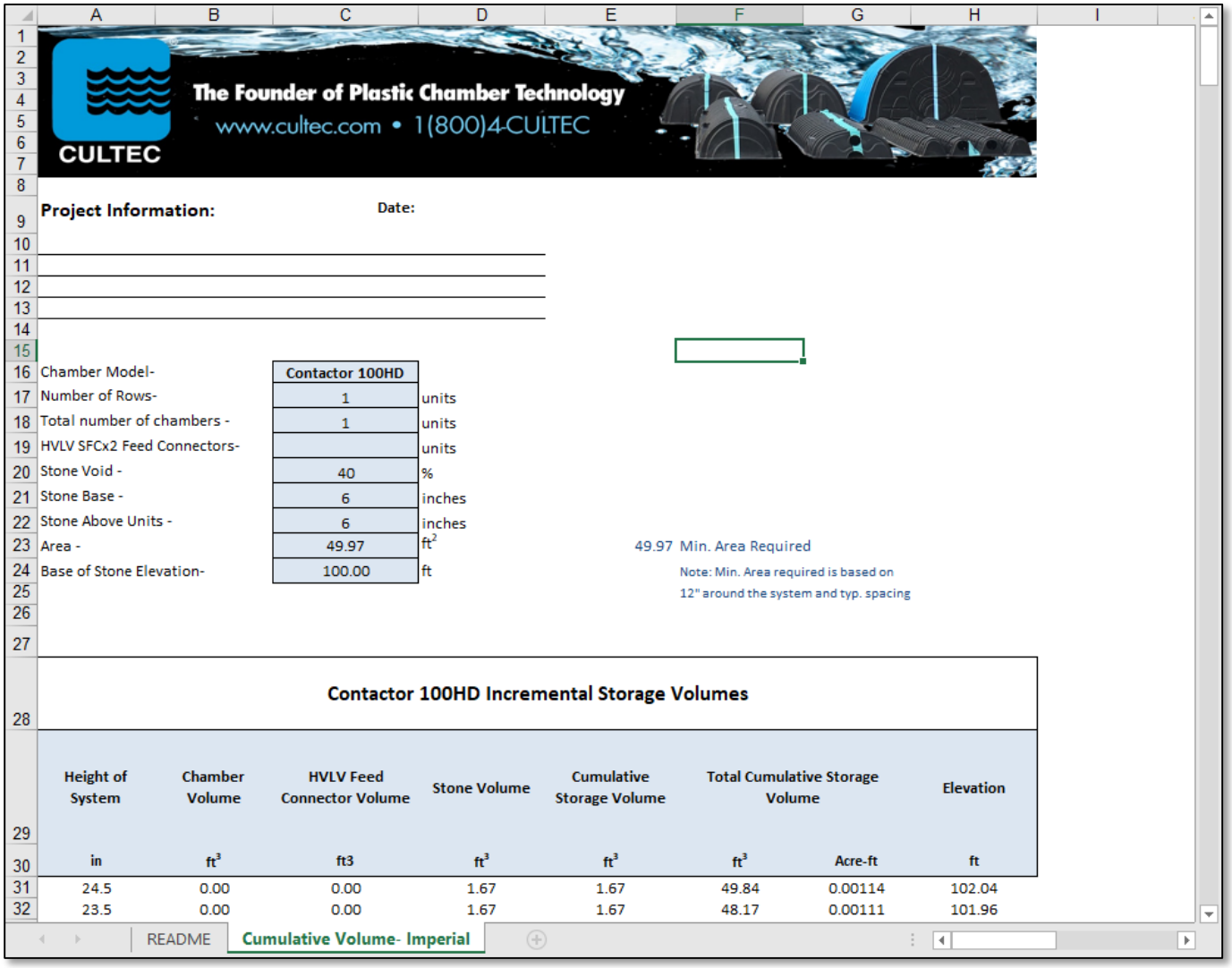
☑ Include Perimeter Stone in Calculations

StormTech MC-3500 Cumulative Storage Volumes

Height of System (inches)	Incremental Single Chamber (cubic feet)	Incremental Single End Cap (cubic feet)	Incremental Chambers (cubic feet)	Incremental End Cap (cubic feet)	Incremental Stone (cubic feet)	Incremental Ch, EC and Stone (cubic feet)	Cumulative System (cubic feet)	Elevation (feet)
66	0.00	0.00	0.00	0.00	187.50	187.50	19061.57	105.50
65	0.00	0.00	0.00	0.00	187.50	187.50	18874.07	105.42
64	0.00	0.00	0.00	0.00	187.50	187.50	18686.57	105.33
63	0.00	0.00	0.00	0.00	187.50	187.50	18499.07	105.25
62	0.00	0.00	0.00	0.00	187.50	187.50	18311.57	105.17
61	0.00	0.00	0.00	0.00	187.50	187.50	18124.07	105.08
60	0.00	0.00	0.00	0.00	187.50	187.50	17936.57	105.00
59	0.00	0.00	0.00	0.00	187.50	187.50	17749.07	104.92
58	0.00	0.00	0.00	0.00	187.50	187.50	17561.57	104.83

Cumulative Volumes Imperial | Cumulative Volumes Metric

CULTEC Calculator



Project Information: Date:

	Contactor 100HD	
Chamber Model-		
Number of Rows-	1	units
Total number of chambers -	1	units
HVLV SFCx2 Feed Connectors-		units
Stone Void -	40	%
Stone Base -	6	inches
Stone Above Units -	6	inches
Area -	49.97	ft^2
Base of Stone Elevation-	100.00	ft

49.97 Min. Area Required

Note: Min. Area required is based on 12" around the system and typ. spacing

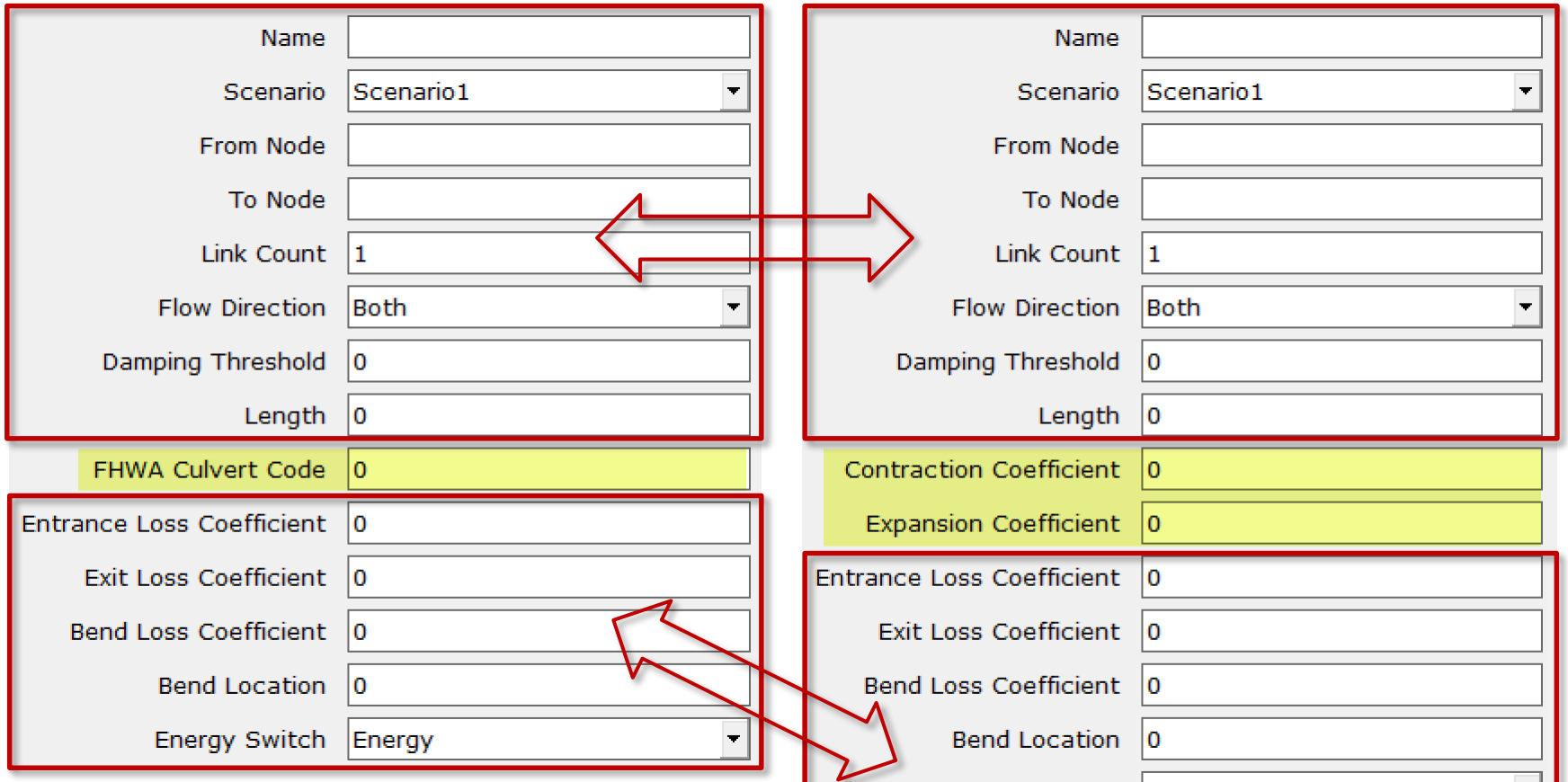
Contactor 100HD Incremental Storage Volumes

Height of System	Chamber Volume	HVLV Feed Connector Volume	Stone Volume	Cumulative Storage Volume	Total Cumulative Storage Volume		Elevation
in	ft^3	ft3	ft^3	ft^3	ft^3	Acre-ft	ft
24.5	0.00	0.00	1.67	1.67	49.84	0.00114	102.04
23.5	0.00	0.00	1.67	1.67	48.17	0.00111	101.96

README | Cumulative Volume- Imperial

Pipe & Channel Links

Data Forms



Pipe Link Data Form

Channel Link Data Form

Pipe & Channel Links

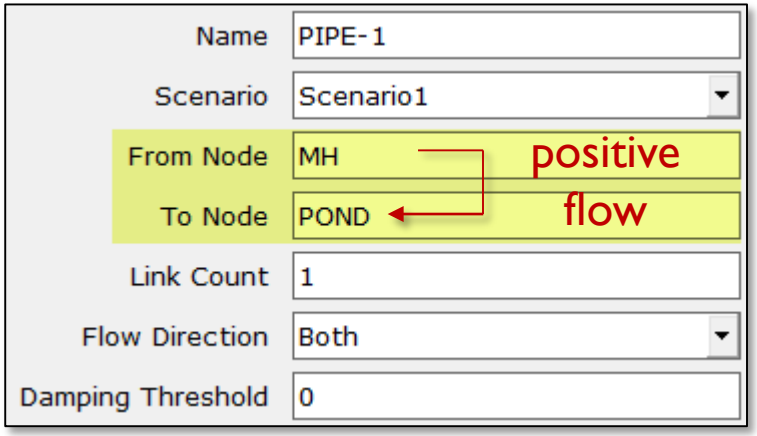
General Considerations

- Connectivity
- Count
- Flow Direction
- Damping Threshold
- Energy Switch

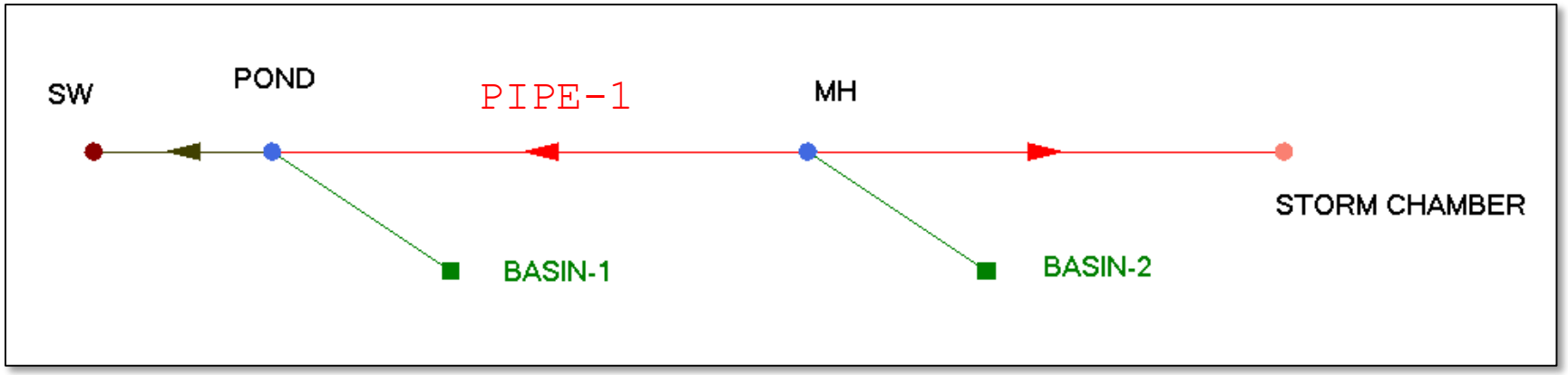
Pipe & Channel Links

General Considerations

- Connectivity -



- Links are used to move water "from" one node "to" another node
- Connectivity is established by setting a "from node" (upstream node) and a "to node" (downstream node)
- The positive flow direction is established with the connectivity



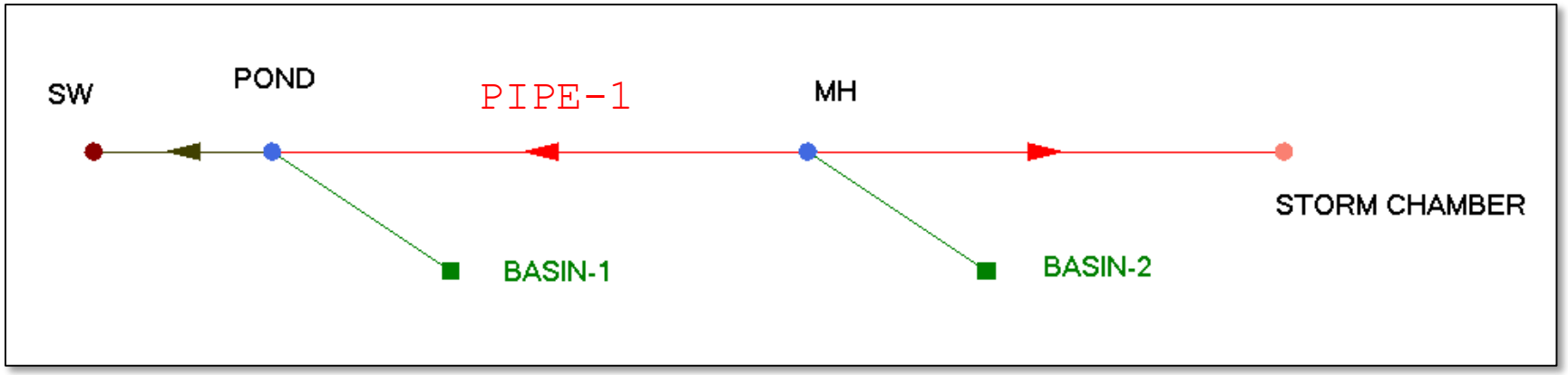
Pipe & Channel Links

General Considerations

- Link Count -

Name	PIPE-1
Scenario	Scenario1
From Node	MH
To Node	POND
Link Count	1
Flow Direction	Both
Damping Threshold	0

- The link count is the number of identical links connecting the same two nodes
- It is always a positive integer
- Flow is calculated for one link and then that flow is multiplied by the "Link Count"



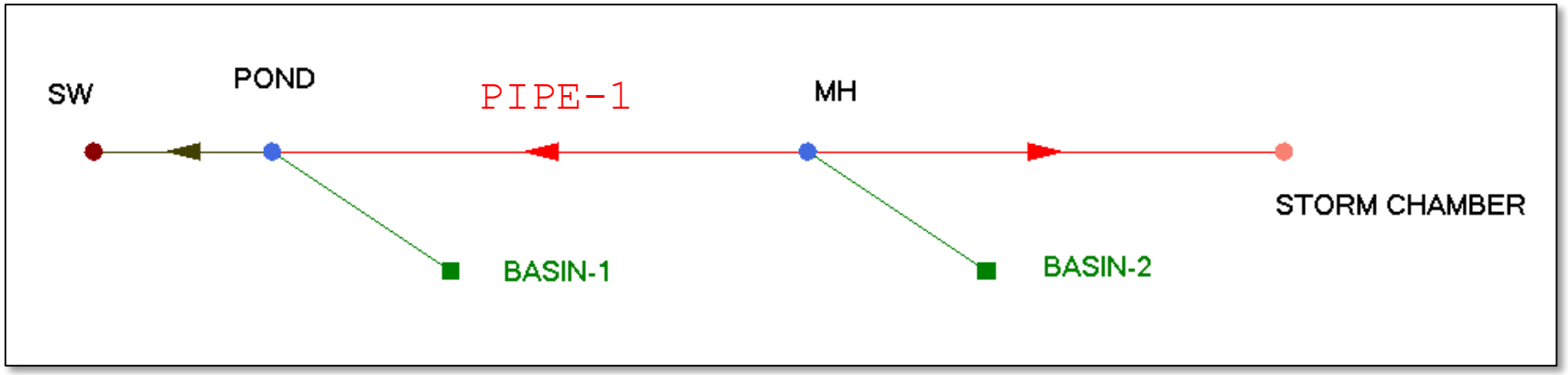
Pipe & Channel Links

General Considerations

- Flow Direction -

Name	PIPE-1
Scenario	Scenario1
From Node	MH
To Node	POND
Link Count	1
Flow Direction	Both
Damping Threshold	0

- "Both" allows flow in the positive and negative directions
- "Positive" only allows flow in the direction of the defined connectivity
- "None" turns the link off, but retains the link data in the project

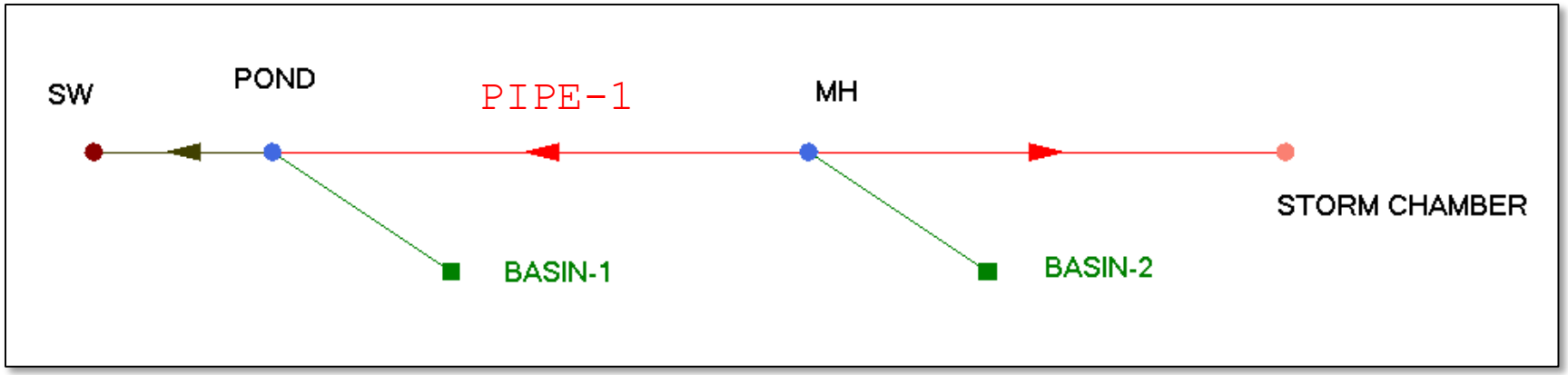


Pipe & Channel Links

General Considerations
- Damping Threshold -

Name	PIPE-1
Scenario	Scenario1
From Node	MH
To Node	POND
Link Count	1
Flow Direction	Both
Damping Threshold	0

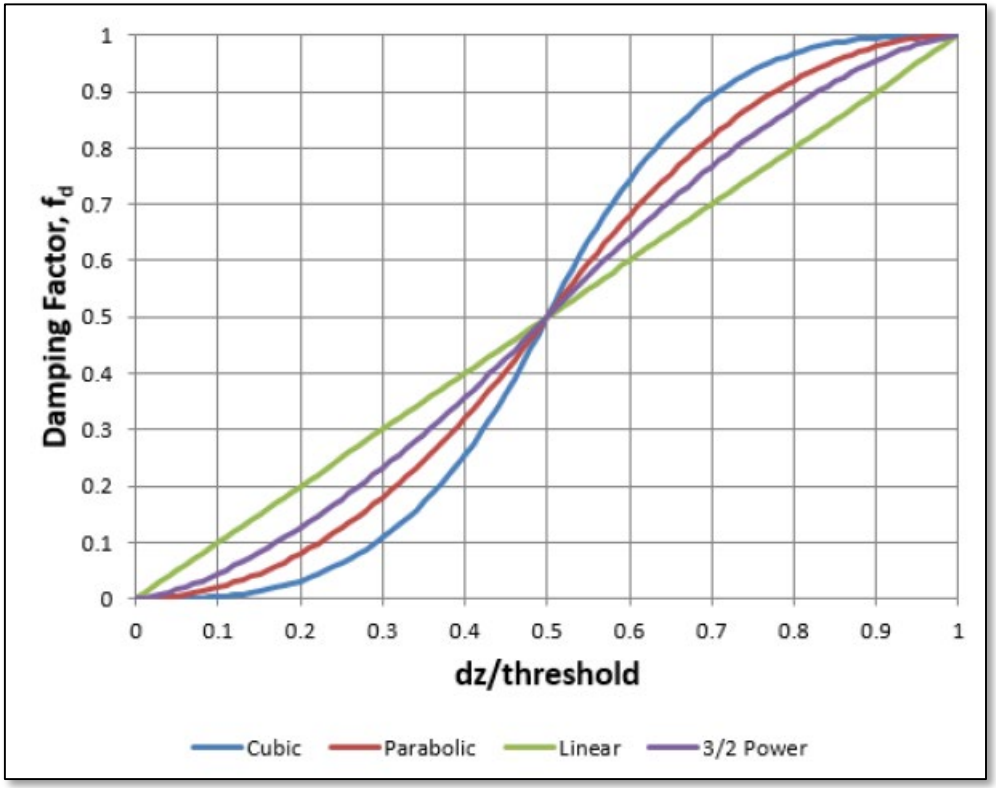
- This parameter can be used to help smooth out instabilities
- It is normally set to zero on the link data form unless there is a problematic link
- Typically, values range from 0.0001' to 0.01' when used, and should rarely exceed 0.1'



Pipe & Channel Links

General Considerations

- Damping Threshold -



When the absolute value of the difference in water levels at both ends of a link fall within the specified "Damping Threshold", the calculated flow is reduced in accordance with the equation below.

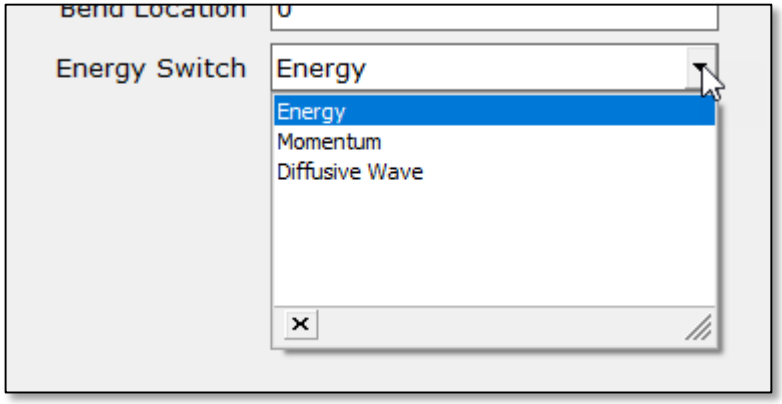
$$Q' = f_d Q$$

where, Q', is the reduced flow.

The parabolic function is currently used in ICPR.

Pipe & Channel Links

Energy Switch



Momentum (St. Venant Eq)

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(Q^2/A\right)}{\partial x}+gA\frac{\partial Z}{\partial x}+gAS_f+gA\left(h_{eddy}+h_{entrance}+h_{exit}+h_{bend}\right)=0$$

Energy

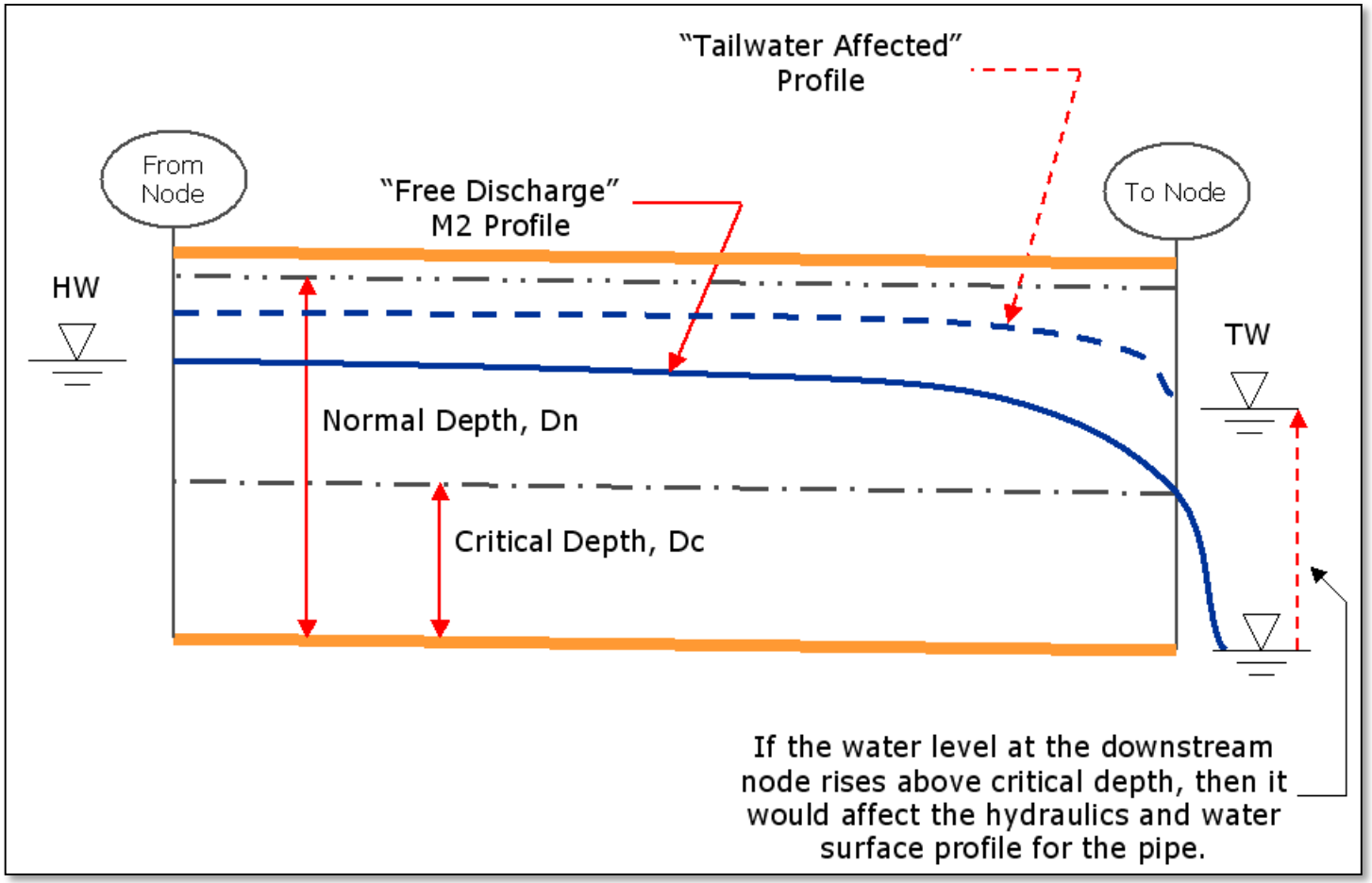
$$Z_1+\frac{V_1^2}{2g}=Z_2+\frac{V_2^2}{2g}+h_f+h_{eddy}+h_{entrance}+h_{exit}+h_{bend}$$

Diffusive Wave

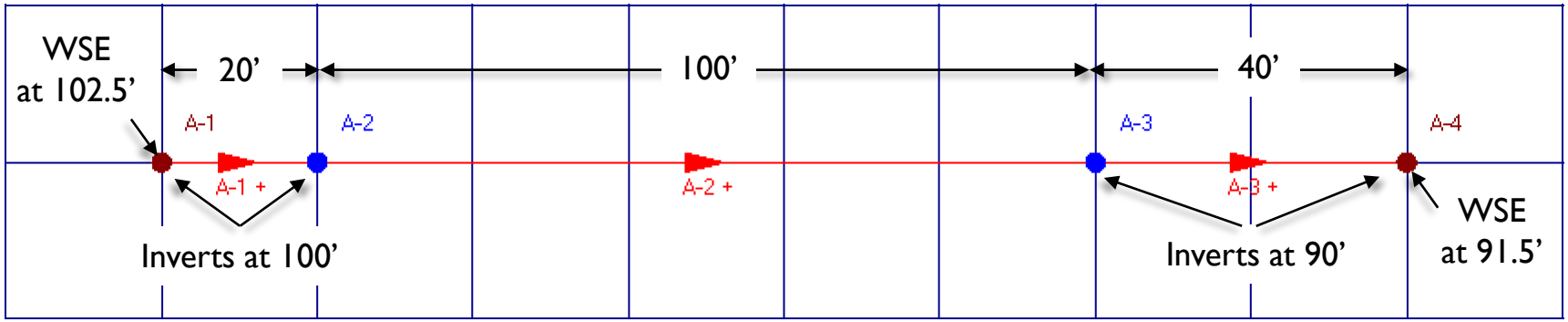
$$Z_1+=Z_2+h_f+h_{eddy}+h_{entrance}+h_{exit}+h_{bend}$$

Pipe & Channel Links

Subcritical Flow (Outlet Control)



Subcritical & Supercritical Pipe Transitions



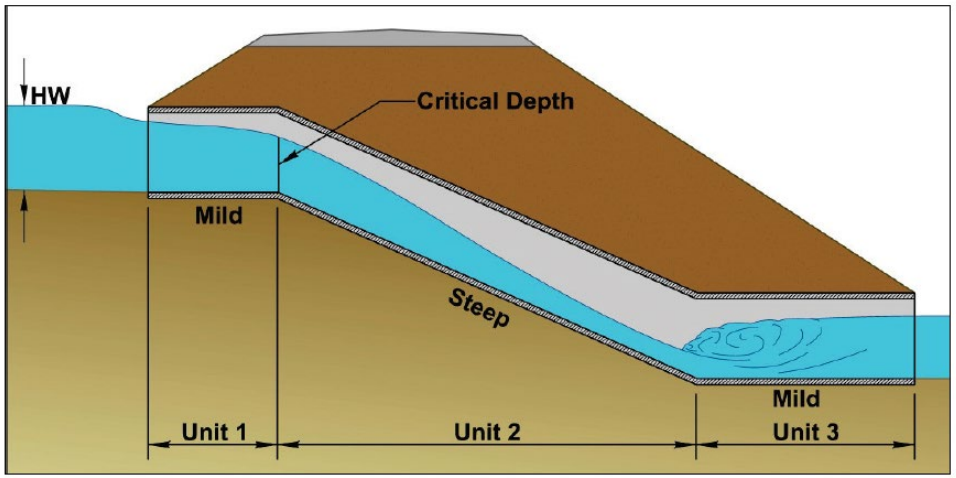
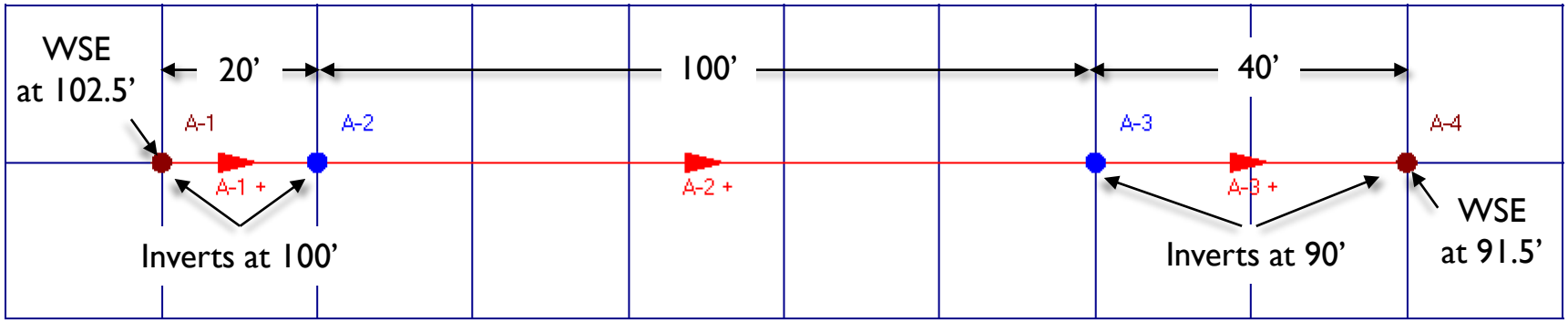
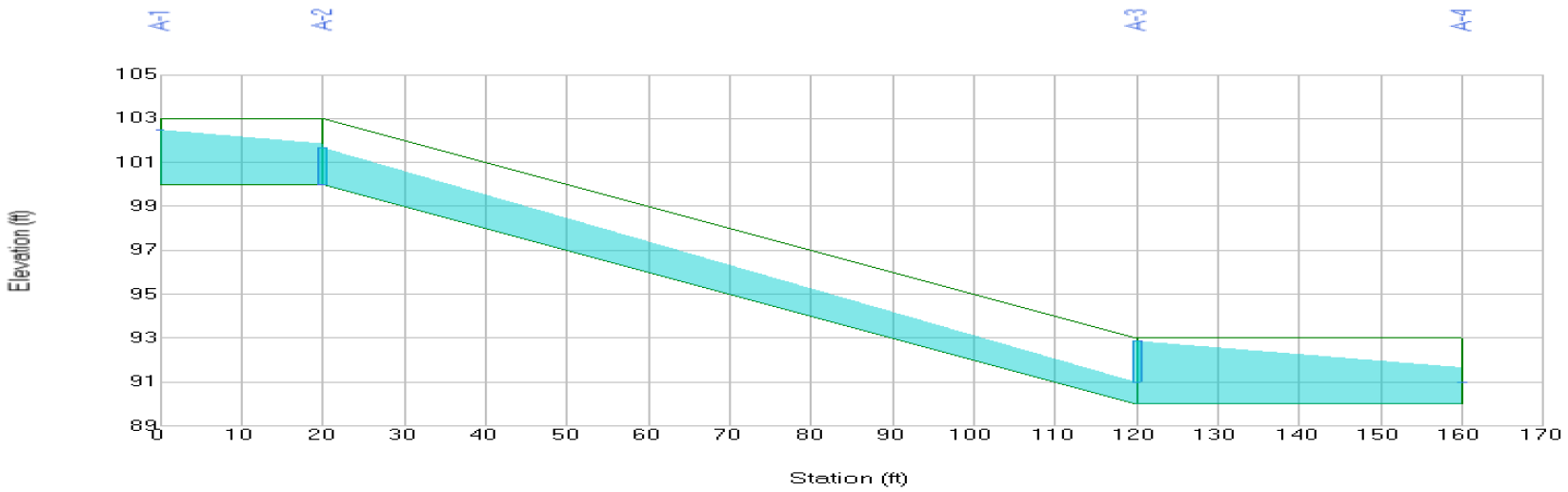


Figure 5.22. Three-unit broken-back culvert.

Source: FHWA 2012 "Hydraulic Design of Highway Culverts" 3rd Edition

Subcritical & Supercritical Pipe Transitions



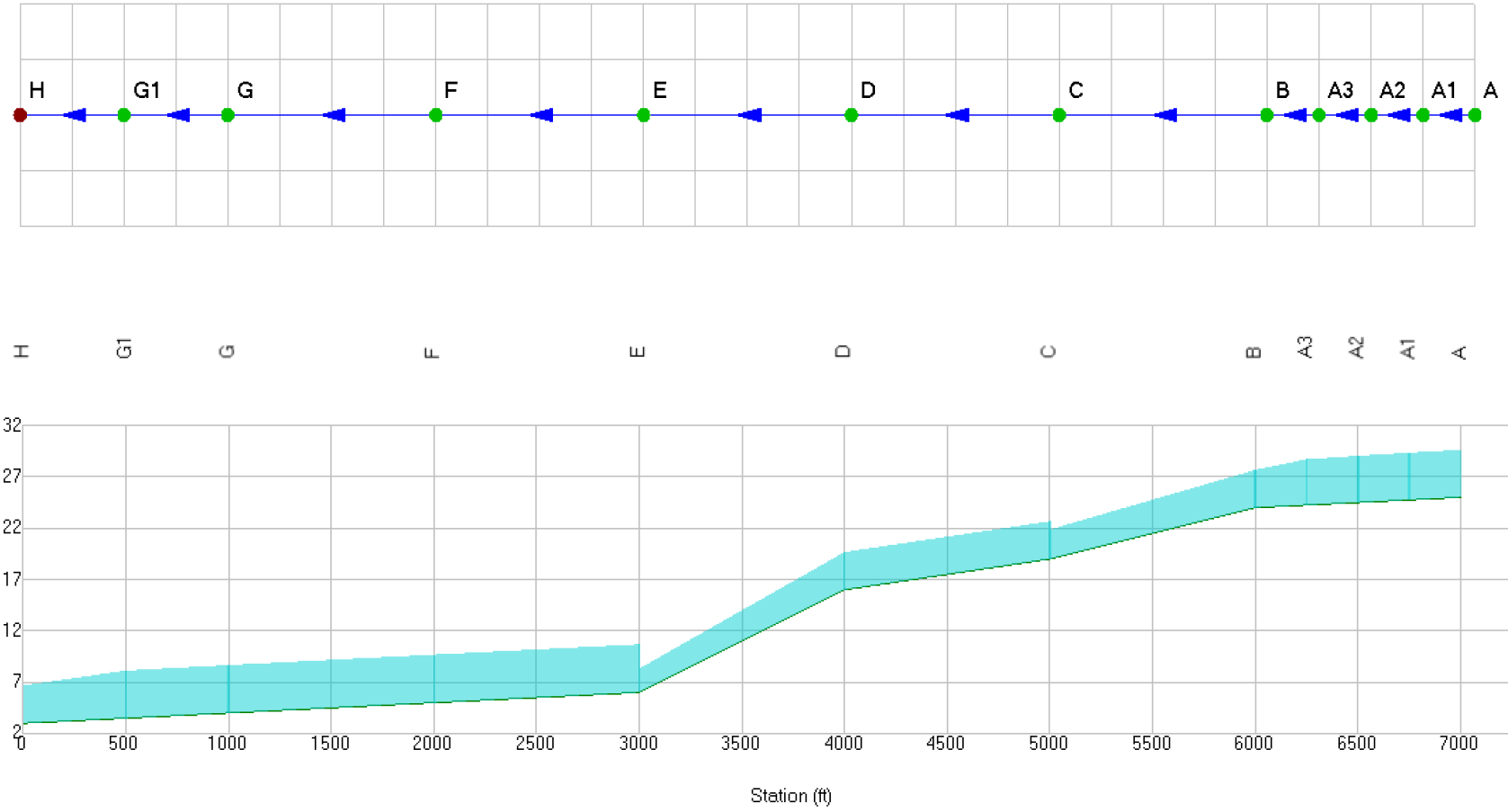


0.0000

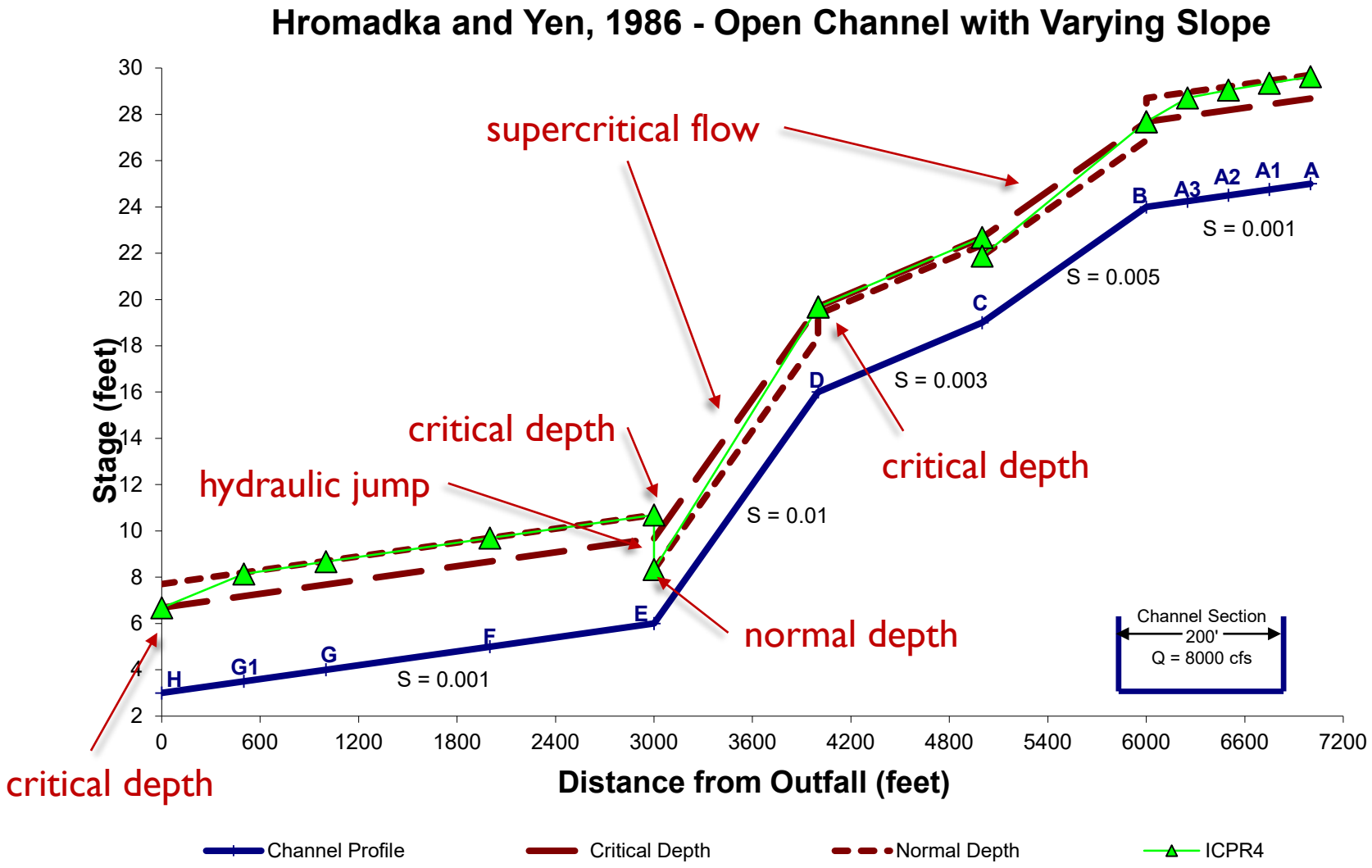
Subcritical & Supercritical Channel Transitions

8,000 cfs

Rectangular cross section – 200' wide



Subcritical & Supercritical Channel Transitions



Pipe & Channel Links

Friction Minor Losses

- Friction Loss
- Contraction/Expansion Loss (channels only)
- Entrance Loss
- Exit Loss
- Bend Loss

Pipe & Channel Links

Friction Loss

	Upstream	Downstream
Invert	0	0
Manning's N	0	0

$$h_f = L\bar{S}_f$$

The friction slope is derived from Manning's Equation as follows:

$$S_f = (Q / K)^2$$

$$K = \frac{1.486R^{2/3}A}{n}$$

Pipe & Channel Links

Friction Loss

Average Conveyance:

$$S_{f_{avg}} = \frac{4Q^2}{\left(K_1 + K_2\right)^2}$$

Average Friction Slope:

$$S_{f_{avg}} = \frac{Q^2\left(1/K_1^{\,2} + 1/K_2^{\,2}\right)}{2}$$

Geometric Mean Friction Slope:

$$S_{f_{avg}} = Q^2\left(\frac{1}{K_1^{\,2}K_2^{\,2}}\right)^{1/2}$$

Harmonic Mean Friction Slope:

$$S_{f_{avg}} = 2Q^2\left[\frac{1}{\left(K_1^{\,2}K_2^{\,2}\right)\left(1/K_1^{\,2} + 1/K_2^{\,2}\right)}\right]$$

ICPR includes several friction slope averaging techniques. These are automatically applied and depend on the flow regime.

Channel Links

Contraction/Expansion Loss Coefficients

Contraction Coefficient	0
Expansion Coefficient	0

$$h_{eddy} = C_{eddy} \left| \left[\frac{V_1^2}{2g} - \frac{V_2^2}{2g} \right] \right|$$

Subcritical Flow Contraction and Expansion Coefficients

	Contraction	Expansion
No transition loss computed	0.0	0.0
Gradual transitions	0.1	0.3
Typical bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

Source: HEC-RAS Reference Manual

- Eddy losses account for contracting or expanding flow from one end of a channel link to the other.
- They do not account for contractions or expansions beyond the extents of the channel link.
- The eddy loss for a channel link is a function of the velocity heads at its upstream and downstream ends.

Pipe & Channel Links

Entrance Loss Coefficient

Entrance Loss Coefficient	0.5
Exit Loss Coefficient	1
Bend Loss Coefficient	0
Bend Location	0

Press "F1" key for list of entrance loss coefficients

$$h_{entrance} = \frac{C_{entrance} V_1^2}{2g}$$

Table C.2. Entrance Loss Coefficients.

Outlet Control, Full or Partly Full Entrance Head Loss

$$H_e = K_e\left[\frac{V^2}{2g}\right]$$

Type of Structure and Design of Entrance	Coefficient K_e
• Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end	0.2
Square-edge	0.5
Rounded (radius = D/12	0.2
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2

Partial listing of entrance loss coefficients for pipes

Pipe & Channel Links

Exit Loss Coefficient

Entrance Loss Coefficient	0.5
Exit Loss Coefficient	1
Bend Loss Coefficient	0
Bend Location	0

$$h_{exit} = \frac{C_{exit} V_2^2}{2g}$$

The exit loss coefficient, C_{exit}, can vary from 0 to 1 and, in general, depends on the differences in velocities between the outlet of the pipe and immediately downstream of the outlet.

- If exit velocity is expected to drop to zero or near zero after leaving a pipe or channel outlet, then C_{exit} = 1.0
- If exit velocity is expected to be unchanged, then C_{exit} = 0.0

$C_{ext} = (V_{pipe}^2 - V_{downstream}^2) / V_{pipe}^2$

Or, from the following table:

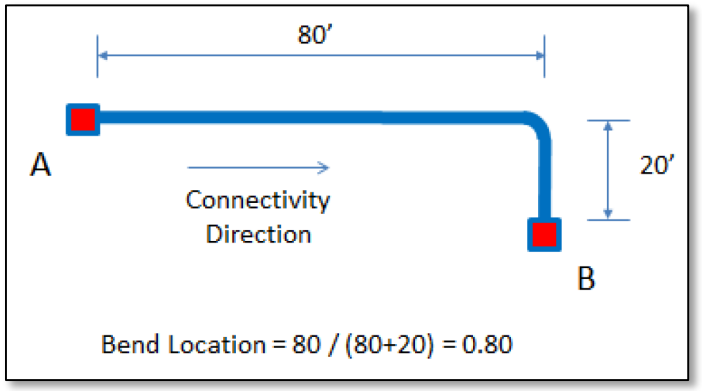
$(V_{pipe} / V_{downstream})$ or $(A_{downstream} / A_{pipe})$	C_{ext}
1.00	0.000
1.10	0.174
1.25	0.450
1.50	0.556
1.75	0.673
2.00	0.750
3.00	0.889
4.00	0.938
8.00	0.984
infinity	1.000

Pipe & Channel Links

Exit Loss Coefficient

Entrance Loss Coefficient	0.5
Exit Loss Coefficient	1
Bend Loss Coefficient	0
Bend Location	0

$$h_{bend} = \frac{C_{bend} V_{bend}^{\ 2}}{2g}$$



Bend Location = 80 / (80+20) = 0.80

Bend Loss Coefficients

R = 31,500		r/b = 1.0	
r/b	C_{bend}	R	C_{bend}
2.5	0.02	10,000	0.59
2.0	0.07	30,000	0.27
1.5	0.12	50,000	0.25
1.0	0.25	70,000	0.35

Source: Brater and King, 1976, p. 8-31.

Pipe Links

FHWA Inlet Control Equations

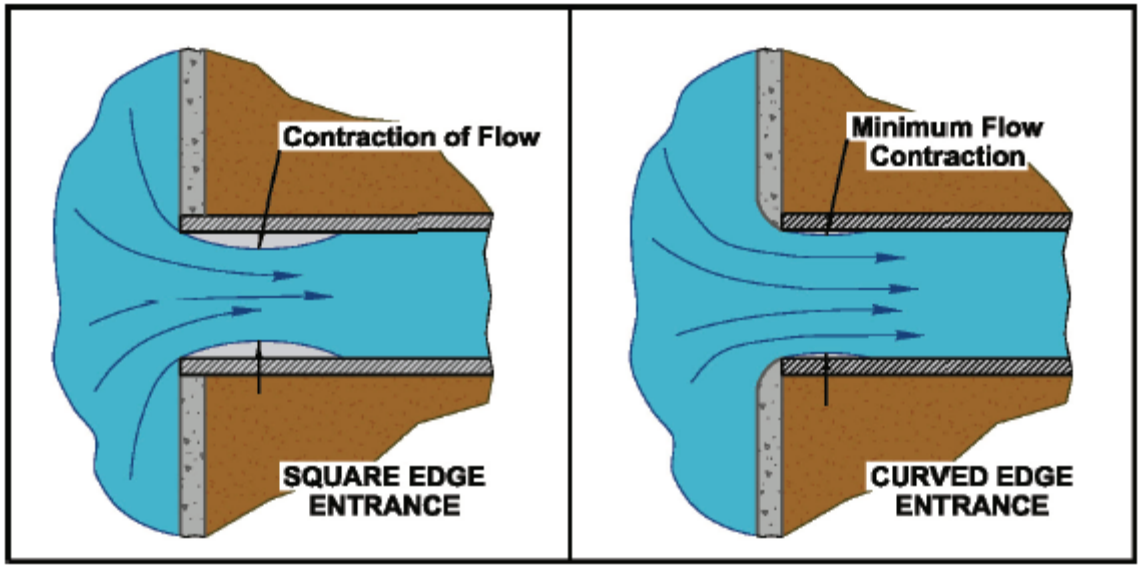
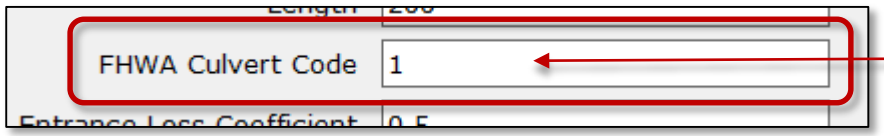


Figure 1.9. Entrance contraction.

Source: FHWA 2012 "Hydraulic Design of Highway Culverts" 3rd Edition

Pipe Links

FHWA Inlet Control Equations



Press "F1" key for list of FHWA codes

Unsubmerged:

Form 1: $Q = AD^{1/2}[\{(z_1 - H_c)/D + 0.5S\} / K]^{1/M}$

Form 2: $Q = AD^{1/2}[z_1/(DK)]^{1/M}$

Submerged:

$Q = AD^{1/2}[(z_1/D - Y + 0.5S) / c]^{1/2}$

When a non-zero FHWA control code is specified for a pipe link, ICPR calculates *flows for both inlet and outlet control* and then *uses the most restrictive*. Normal depth at the pipe outlet is used for inlet control.

Pipe Links

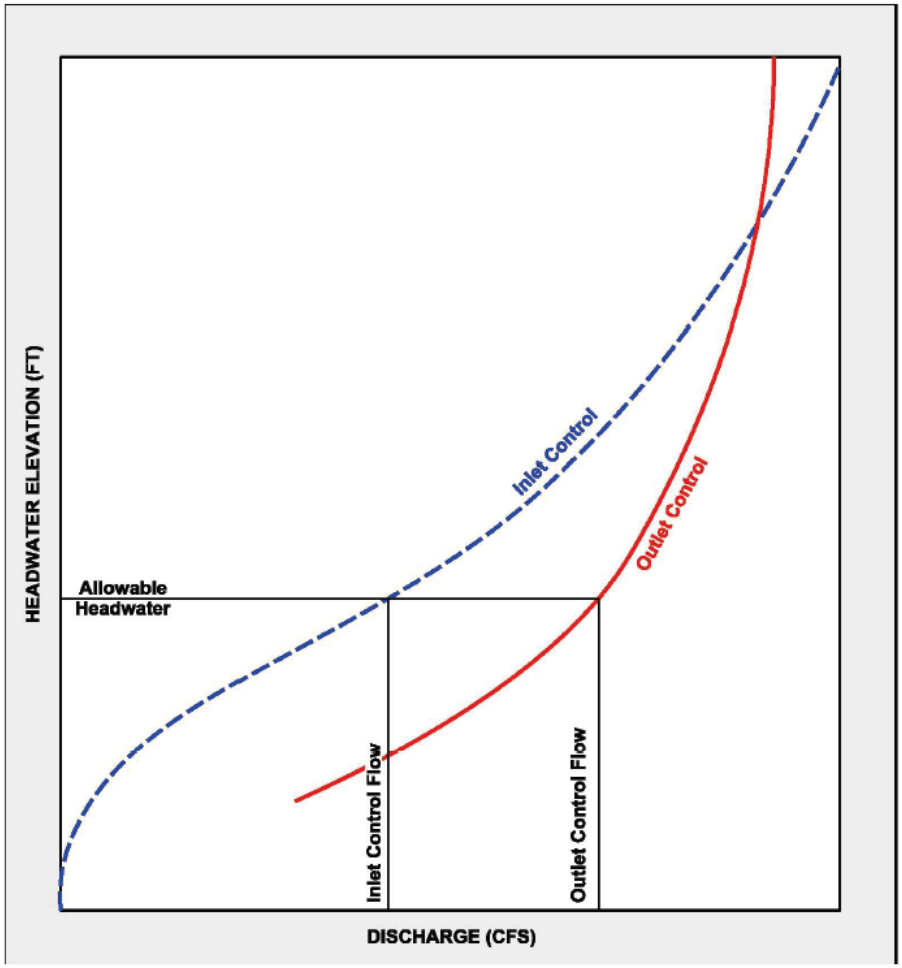
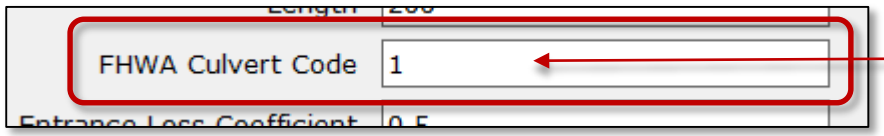


Figure 1.19. Culvert performance curve.

Source: FHWA 2012 "Hydraulic Design of Highway Culverts" 3rd Edition

Pipe Links

FHWA Culvert Code



Press "F1" key for list of FHWA codes

- If FHWA code set to zero, critical depth at entrance used for supercritical flow
- Normal depth is used at the pipe outlet for inlet controlled pipes

FHWA Culvert Code	Shape and Material	Inlet Configuration
0	FHWA Inlet Control Option Not Used	
1	Circular Concrete	Square edge w/headwall
2	Circular Concrete	Groove end w/headwall
3	Circular Concrete	Groove end projecting
4	Circular CMP	Headwall
5	Circular CMP	Mitered to slope
6	Circular CMP	Projecting
7	Circular	Beveled ring, 45° bevels
8	Circular	Beveled ring, 33.7° bevels*

(A) Thin Edge Projecting – The culvert barrel projects out of the embankment.

(B) Mitered entrance – The culvert barrel is cut so it is flush with the embankment slope.

(C) Square edge in headwall – The end of the culvert barrel is flush with the headwall.

(D) Groove edge projecting – A concrete pipe culvert section extends beyond the fill or headwall.

Figure 3.2. Typical inlet configurations.

Source: FHWA 2012 "Hydraulic Design of Highway Culverts" 3rd Edition

Pipe Links

Figure 1.8. Four standard inlet types.

Source: FHWA 2012 "Hydraulic Design of Highway Culverts" 3rd Edition

Pipe Links

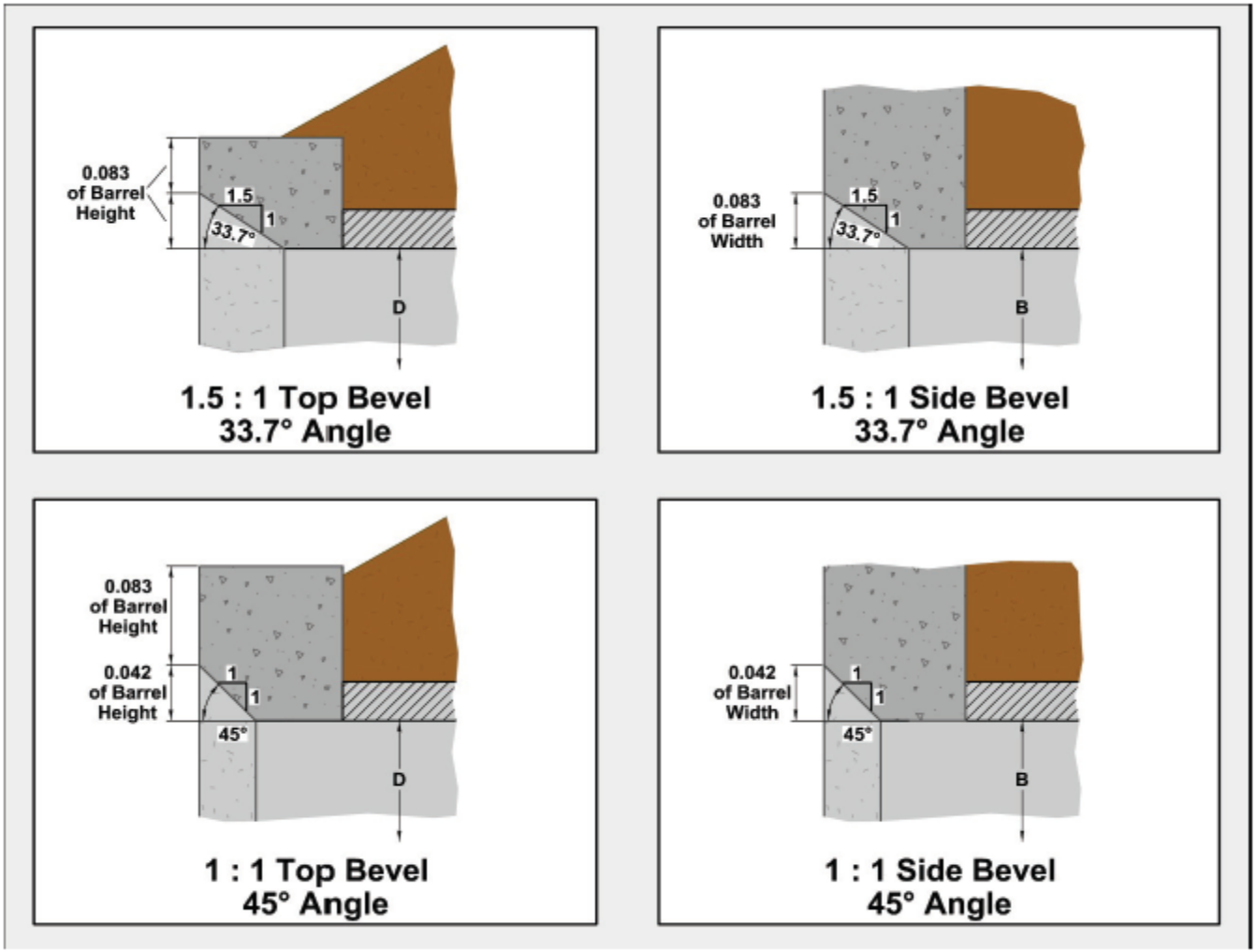
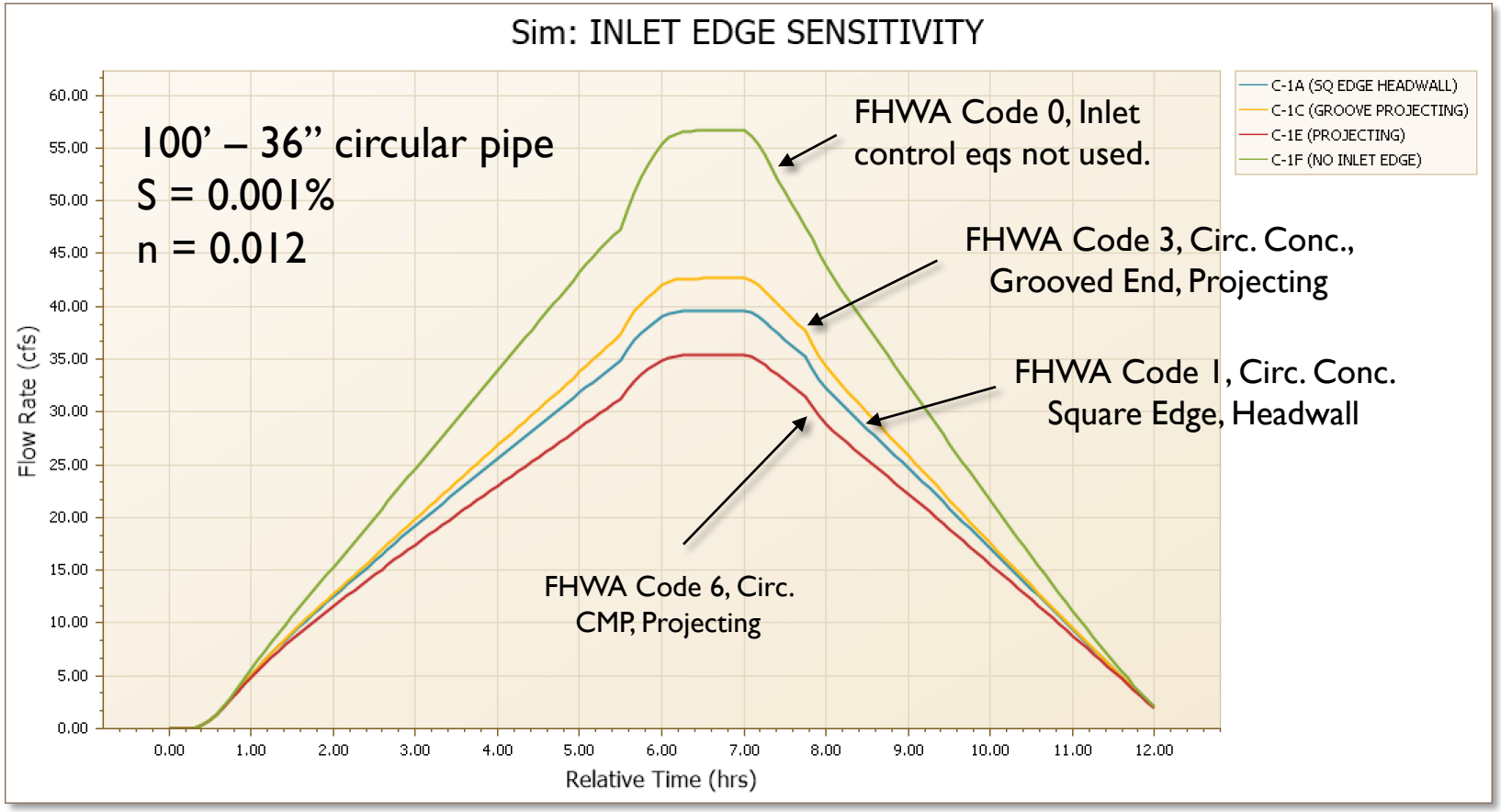


Figure 3.3. Beveled edges.

Source: FHWA 2012 "Hydraulic Design of Highway Culverts" 3rd Edition

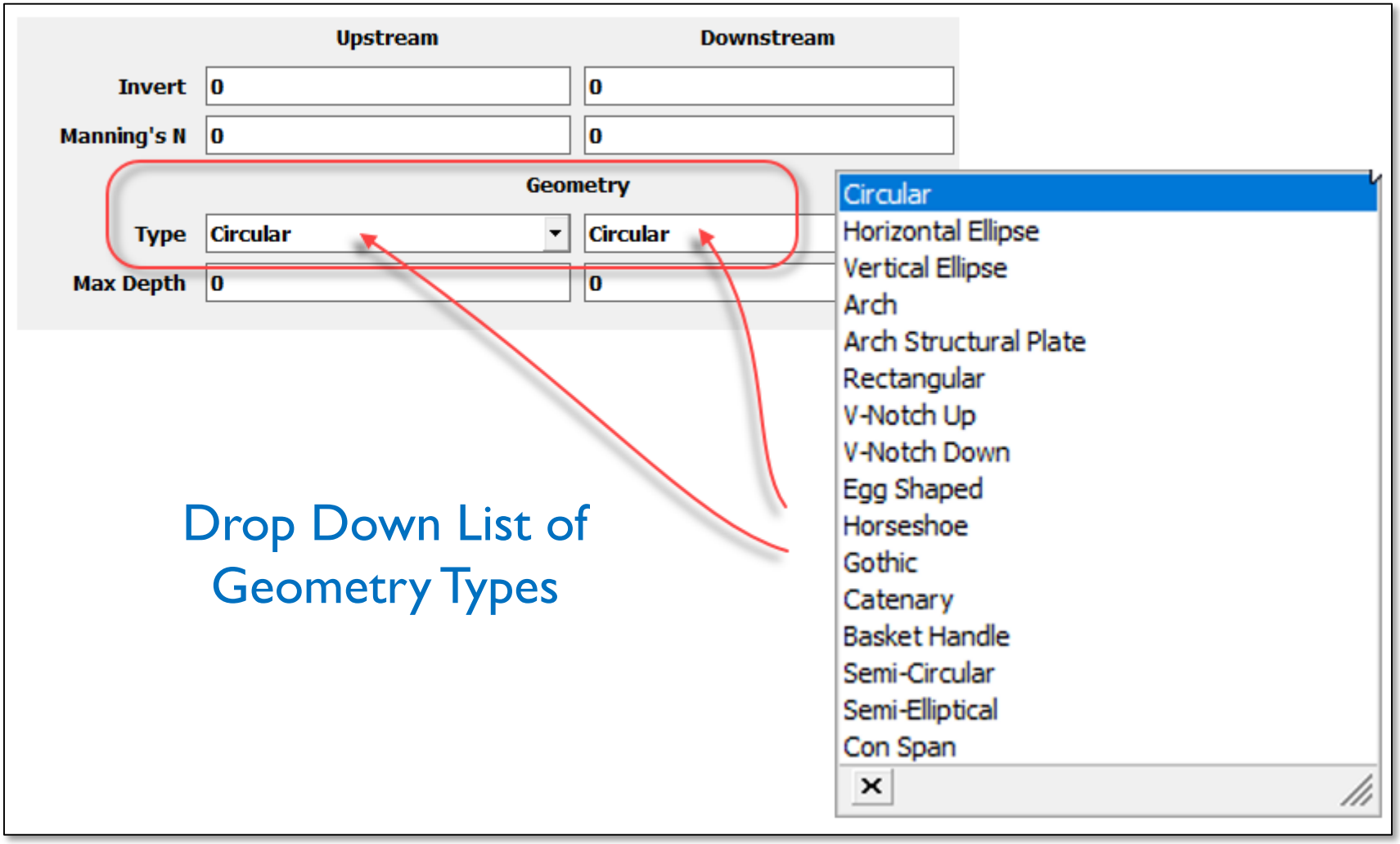
Pipe Links

FHWA Inlet Control – Does it Matter?



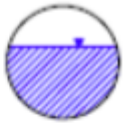
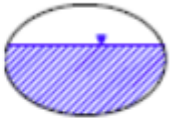
Pipe Links

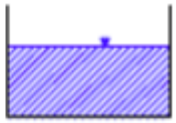
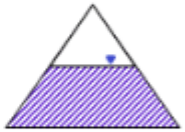
Geometric Considerations



Pipe Links

Geometric Considerations

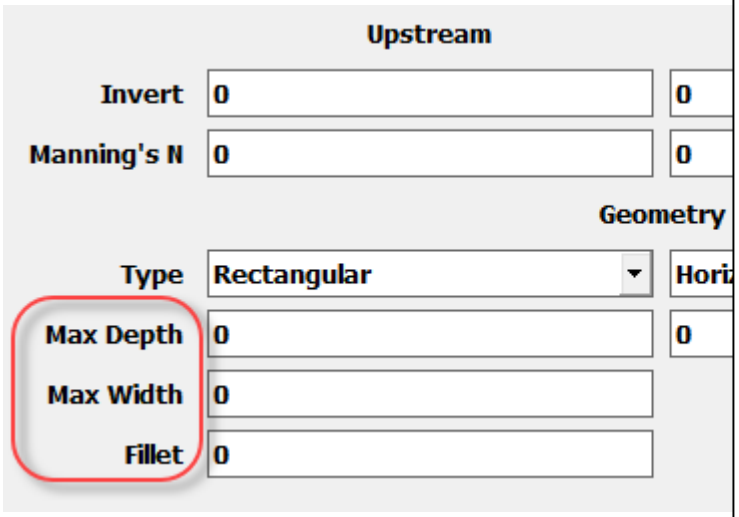
Geometry Type	
Circular	
H-Elliptical	
V-Elliptical	
Arch (2-2/3" x ½")	
Arch Structural Plate	

Geometry Type	
Rectangular	
V-notch Up	
V-notch Down	
Egg Shaped	
Horseshoe	

Geometry Type	
Gothic	
Catenary	
Basket handle	
Semi-Circular	
Semi-Elliptical	

Pipe Links

Geometric Considerations



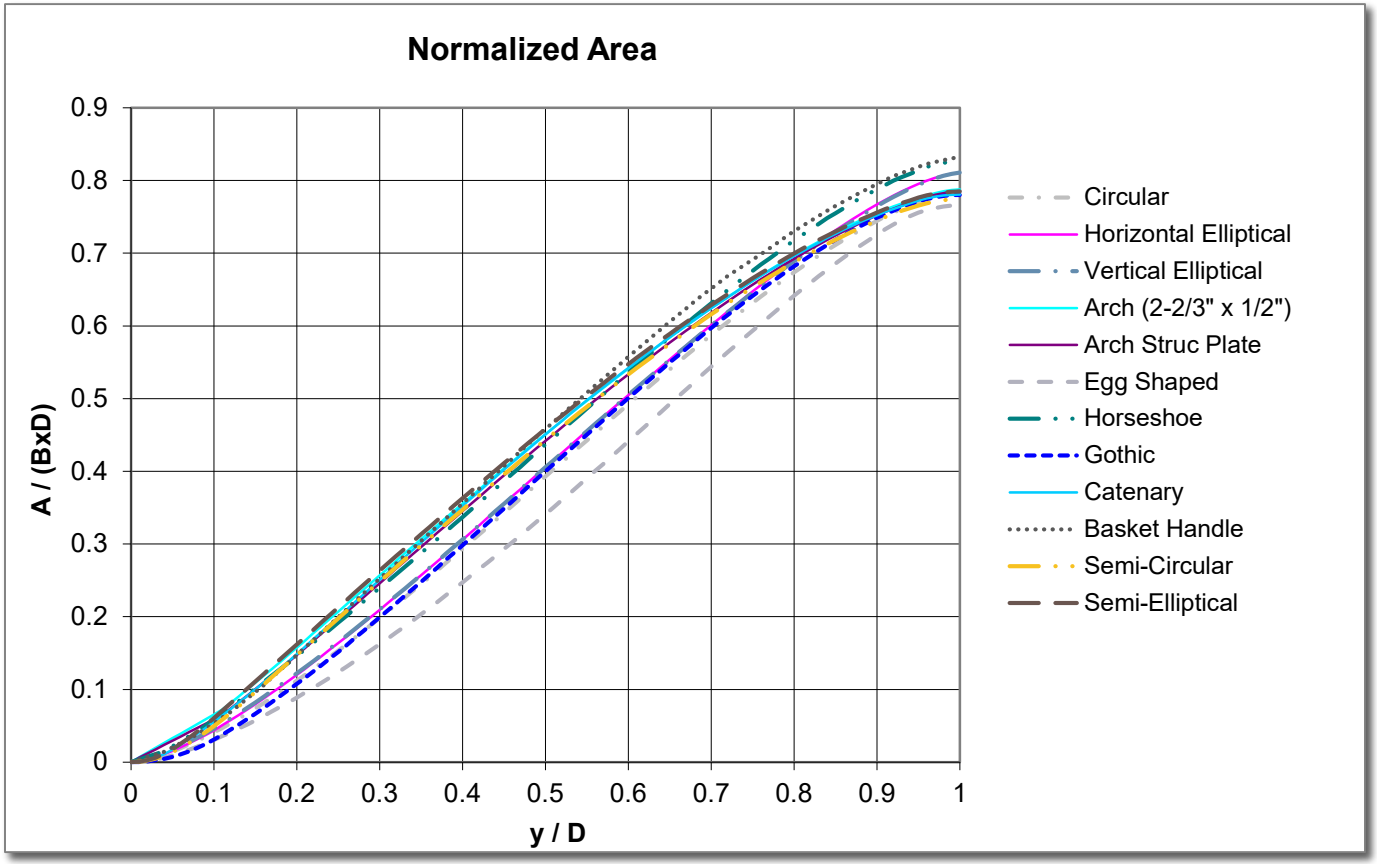
These Fields Depend on Geometry Type

Geometry Type	B/D	Input Requirements	CG/D
Circular	1.00	D	0.500
H-Elliptical	1.56	D	0.500
V-Elliptical	1.00/1.56	D	0.500
Arch (2-2/3" x ½")	1.607	D	0.446
Arch Structural Plate	variable	B, D	0.455
Rectangular	variable	B, D, F	0.500
V-notch Up	variable	B, D	0.677
V-notch Down	variable	B, D	0.333
Egg Shaped	2/3	D	0.529
Horseshoe	1.00	D	0.475
Gothic	0.84	D	0.492
Catenary	0.90	D	0.453
Basket handle	0.944	D	0.467
Semi-Circular	1.64	D	0.456
Semi-Elliptical	1.00	D	0.447
Con Span	variable	Xsec Name	Variable

B = maximum width, D = maximum depth, F = fillet length, CG = center of gravity

Pipe Links

Geometric Considerations



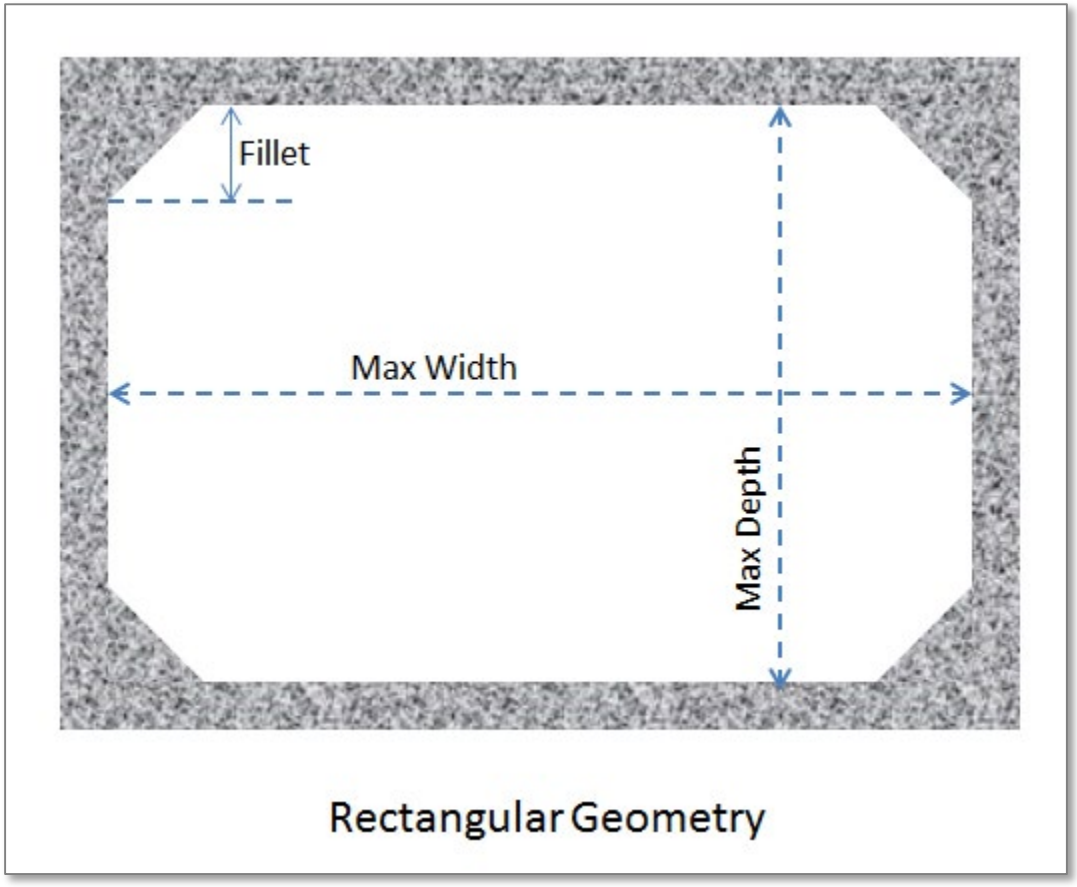
Normalized: Area, Hydraulic Radius & Wetted Perimeter

Pipe Links

Geometric Considerations

Pipe Links

Geometric Considerations



Pipe Links

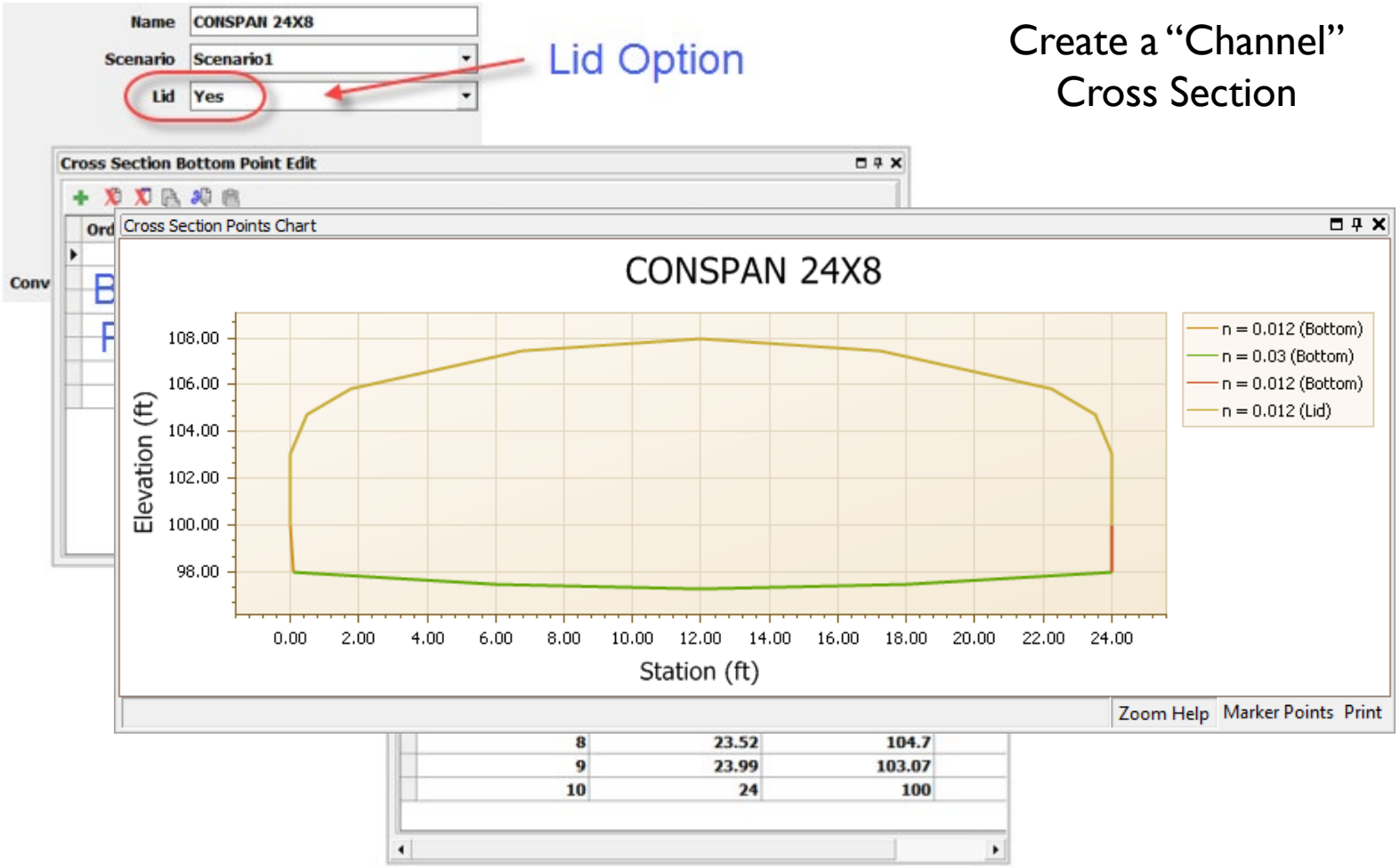
Geometric Considerations

Source: CONTECH

CONSPAN BRIDGE

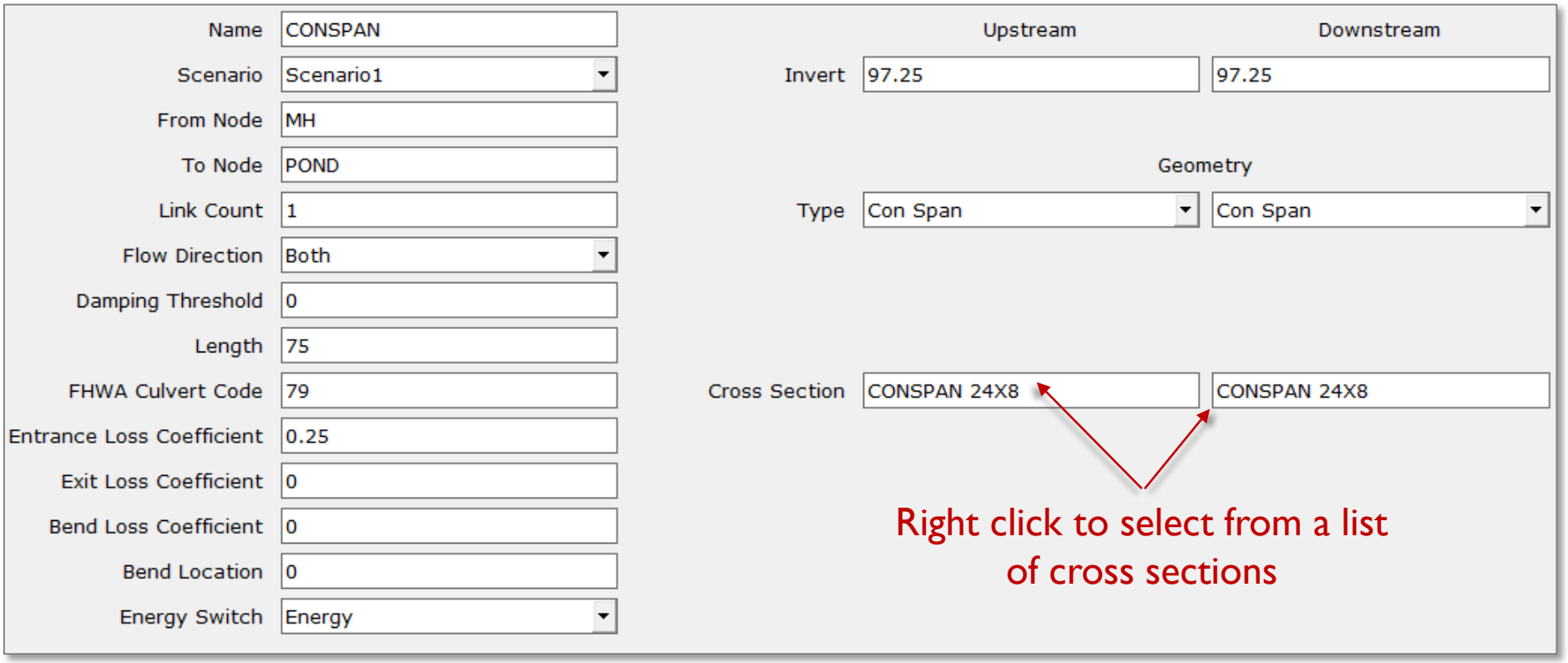
Pipe Links

Geometric Considerations



Pipe Links

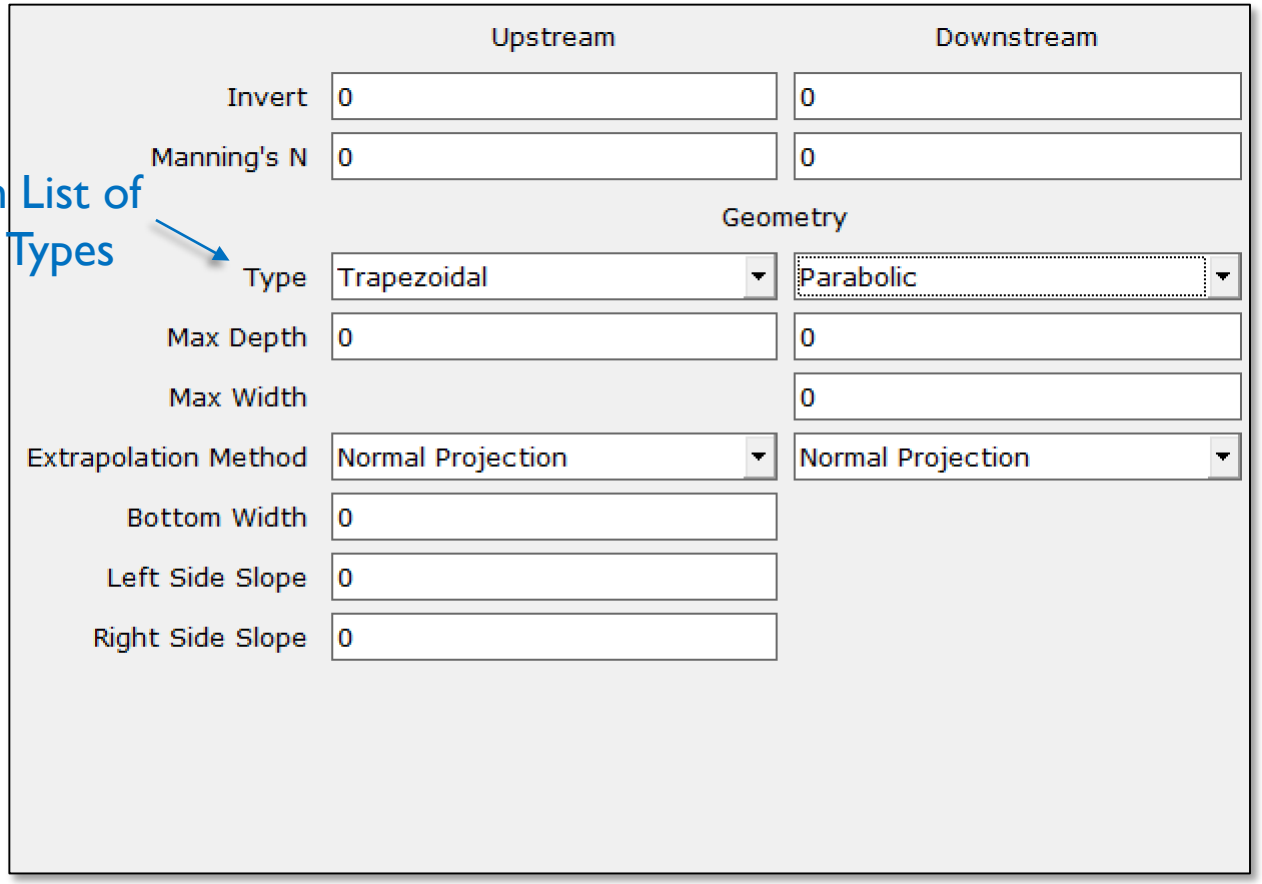
Geometric Considerations



Channel Links

Geometric Considerations

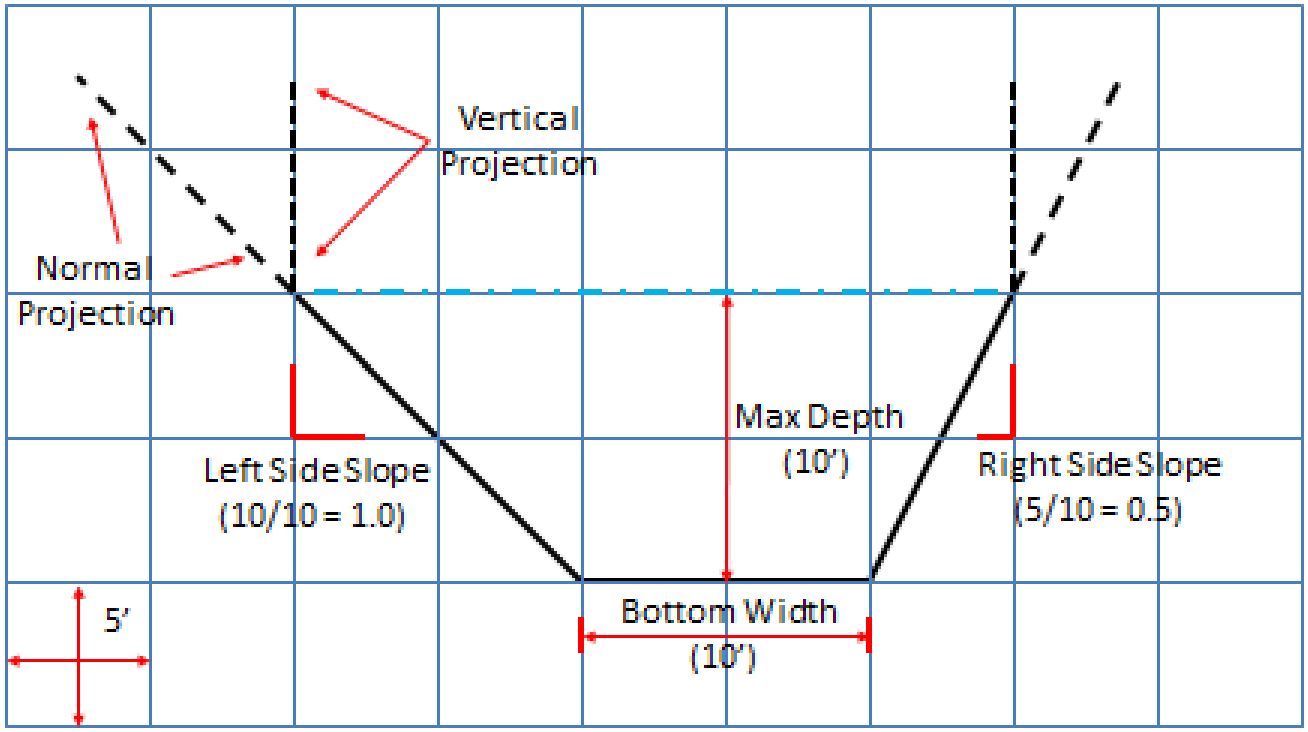
Drop Down List of Geometry Types



Channel Links

Geometric Considerations

Trapezoidal

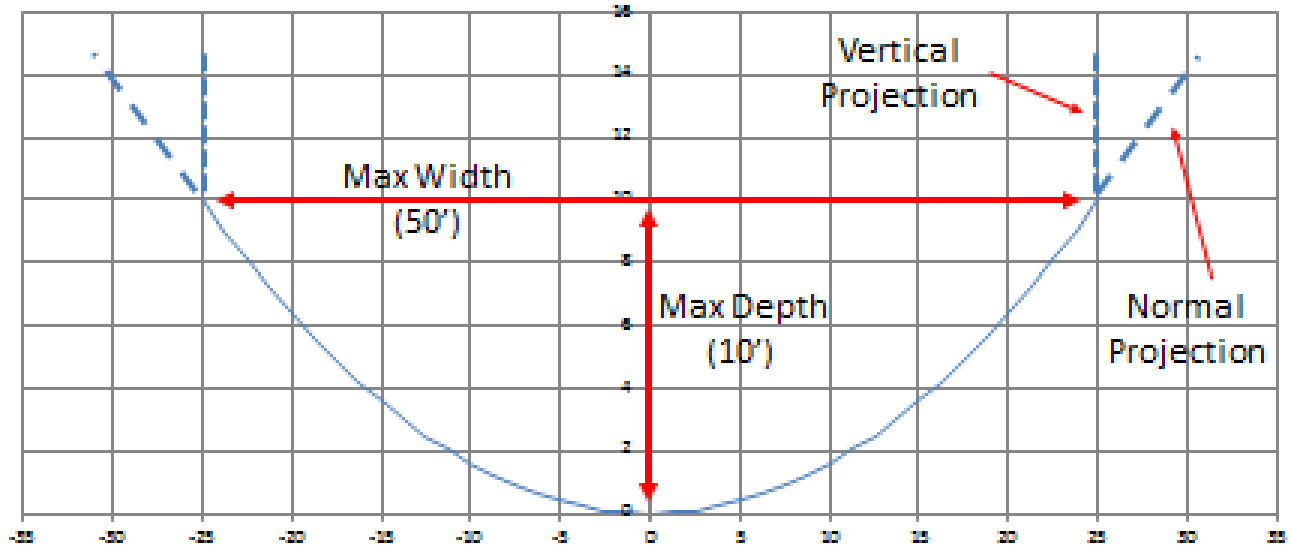


Wetted Perimeter Held Constant Above Max Depth

Channel Links

Geometric Considerations

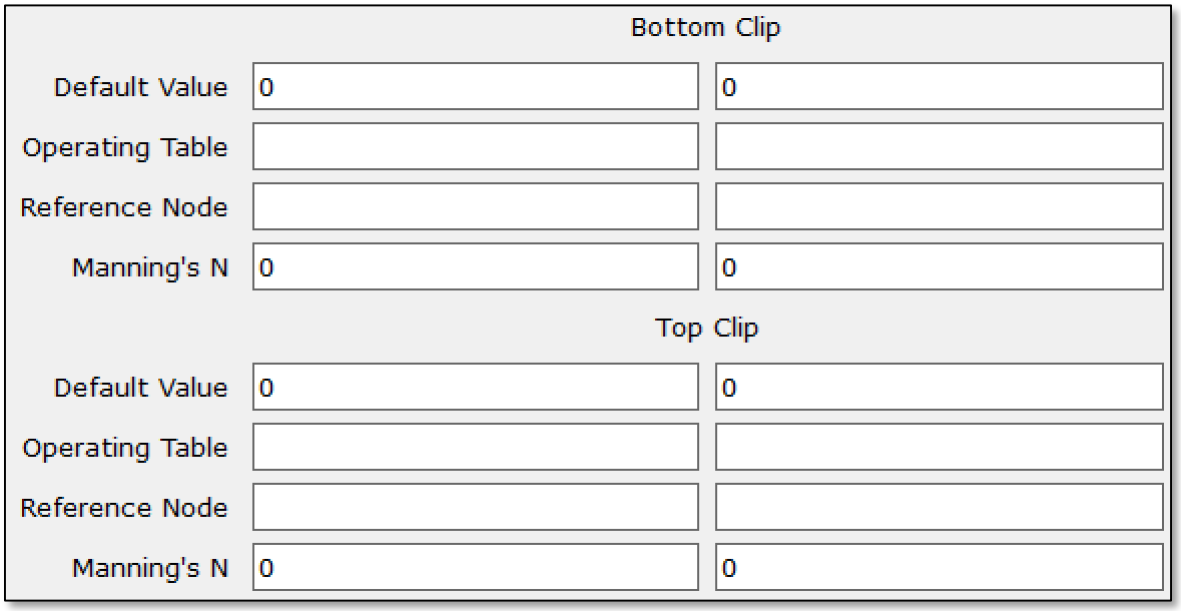
Parabolic



Wetted Perimeter Held Constant Above Max Depth

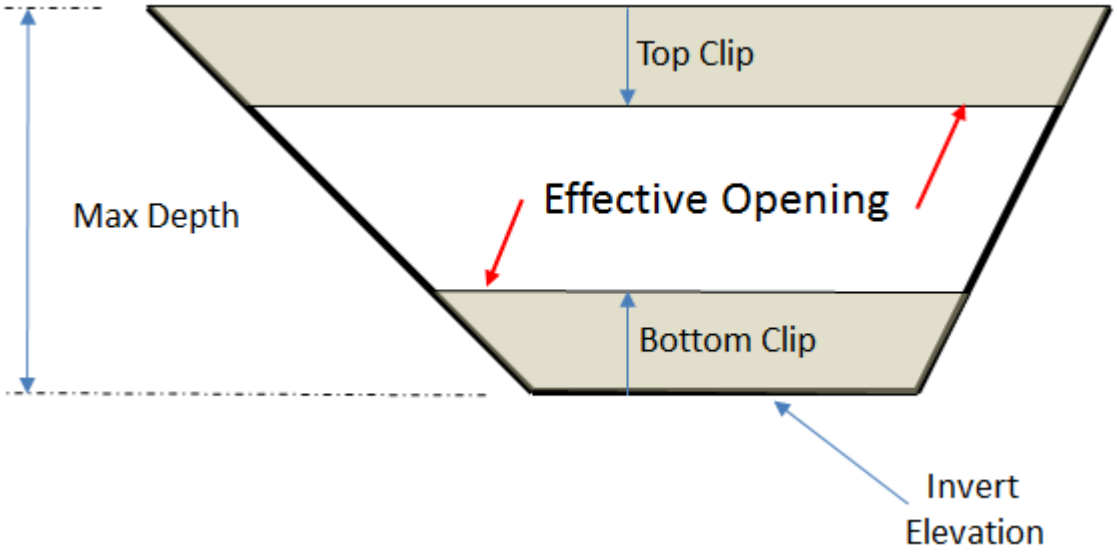
Pipe & Channel Links

Bottom and Top Clips



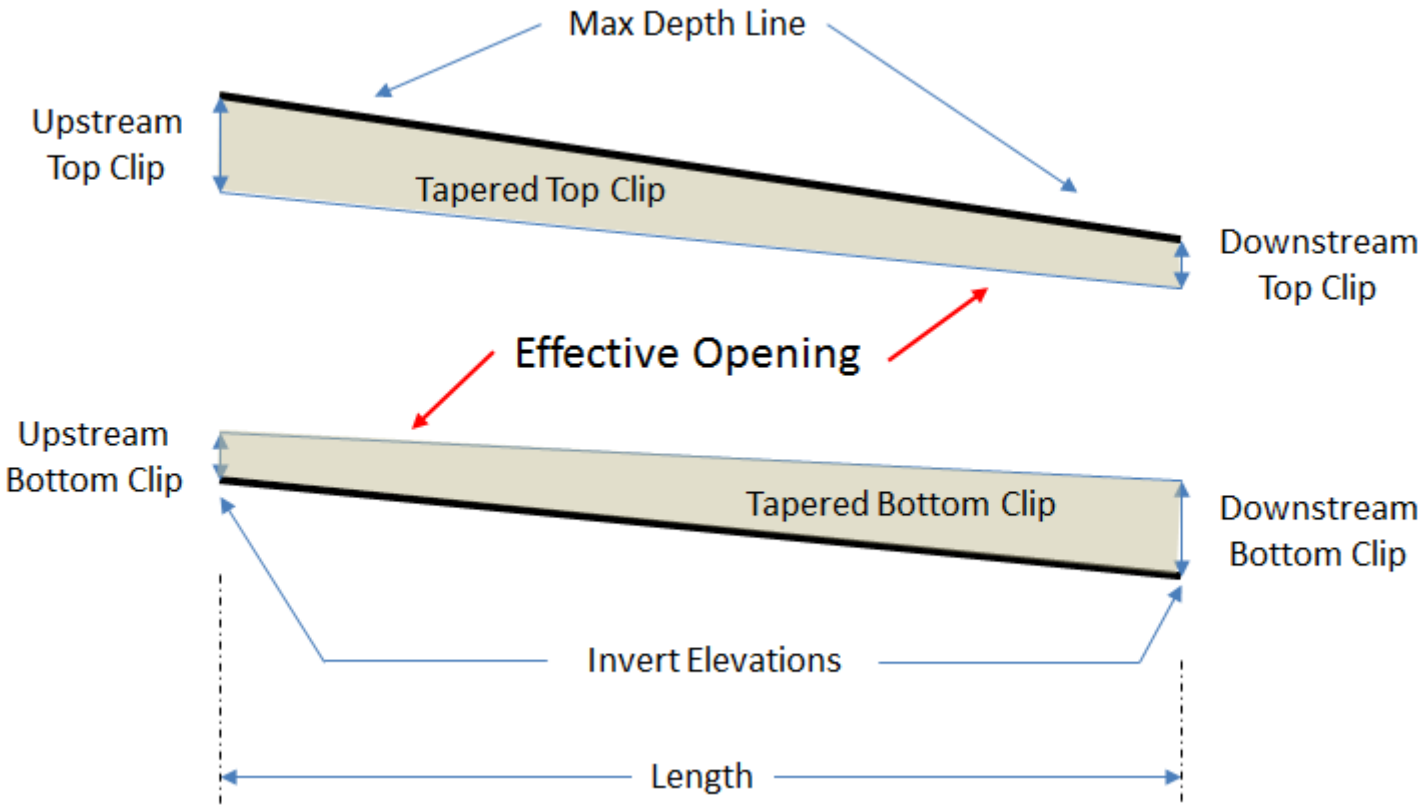
Pipe & Channel Links

Bottom and Top Clips



Pipe & Channel Links

Bottom and Top Clips



Channel Links

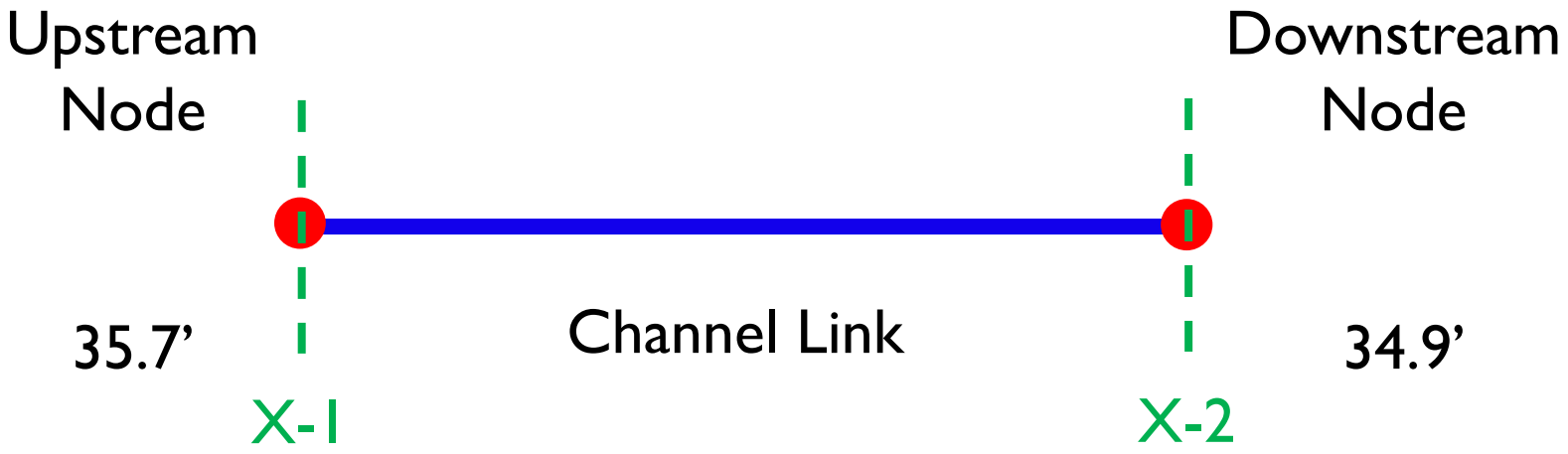
Placement of Irregular Cross Sections

Channel invert elevations are specified at each end of a channel link.

Channel Links

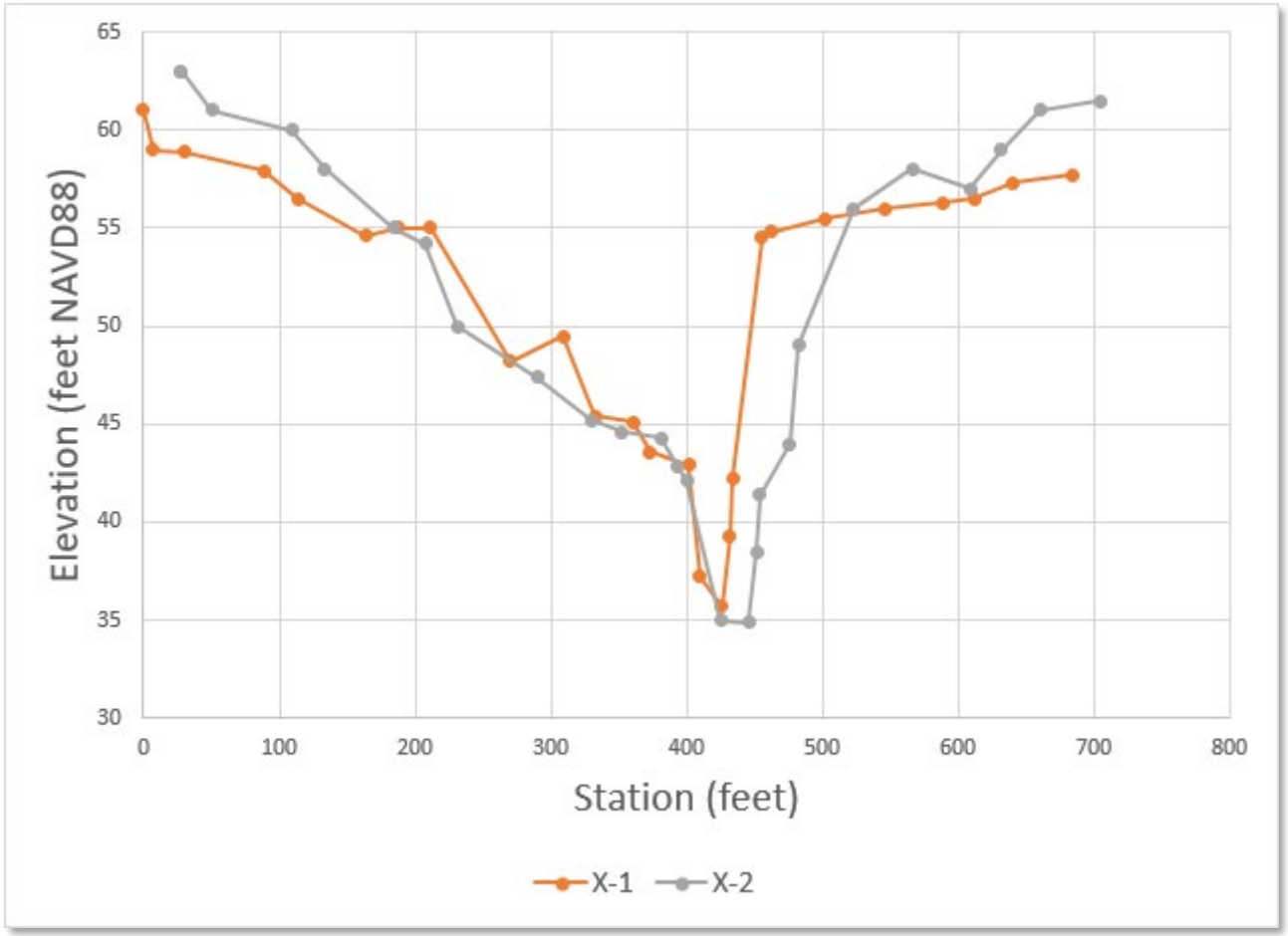
Placement of Irregular Cross Sections

Typically, different cross sections are used at each end of the link for natural channels.



Channel Links

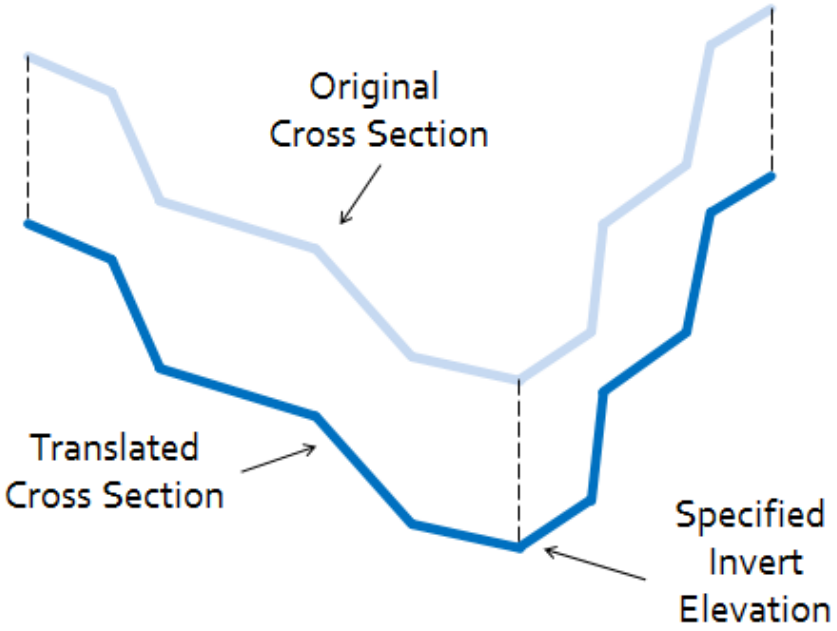
Placement of Irregular Cross Sections



Channel Links

Placement of Irregular Cross Sections

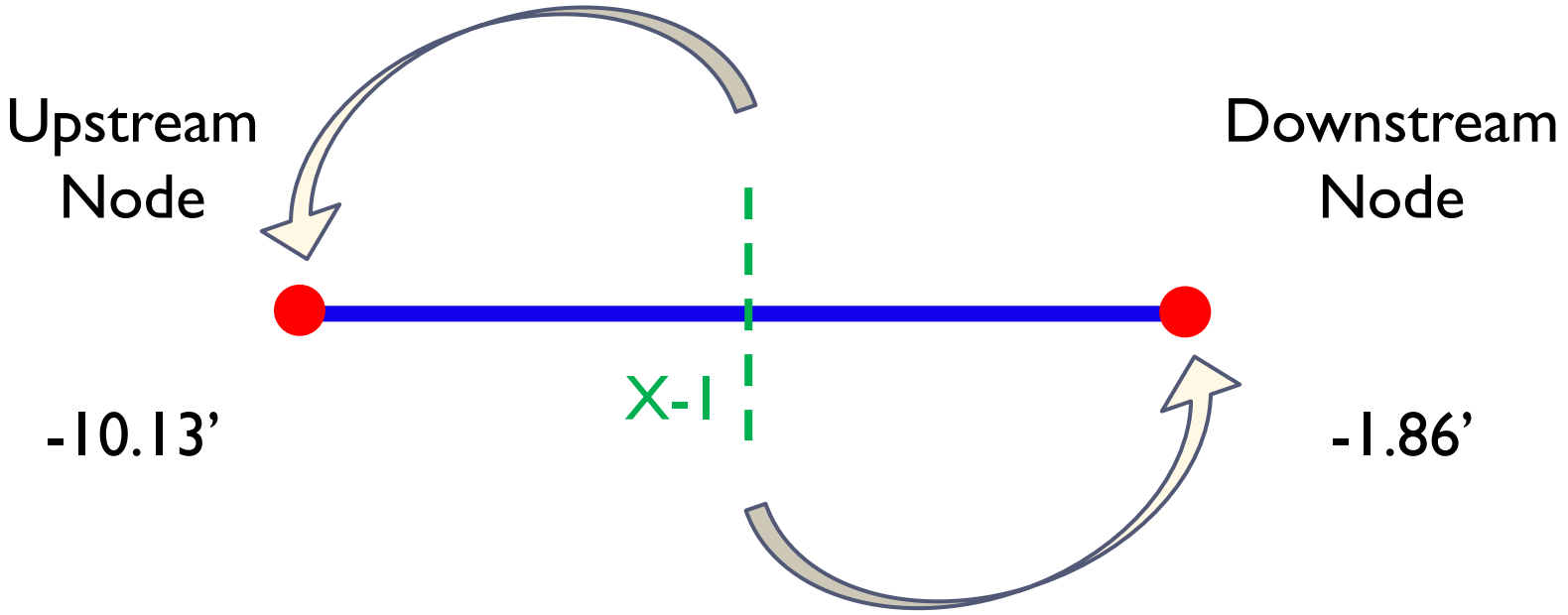
If a channel invert elevation is different than the low elevation of the corresponding channel cross section, then every data point in the cross section is translated vertically by a distance equal to the difference in elevation between the invert and the low spot on the cross section, including overbank areas.



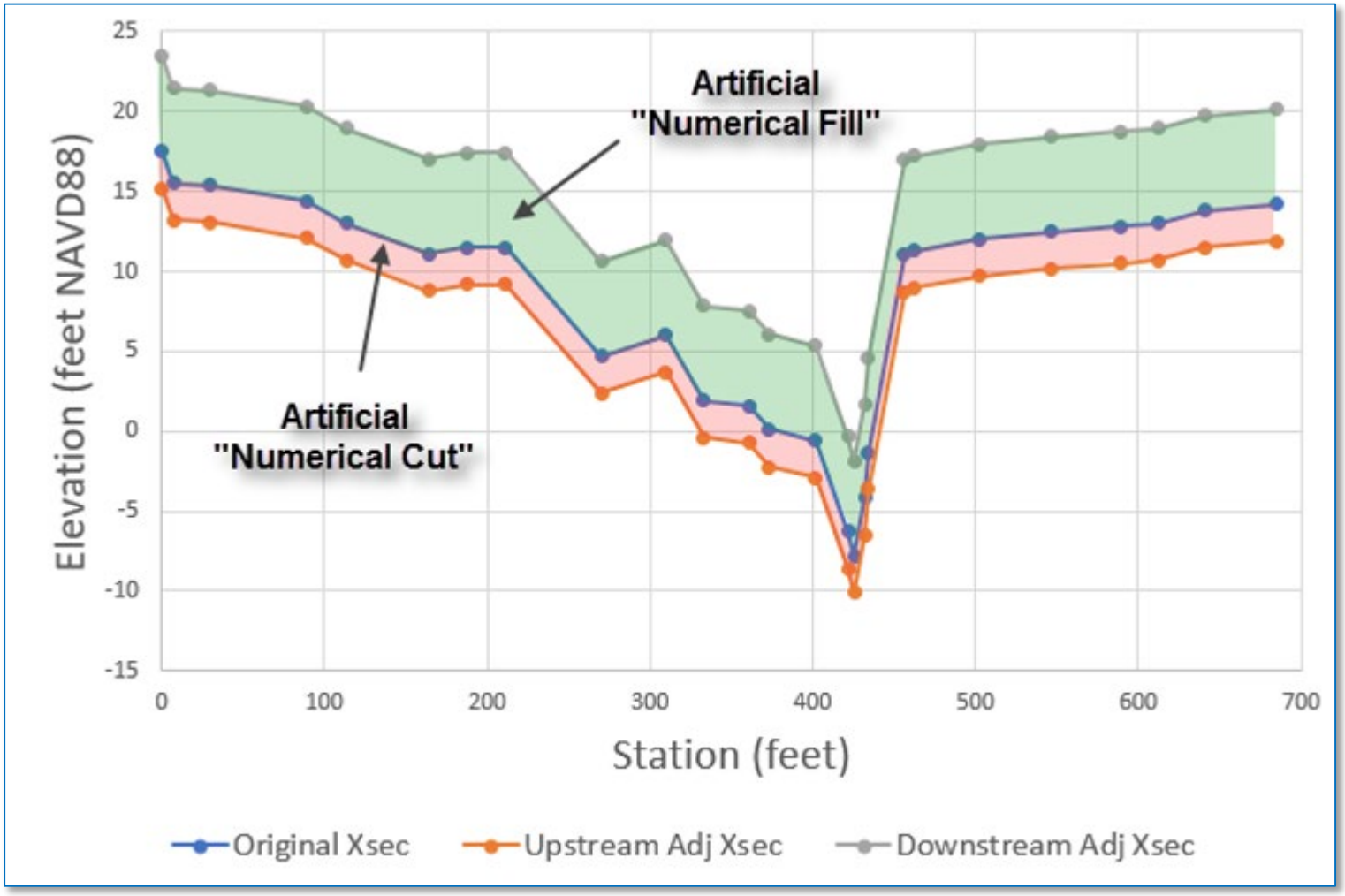
Channel Links

Placement of Irregular Cross Sections

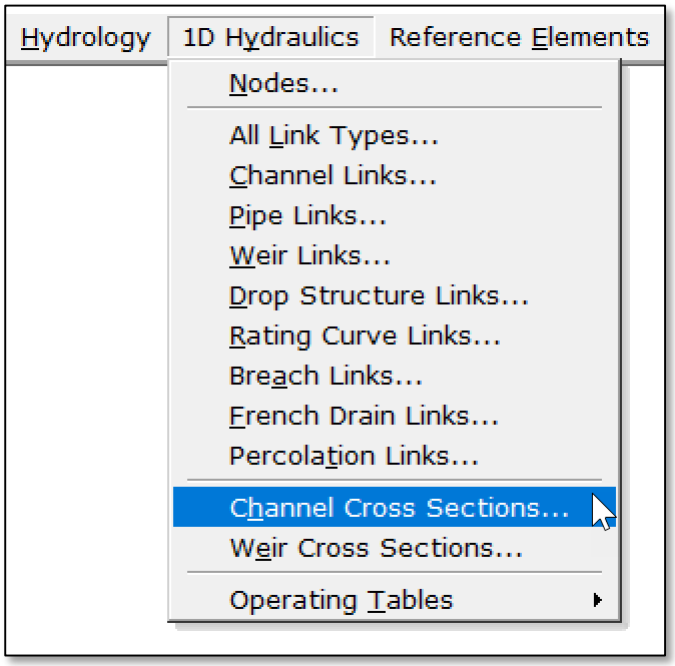
Be careful when applying the same cross section to both ends of a channel link!



If the terrain in the overbank areas does not follow the slope along the channel bottom, artificial cuts and fills can occur and potentially produce erroneous results.

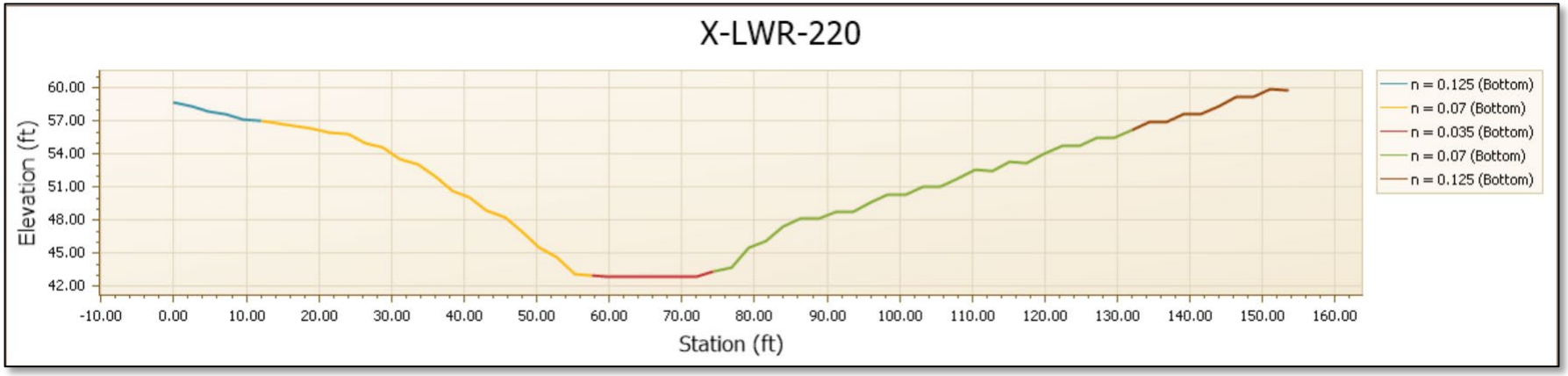


Channel Cross Sections



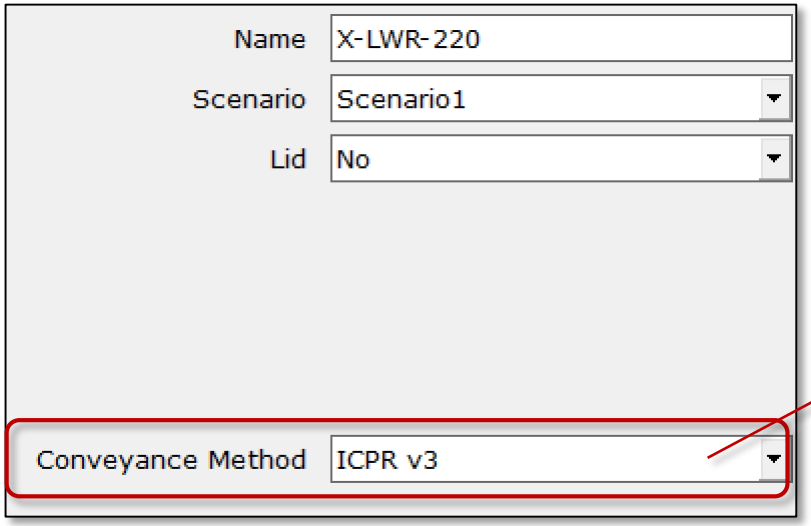
Cross Section Bottom Point Edit

Order	Station	Elevation	Manning's N
0	0	58.666241	0.125
1	2.398465	58.337521	0.125
2	4.79693	57.895653	0.125
3	7.195395	57.579197	0.125
4	9.593861	57.14188	0.125
5	11.992326	57.026146	0.125
6	14.390791	56.832737	0.07
7	16.789256	56.523327	0.07
8	19.187721	56.328396	0.07
9	21.586186	56.005196	0.07
10	23.984652	55.806759	0.07
11	26.383117	54.958363	0.07
12	28.781582	54.635201	0.07



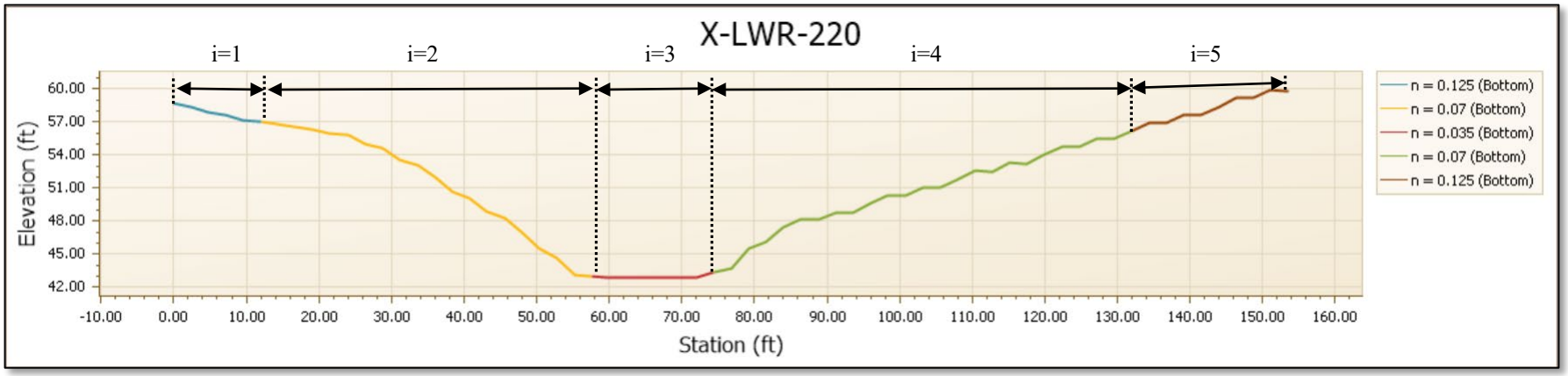
Channel Cross Sections

Conveyance Method "ICPR v3"



subdivides the conveyance calculation based on roughness

$$K = \sum_{i=1,S} \left[\frac{1.486 R_i^{2/3} A_i}{n_i} \right]$$



Channel Cross Sections

Conveyance Method "HEC-RAS"

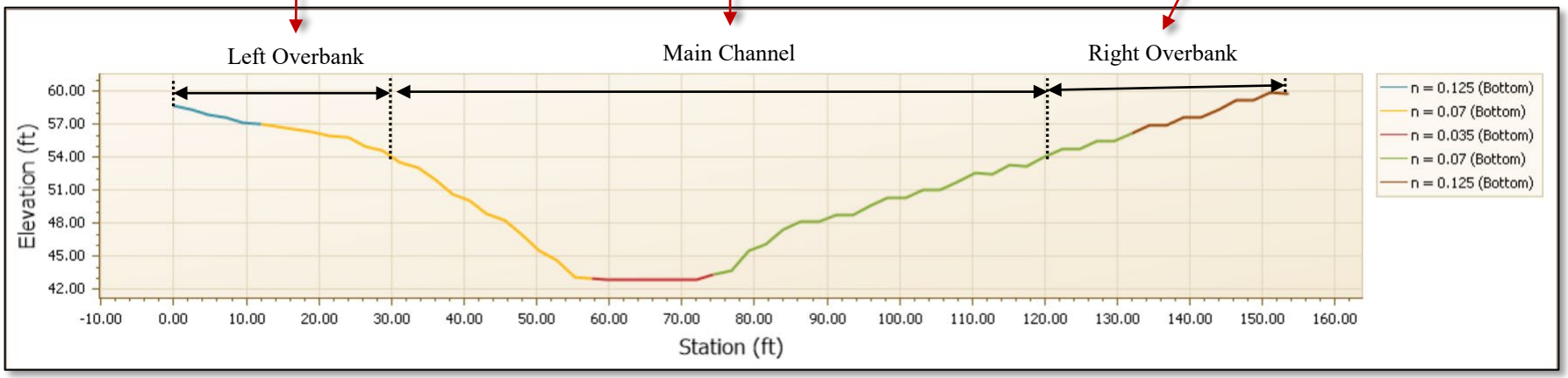
Conveyance Method	HEC-RAS
Left Overbank Station	30
Right Overbank Station	120

Composite n-value used for the main channel if side slopes steeper than 5H:1V

$$K = \sum_{i=1,S}\left[\frac{1.486 R_i^{2/3} A_i}{n_i}\right]$$

$$n_c = \left[\frac{\sum_{i=1,S}(P_i n_i^{1.5})}{P}\right]^{2/3}$$

$$K = \sum_{i=1,S}\left[\frac{1.486 R_i^{2/3} A_i}{n_i}\right]$$

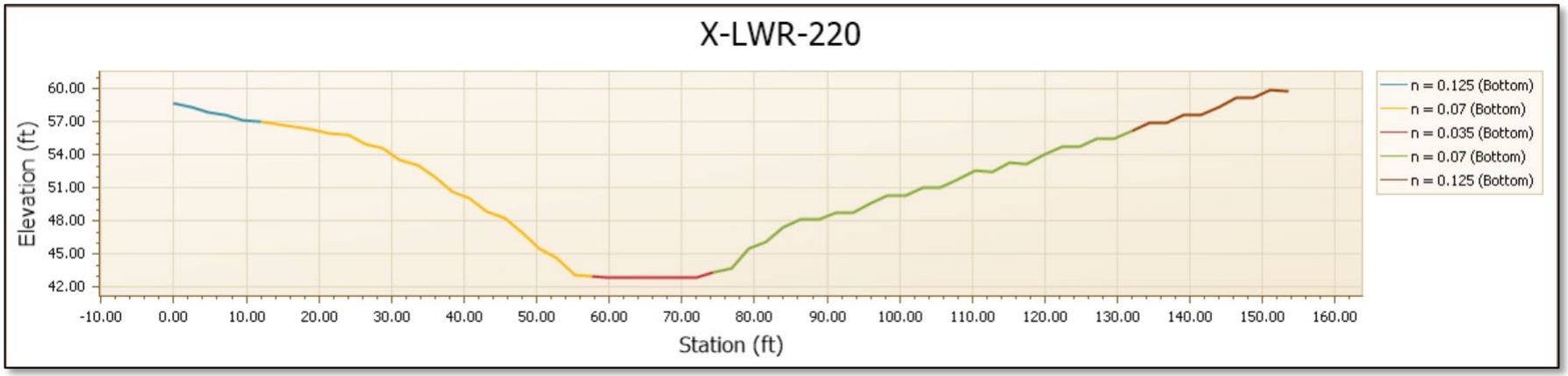


Channel Cross Sections

Conveyance Method "Composite Manning's n"

$$n_c = \left[\frac{\sum_{i=1,S} (P_i n_i^{1.5})}{P} \right]^{2/3}$$

The composite Manning's n conveyance method calculates a composite n-value and conveyance at each unique elevation included in the data entered for the cross section by the user.

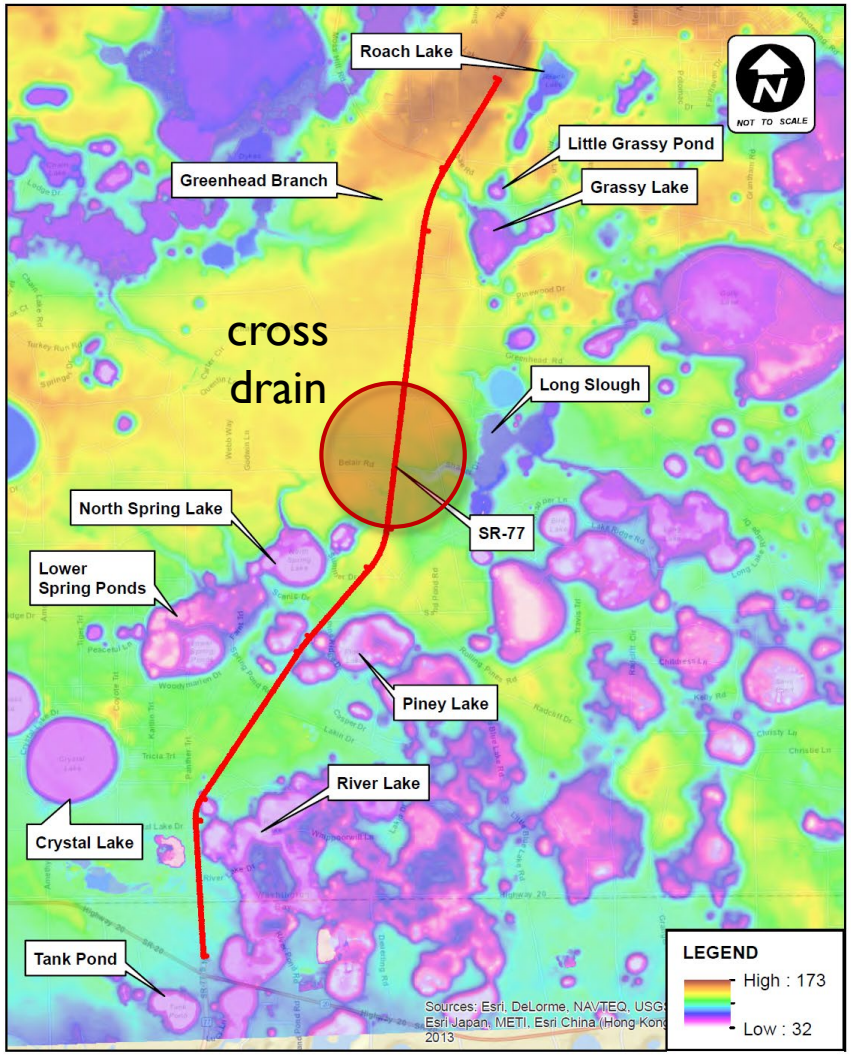


Example #1

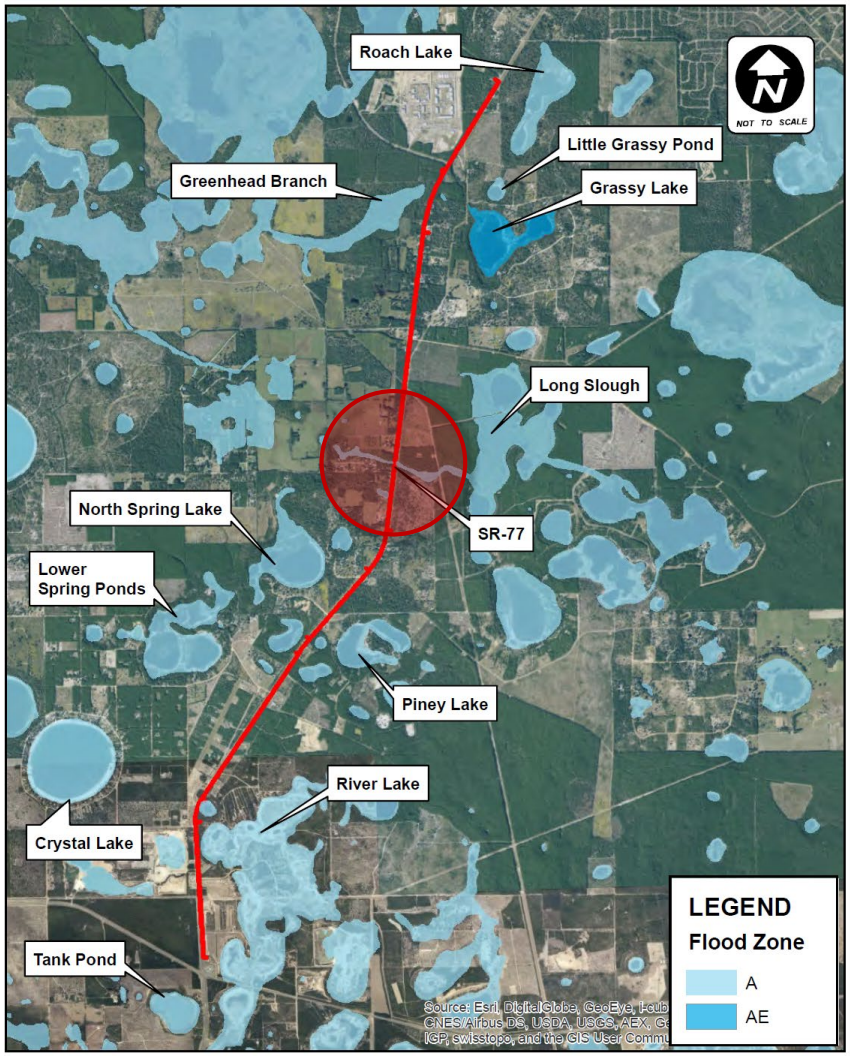
Highway Cross Drain & Channel

Acknowledgement:

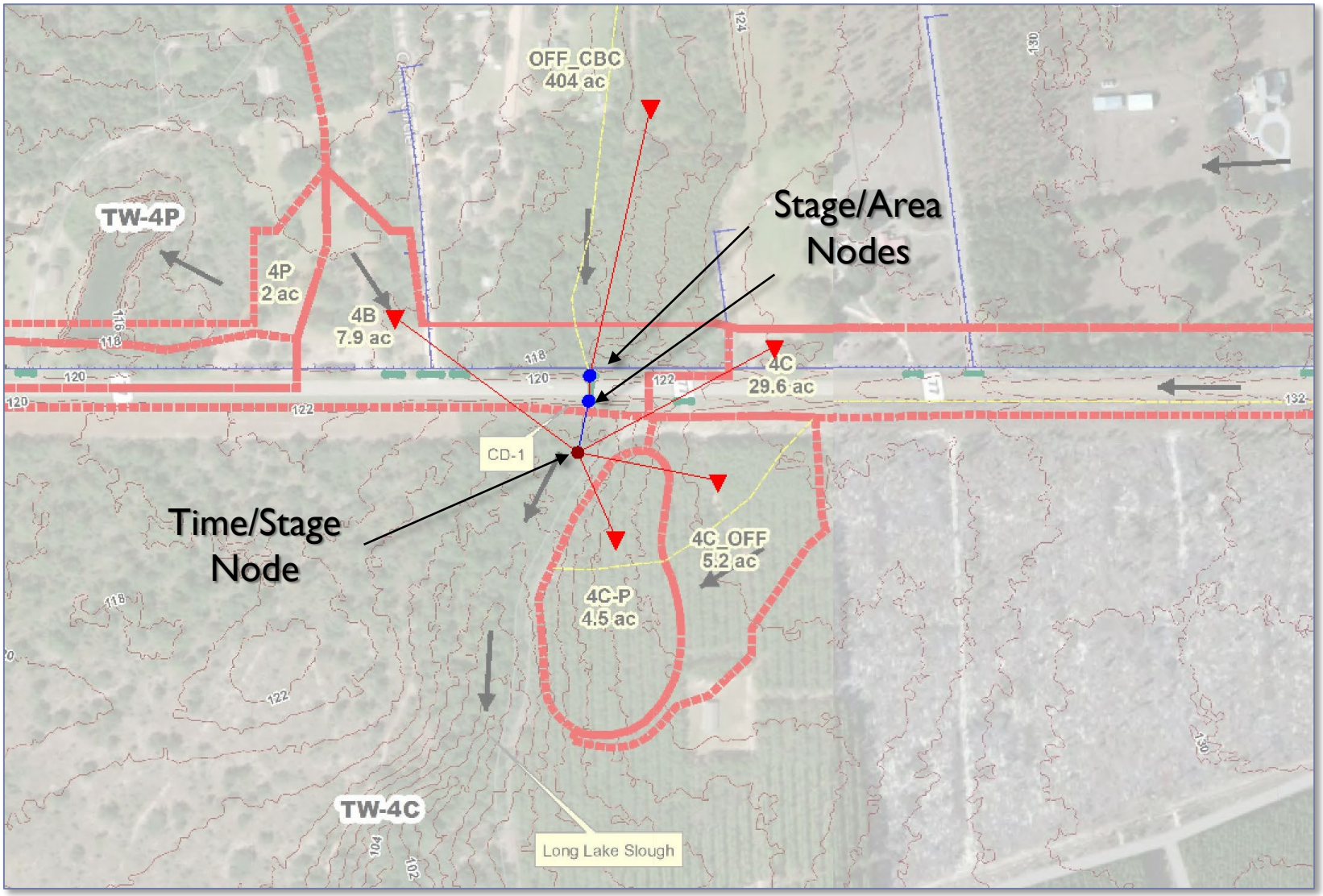
ATKINS
Drainage Report
SR 77, from Bay County Line to North of CR 279
Washington County, Florida

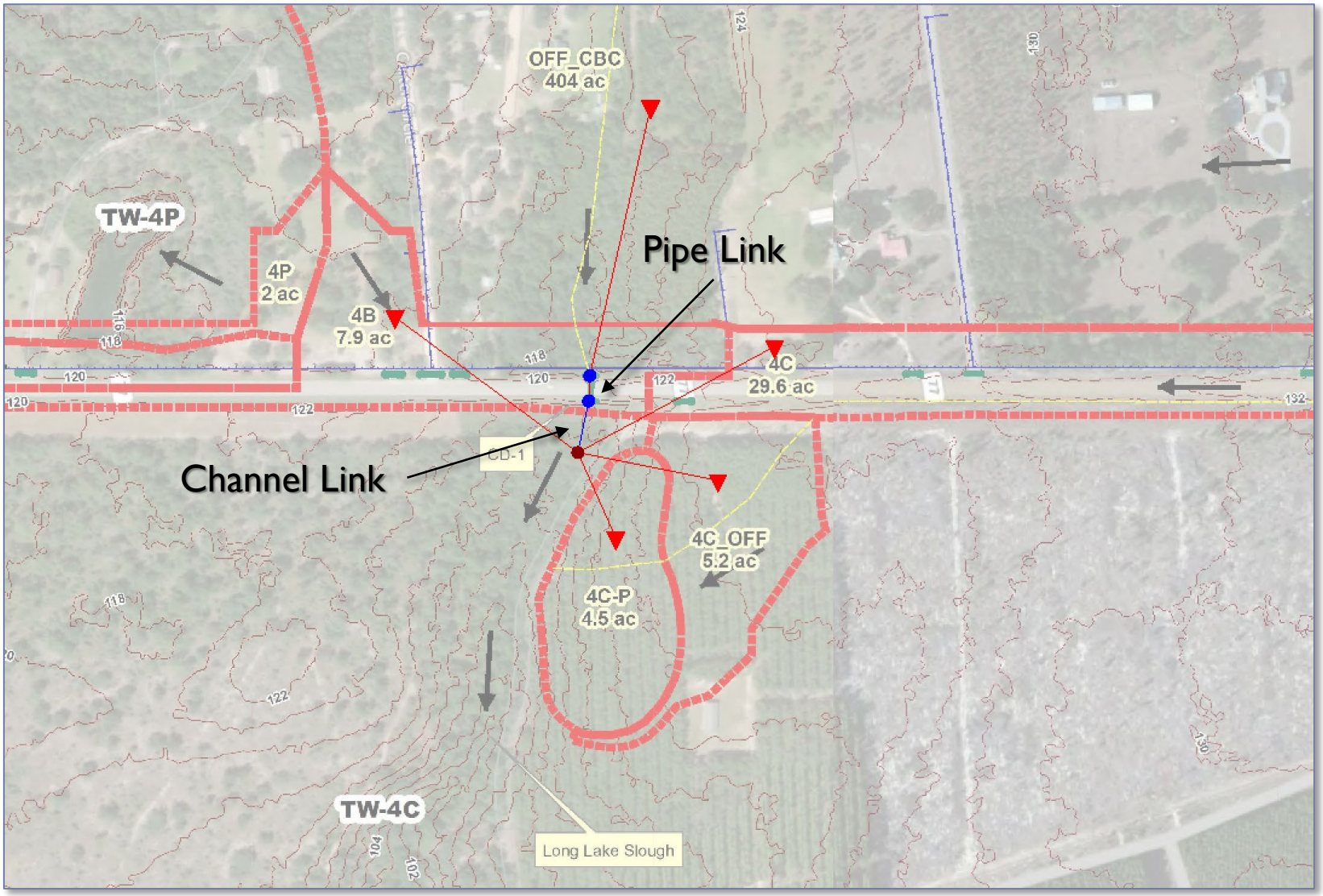


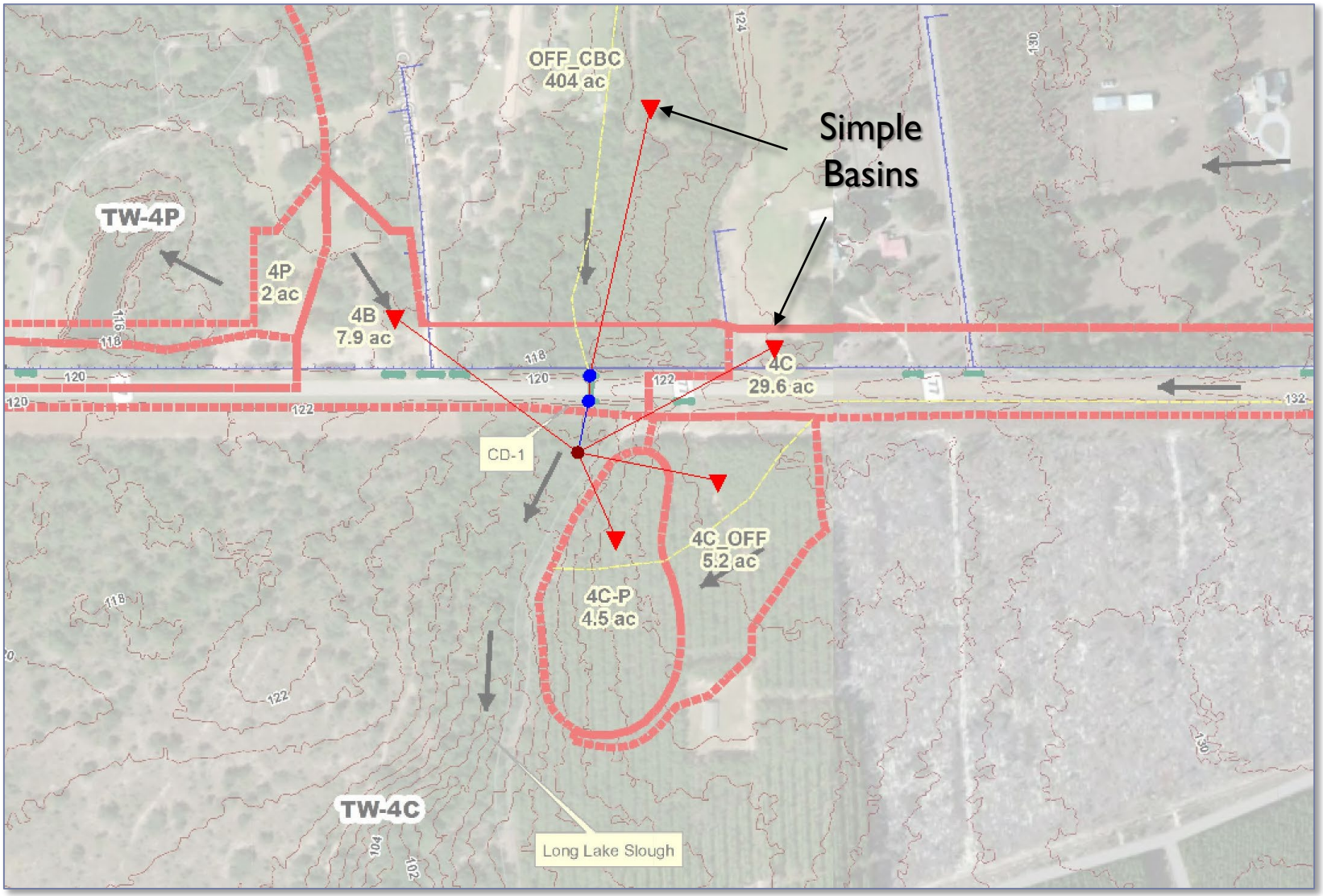
SR-77 BAY CO. LINE TO CR 279 WASHINGTON COUNTY	FIGURE 4 TOPOGRAPHY MAP



SR-77 BAY CO. LINE TO CR 279 WASHINGTON COUNTY	FIGURE 6 FEMA FLOODPLAIN MAP







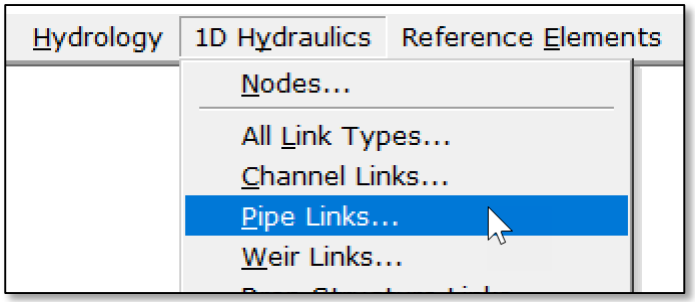
Simple Basin Data Form

Name	OFF_CBC
Scenario	Cross Drain
Node	US CROSSDRAIN
Hydrograph Method	NRCS Unit Hydrograph
Infiltration Method	Curve Number
Time of Concentration	165
Max Allowable Q	999999
Time Shift	0
Unit Hydrograph	Uh256
Peaking Factor	256
Area	404
Curve Number	43
% Impervious	0
% DCIA	0
% Direct	0
Rainfall Name	

CN Worksheet

BASIN ID	LANDUSE TYPE	STATUS	Area (ac)	Impervious (ac)	Pervious (ac)	SOIL GROUP	CN	CN x A	CCN
OFF_CBC	Open-Space	ROW	0.29			A	39	11.43	
OFF_CBC	Roads-Dirt	ROW	0.02			A	72	1.38	
OFF_CBC	Woods	ROW	0.20			A	30	6.14	
OFF_CBC	Open-Space	ROW	1.99			A/D	80	158.91	
OFF_CBC	Impervious	ROW	0.14			A/D	98	13.47	
OFF_CBC	Woods	ROW	0.13			A/D	77	9.72	
		ROW Total	**2.77**	0.16	2.61				
OFF_CBC	Woods	OFFSITE	88.05			A	30	2641.51	
OFF_CBC	Woods-Tree Farm	OFFSITE	82.05			A	35	2871.90	
OFF_CBC	Woods-Grass	OFFSITE	9.82			A	45	442.01	
OFF_CBC	Roads-Dirt	OFFSITE	4.18			A	72	301.09	
OFF_CBC	Open-Space	OFFSITE	154.46			A	39	6023.94	
OFF_CBC	Impervious	OFFSITE	1.42			A	98	139.24	
OFF_CBC	Fallow	OFFSITE	43.87			A	77	3377.98	
OFF_CBC	Roads-Dirt	OFFSITE	0.27			A/D	89	24.12	
OFF_CBC	Woods	OFFSITE	5.04			A/D	77	387.83	
OFF_CBC	Impervious	OFFSITE	0.37			A/D	98	36.26	
OFF_CBC	Open-Space	OFFSITE	11.86			A/D	80	949.05	
		OFFSITE Total	**401.40**	5.97	395.43				
OFF_CBC Total			**404.17**	**6.13**	**398.04**			17395.97	**43.0**

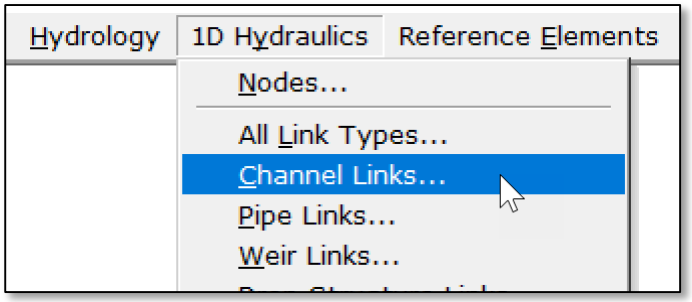
Pipe Data Form



Name	CROSSDRAIN
Scenario	Cross Drain
From Node	US CROSSDRAIN
To Node	DS CROSSDRAIN
Link Count	1
Flow Direction	Both
Damping Threshold	0
Length	66
FHWA Culvert Code	9
Entrance Loss Coefficient	0.5
Exit Loss Coefficient	0.5
Bend Loss Coefficient	0
Bend Location	0
Energy Switch	Energy

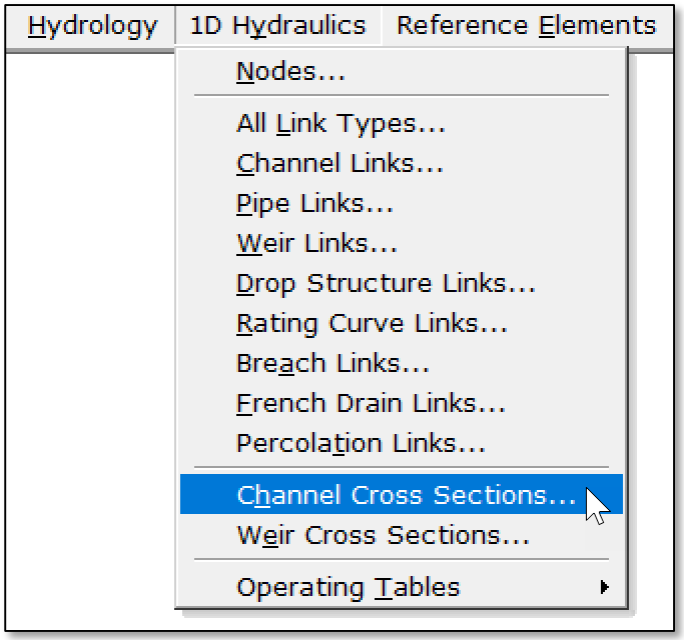
	Upstream	Downstream
Invert	113.82	114.35
Manning's N	0.012	0.012
Geometry		
Type	Rectangular	Rectangular
Max Depth	4	4
Max Width	5	5
Fillet	0	0

Channel Data Form

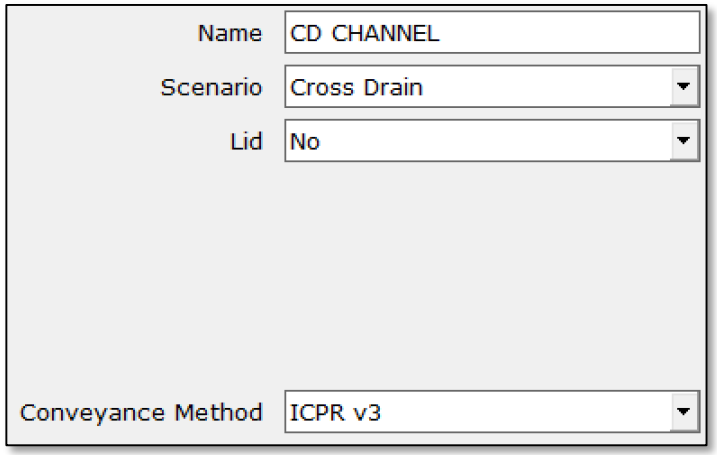


Name	DITCH
Scenario	Cross Drain
From Node	DS CROSSDRAIN
To Node	TW-4C
Link Count	1
Flow Direction	Both
Damping Threshold	0
Length	170
Contraction Coefficient	0.1
Expansion Coefficient	0.3
Entrance Loss Coefficient	0
Exit Loss Coefficient	0
Bend Loss Coefficient	0
Bend Location	0
Energy Switch	Energy

	Upstream	Downstream
Invert	114.35	113.7
	Geometry	
Type	Irregular	Irregular
Main Cross Section	CD CHANNEL	CD CHANNEL

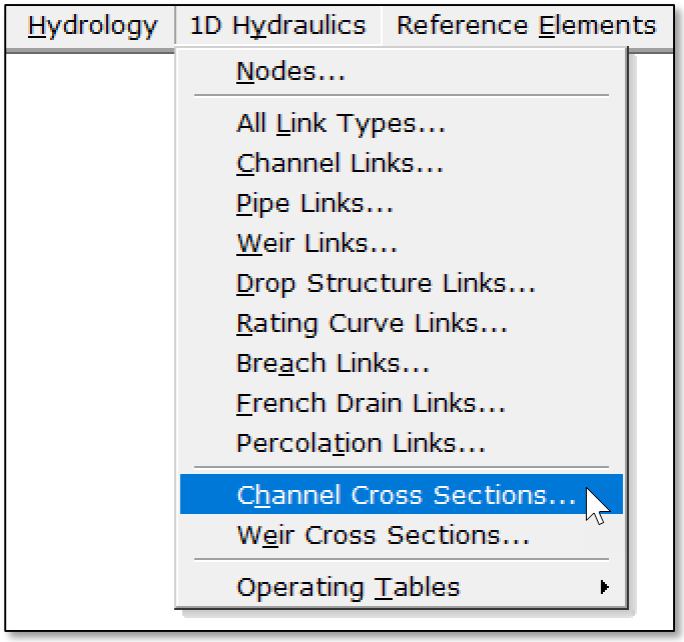


Channel Cross Section Data Form

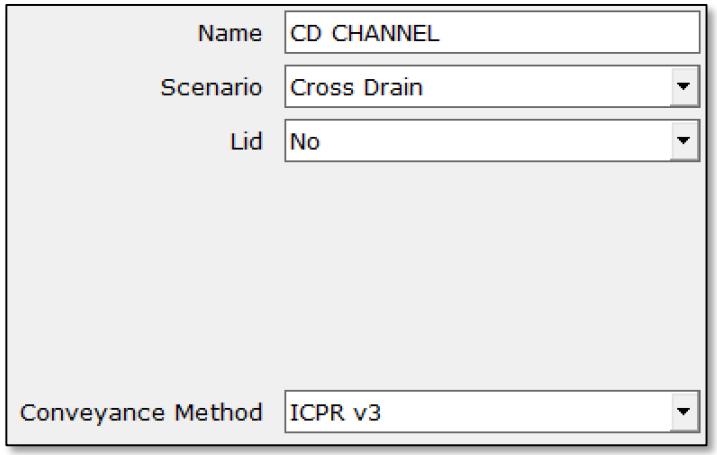


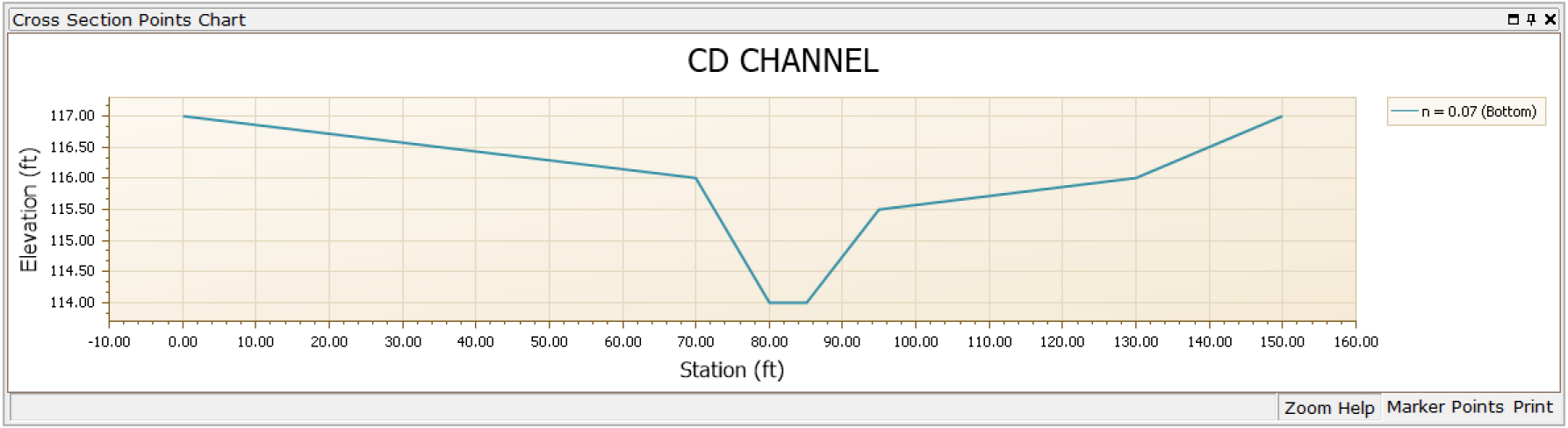
Cross Section Bottom Point Edit

Order	Station	Elevation	Manning's N
0	0	117	0.07
1	70	116	0.07
2	80	114	0.07
3	85	114	0.07
4	95	115.5	0.07
5	130	116	0.07
6	150	117	0.07

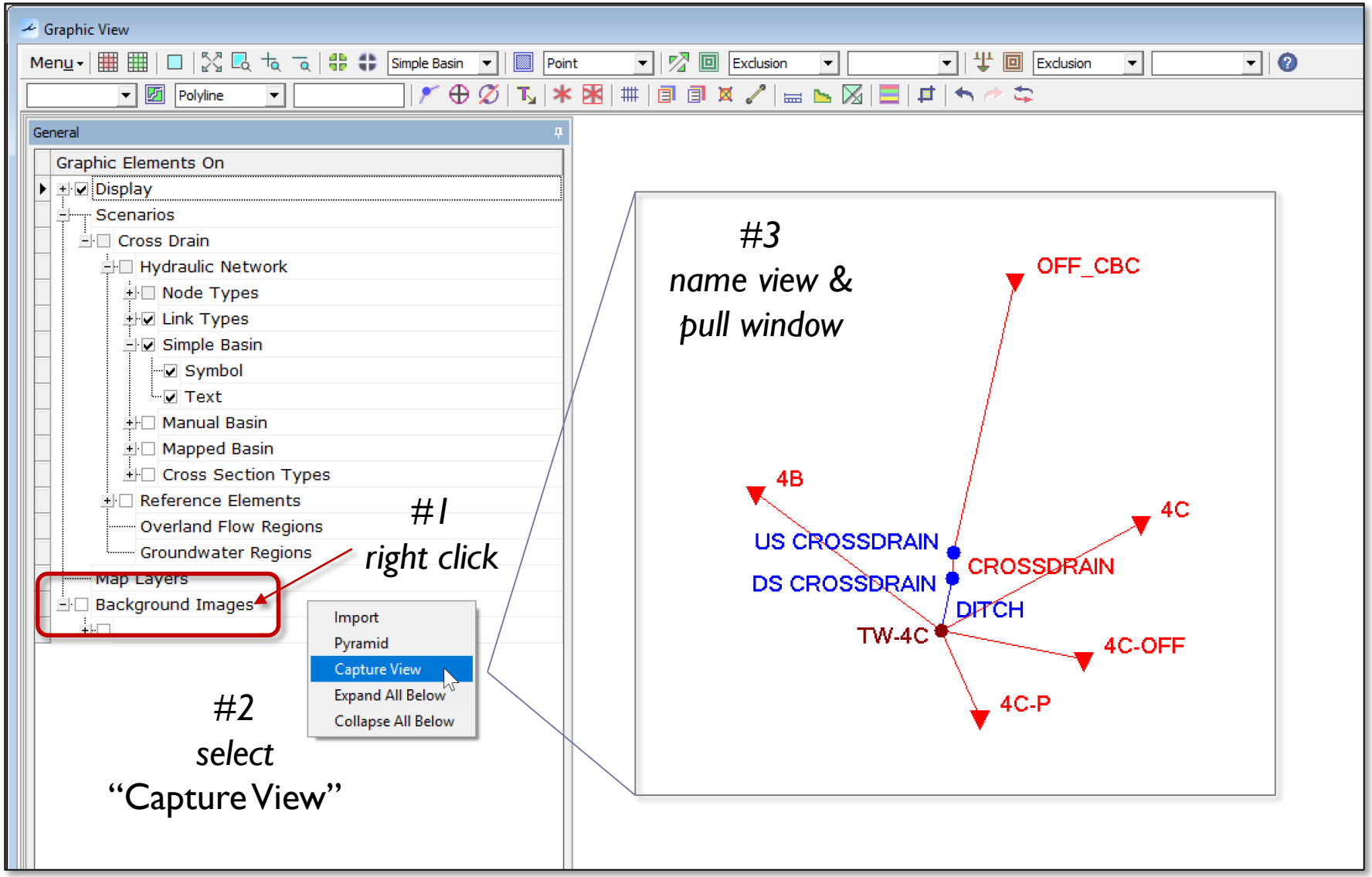


Channel Cross Section Data Form

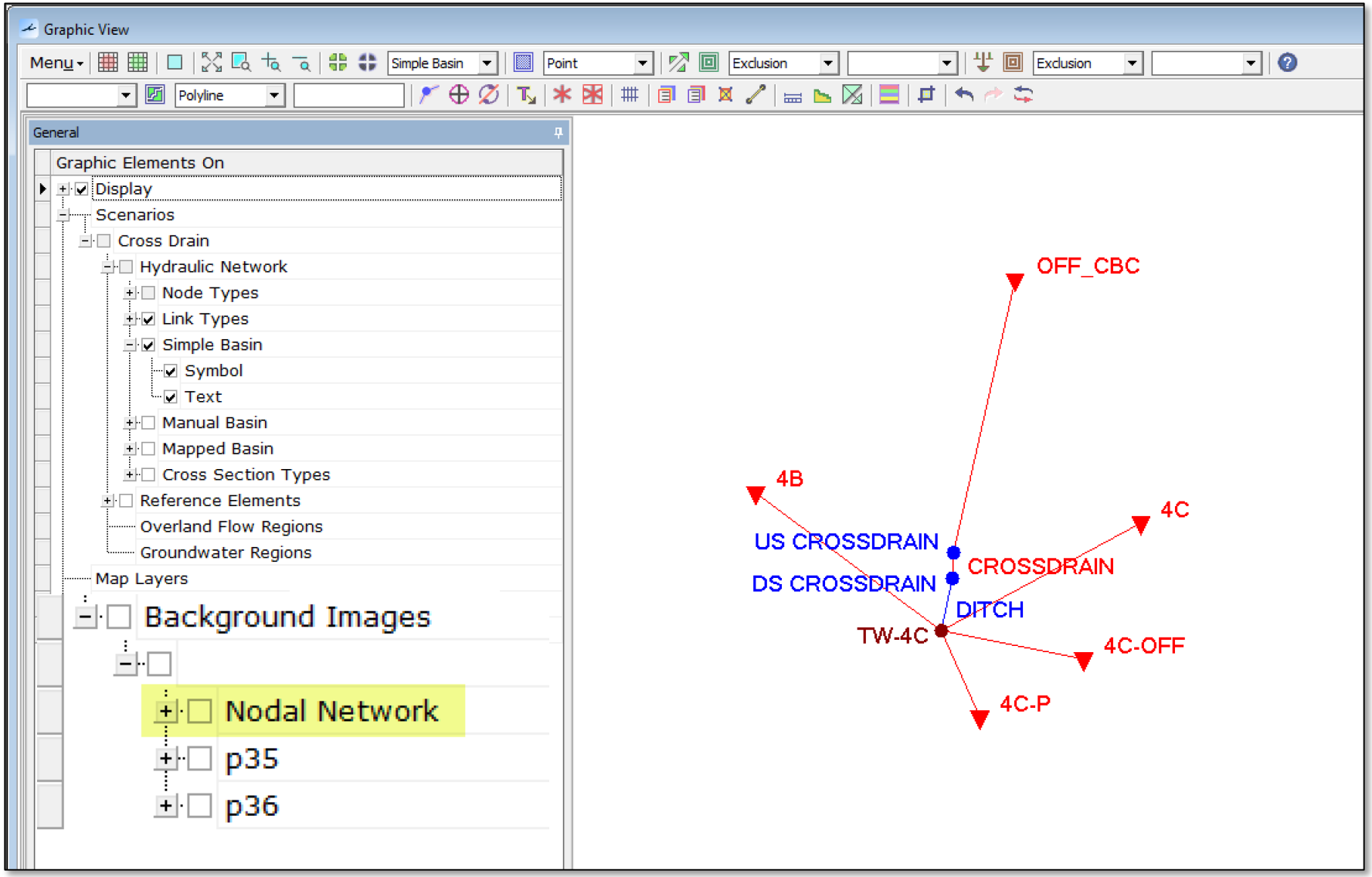




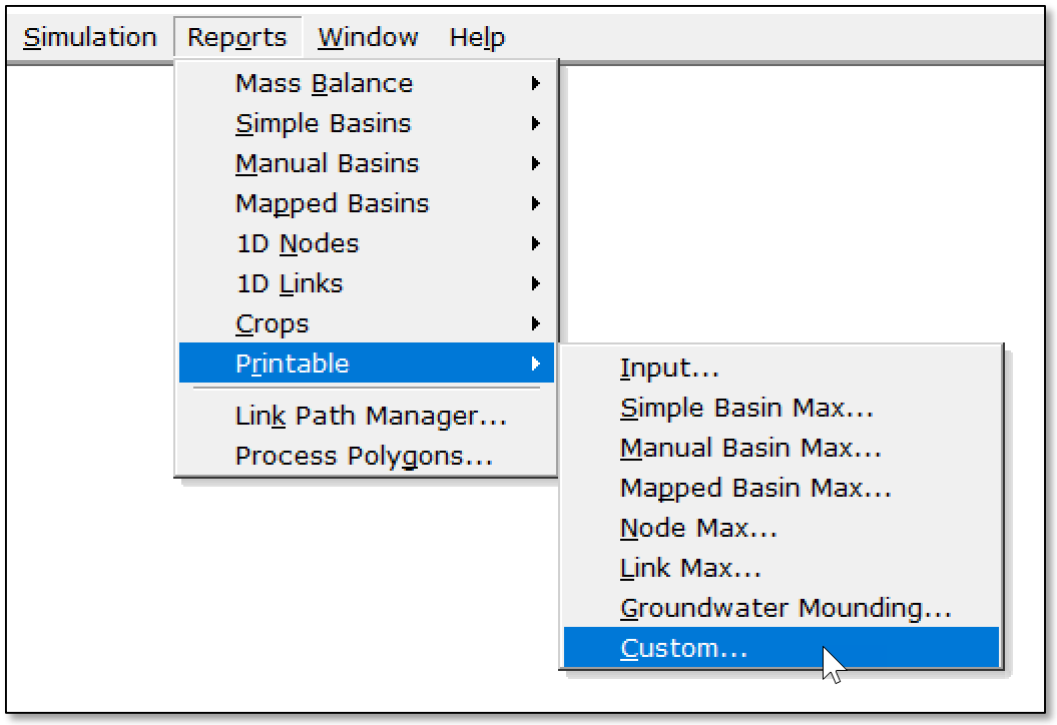
"Capture View" for Custom Report



"Capture View" for Custom Report

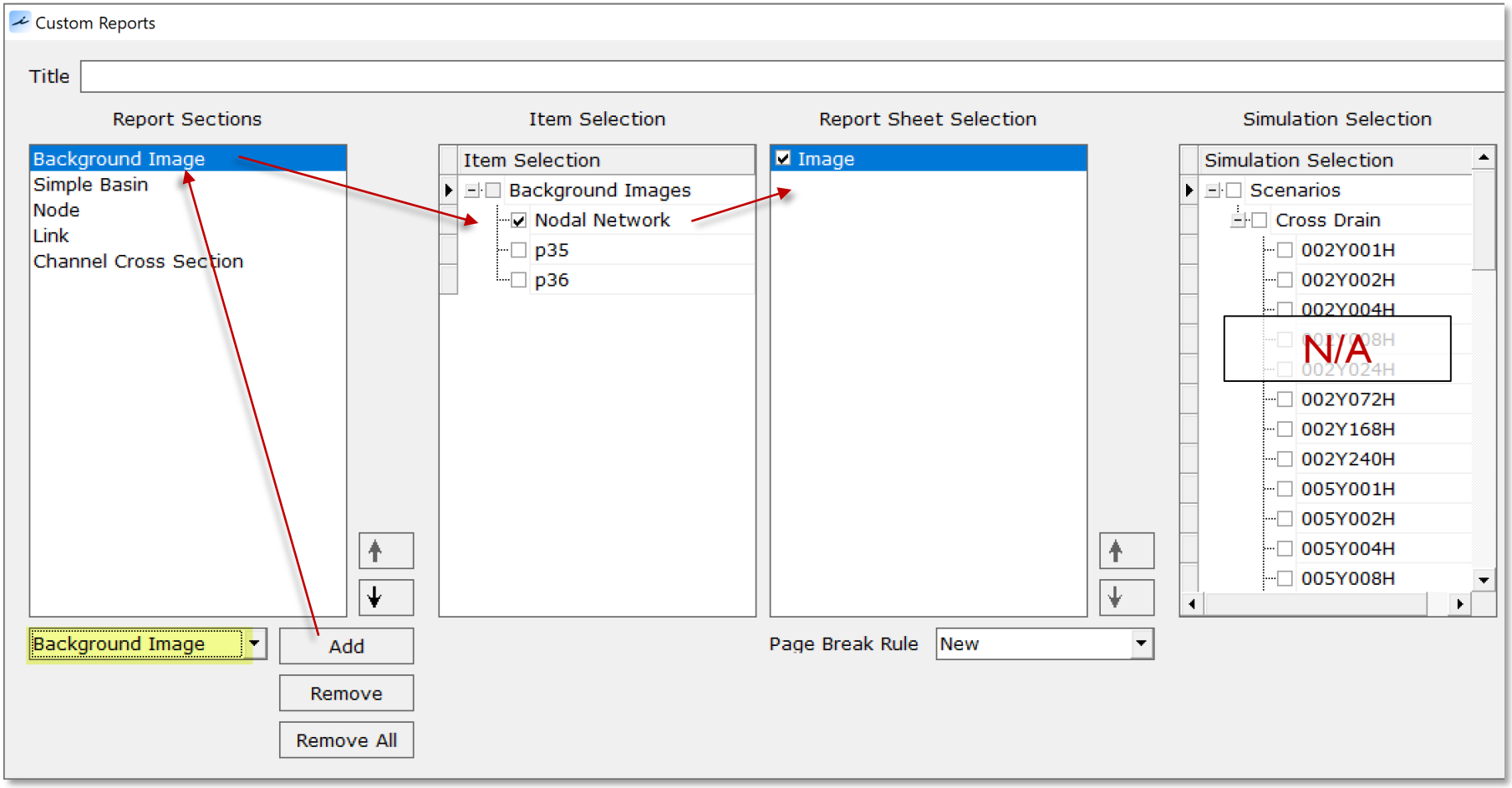


Preparing a Custom Report



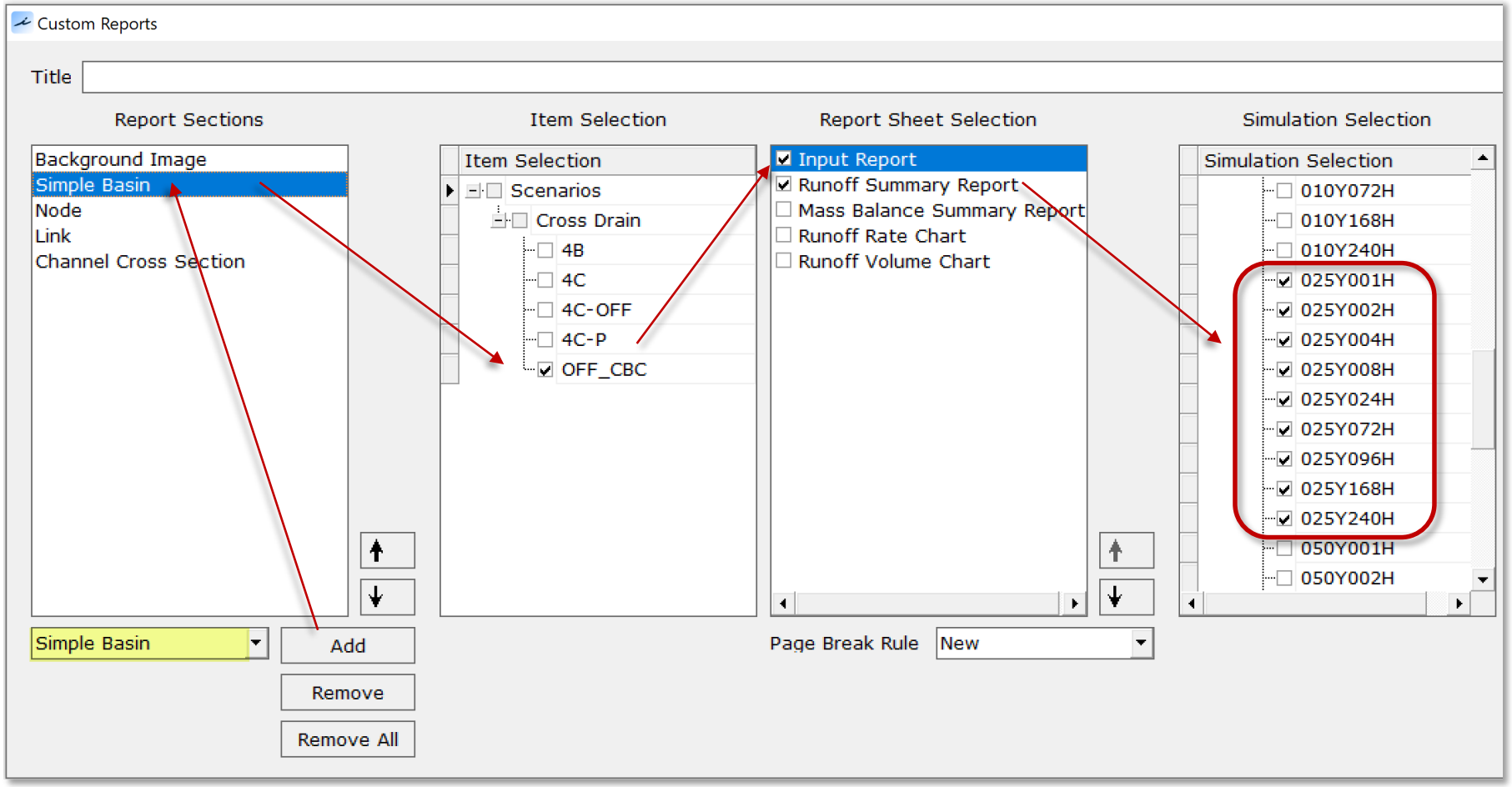
Preparing a Custom Report

Background Image



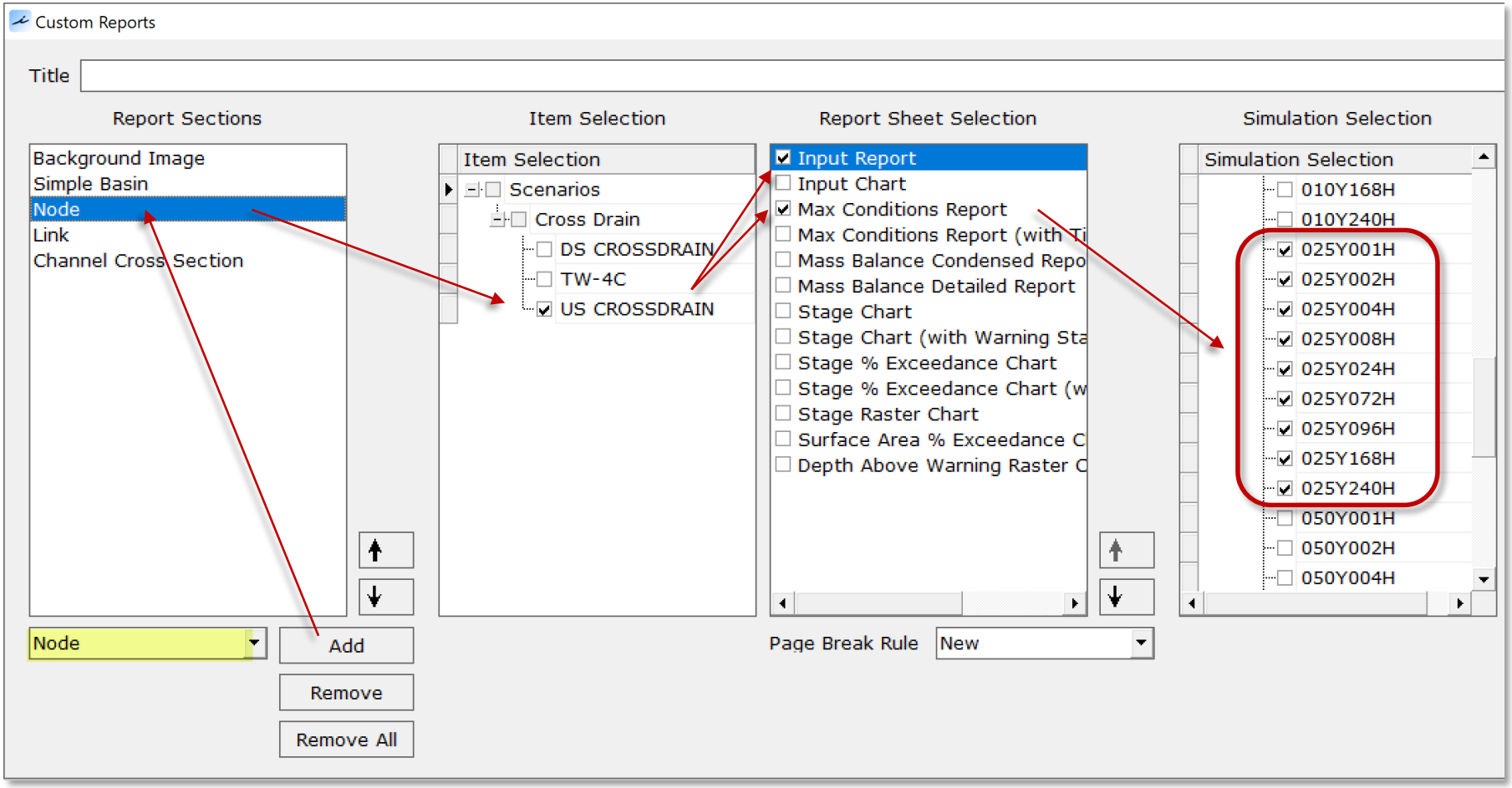
Preparing a Custom Report

Simple Basin



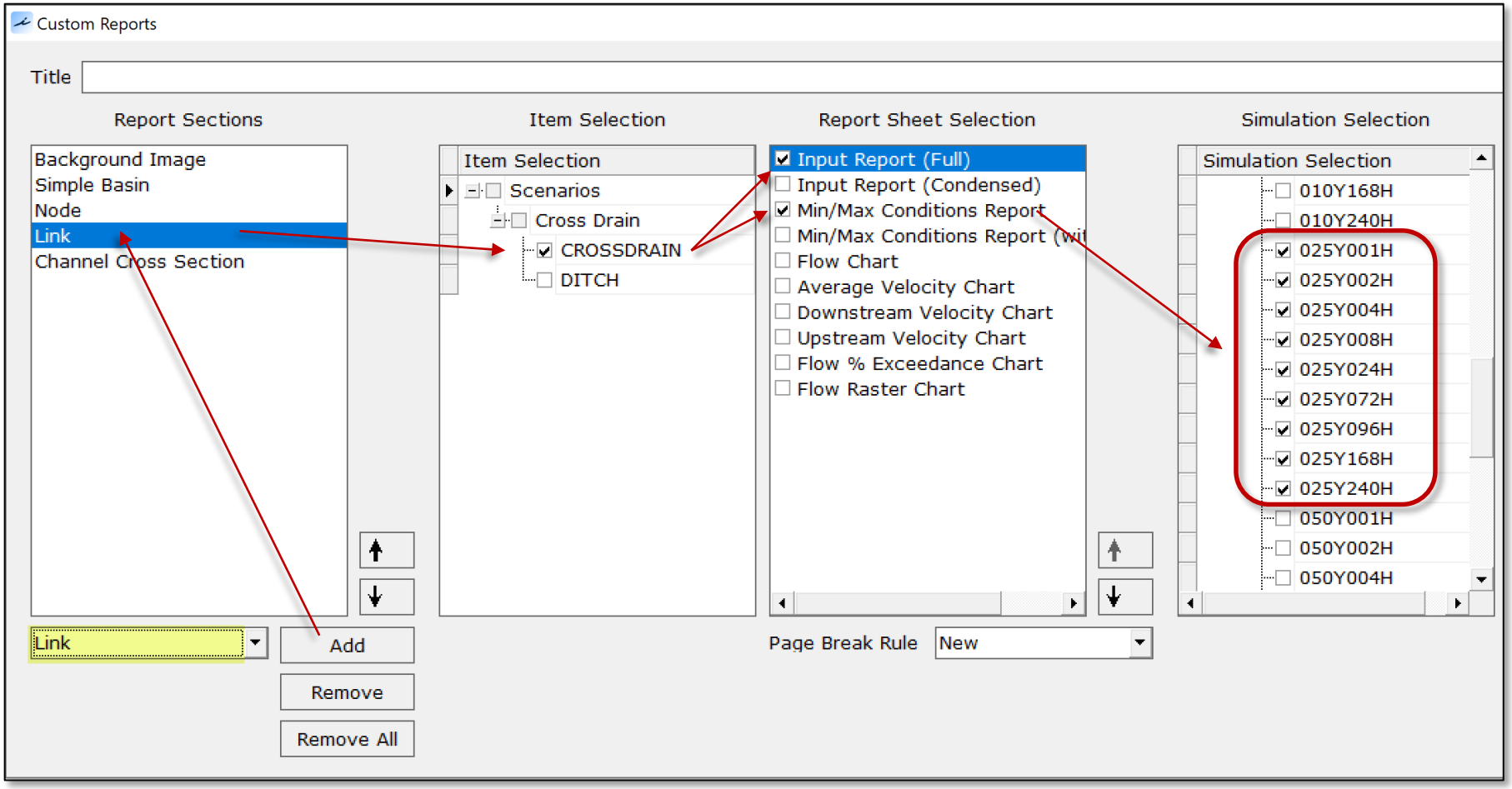
Preparing a Custom Report

Node



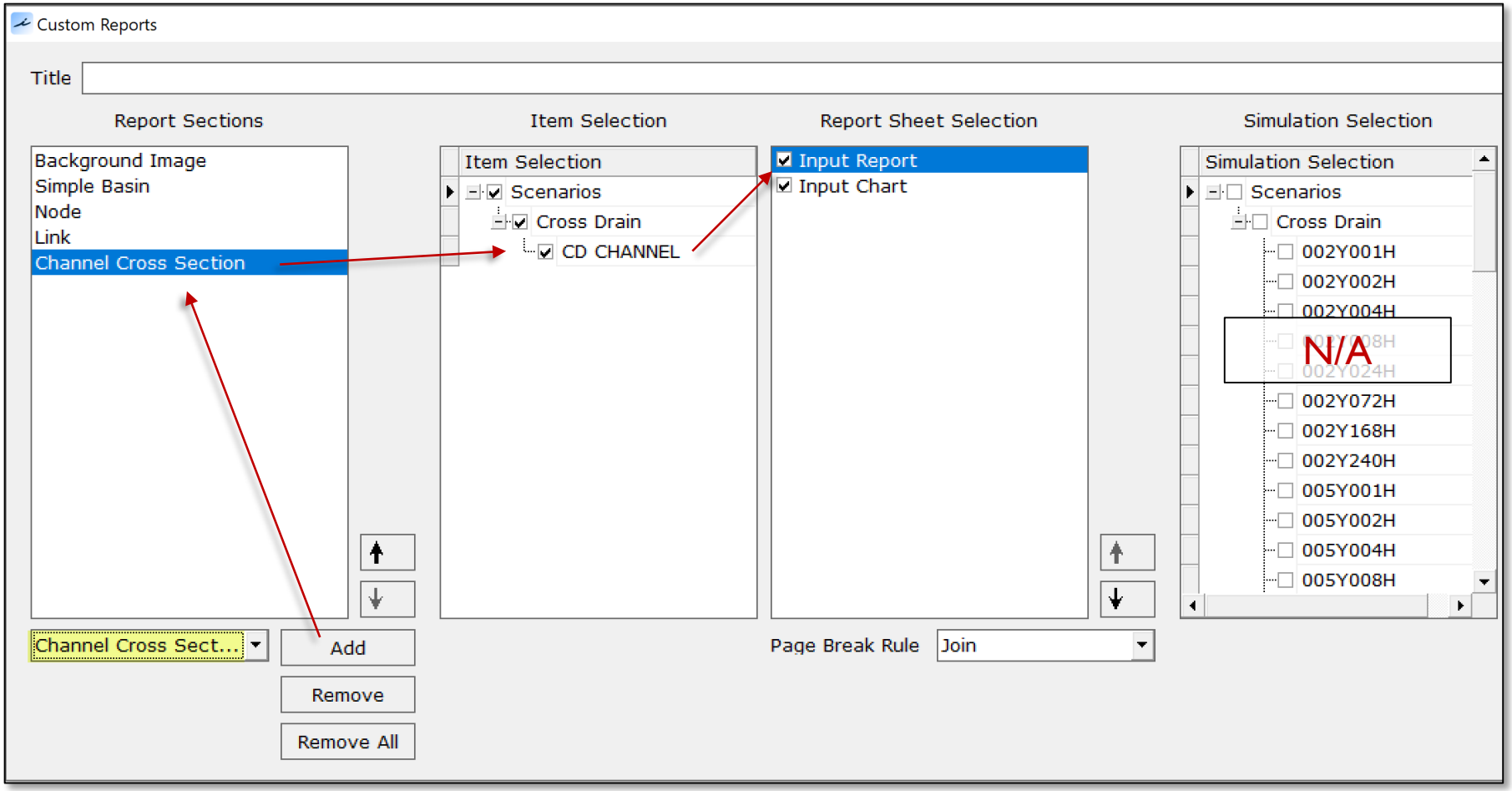
Preparing a Custom Report

Link



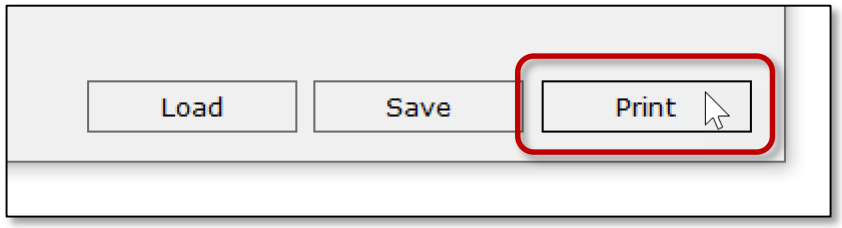
Preparing a Custom Report

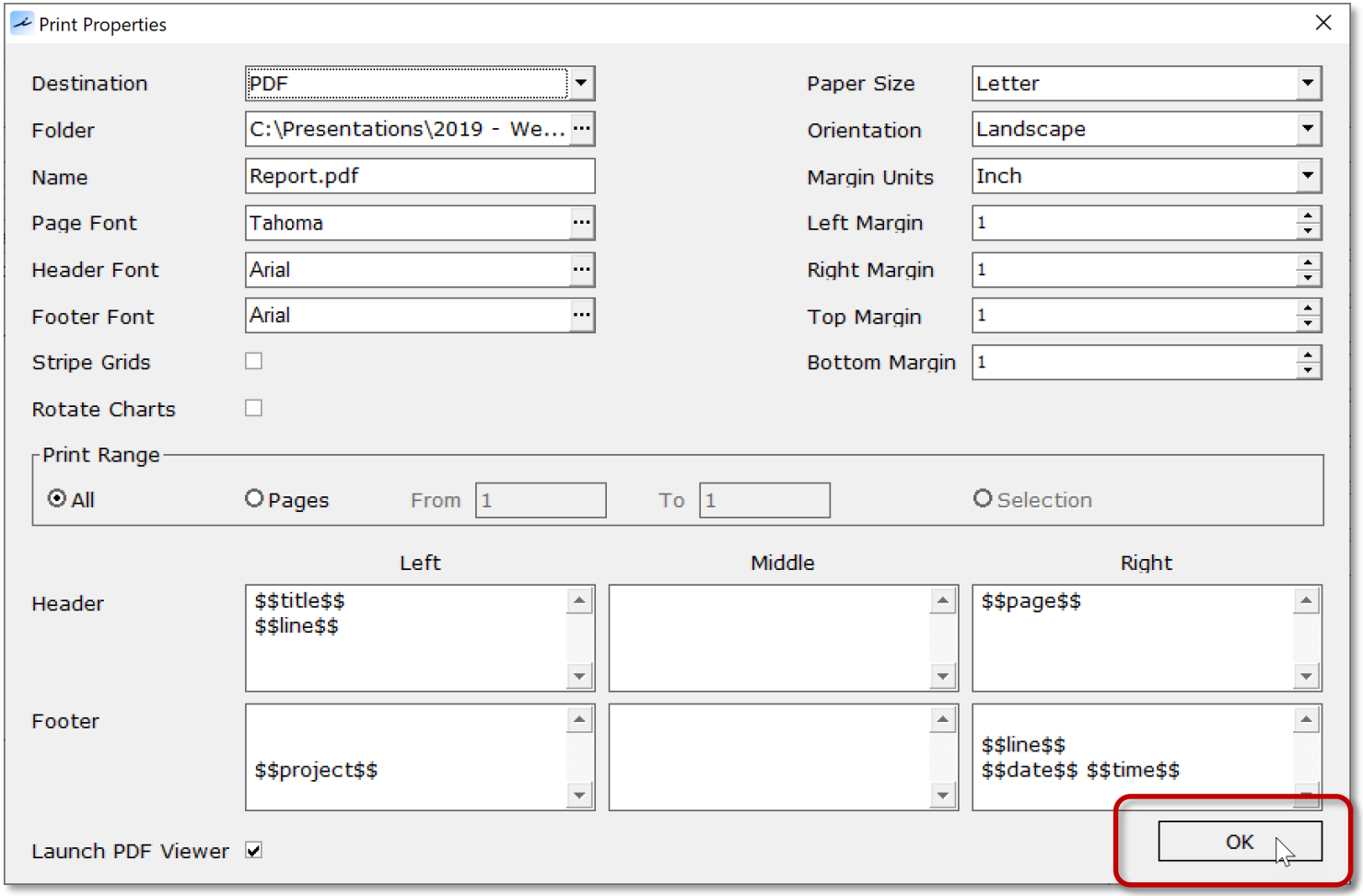
Channel Cross Section



Preparing a Custom Report

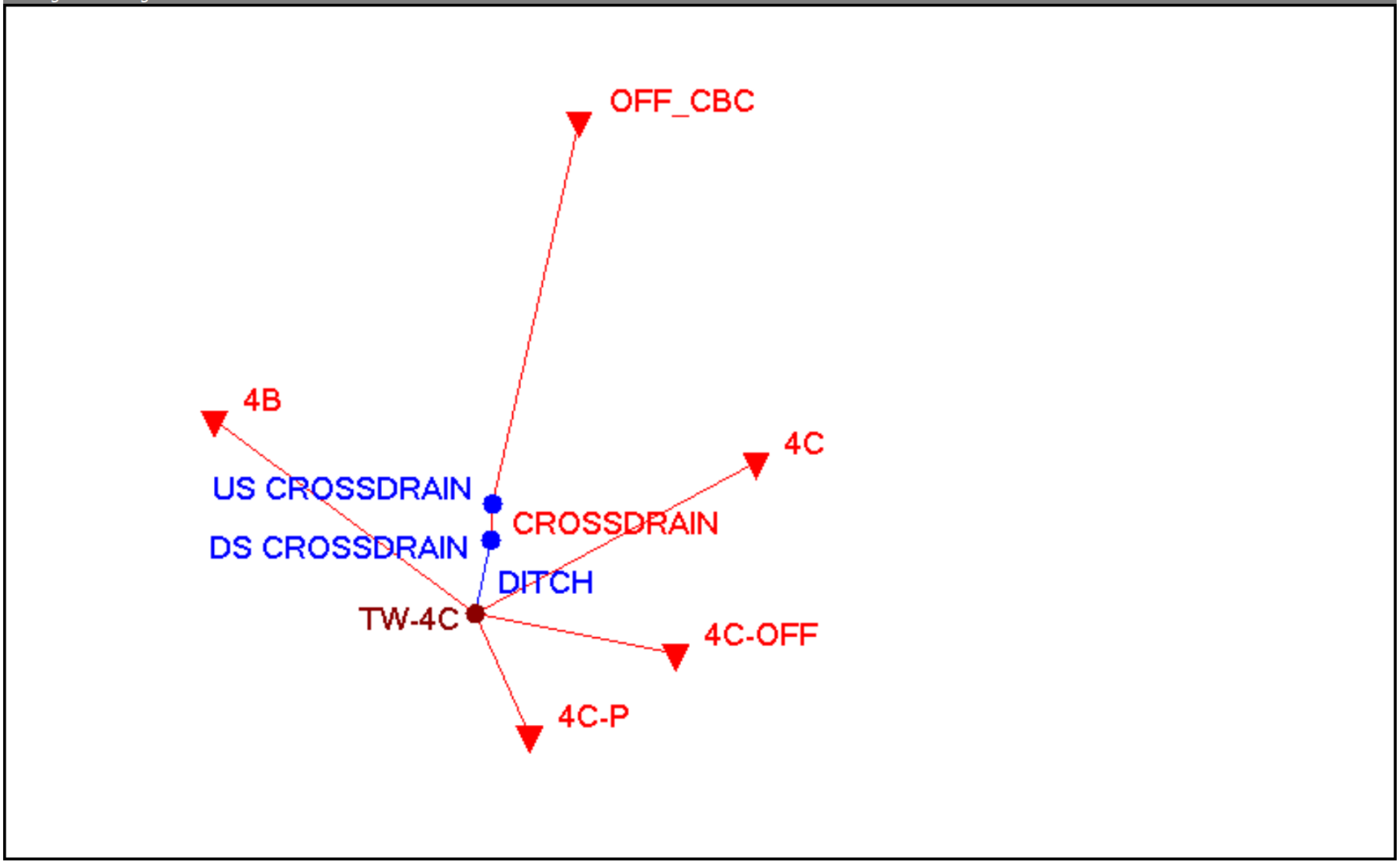
Print Control





Custom Report (Background Image)

Background Image: Nodal Network



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Custom Report (Simple Basin)

Simple Basin: OFF_CBC

Input Data

Scenario:	Cross Drain
Node:	US CROSSDRAIN
Hydrograph Method:	NRCS Unit Hydrograph
Infiltration Method:	Curve Number
Time of Concentration:	165.0000 min
Max Allowable Q:	999999.00 cfs
Time Shift:	0.0000 hr
Unit Hydrograph:	Uh256
Peaking Factor:	256.0
Area:	404.0000 ac
Curve Number:	43.0
% Impervious:	0.00
% DCIA:	0.00
% Direct:	0.00
Rainfall Name:	

Comment:

Basin Runoff Summary

Simple Basin Runoff Summary [Cross Drain]

Basin Name	Sim Name	Max Flow [cfs]	Time to Max Flow [hrs]	Total Rainfall [in]	Total Runoff [in]	Area [ac]	Equivalent Curve Number	% Imperv	% DCIA
OFF_CBC	025Y001H	7.99	2.5667	3.80	0.06	404.0000	43.0	0.00	0.00
OFF_CBC	025Y002H	24.90	3.2667	4.80	0.24	404.0000	43.0	0.00	0.00
OFF_CBC	025Y004H	53.52	4.7500	6.00	0.55	404.0000	43.0	0.00	0.00
OFF_CBC	025Y008H	70.94	6.8000	7.30	1.13	404.0000	43.0	0.00	0.00
OFF_CBC	025Y024H	80.96	19.9667	10.00	2.62	404.0000	43.0	0.00	0.00
OFF_CBC	025Y072H	95.87	61.3833	12.20	3.98	404.0000	43.0	0.00	0.00
OFF_CBC	025Y096H	187.64	62.0000	13.00	4.54	404.0000	43.0	0.00	0.00
OFF_CBC	025Y168H	103.28	160.5167	14.50	5.59	404.0000	43.0	0.00	0.00
OFF_CBC	025Y240H	124.91	184.6000	16.00	6.70	404.0000	43.0	0.00	0.00

Node: US CROSSDRAIN

Input Data

Scenario: Cross Drain
Type: Stage/Area
Base Flow: 0.00 cfs
Initial Stage: 113.82 ft
Warning Stage: 122.20 ft

Comment:

Node Max Conditions

Node Max Conditions [Cross Drain]

Node Name	Sim Name	Warning Stage [ft]	Max Stage [ft]	Min/Max Delta Stage [ft]	Max Total Inflow [cfs]	Max Total Outflow [cfs]	Max Surface Area [ft2]
US CROSSDRAIN	025Y001H	122.20	115.33	0.0010	7.99	8.06	330
US CROSSDRAIN	025Y002H	122.20	116.10	0.0010	24.90	24.90	330
US CROSSDRAIN	025Y004H	122.20	117.02	0.0010	53.52	53.55	330
US CROSSDRAIN	025Y008H	122.20	117.48	0.0010	70.94	71.00	330
US CROSSDRAIN	025Y024H	122.20	117.74	0.0010	80.96	81.01	330
US CROSSDRAIN	025Y072H	122.20	118.16	0.0010	95.87	95.92	330
US CROSSDRAIN	025Y096H	122.20	120.14	0.0010	187.63	187.65	330
US CROSSDRAIN	025Y168H	122.20	118.36	0.0010	103.28	103.28	330
US CROSSDRAIN	025Y240H	122.20	118.93	0.0010	124.91	124.96	330

Custom Report (Link)

Pipe Link: CROSSDRAIN		Upstream		Downstream	
Scenario:	Cross Drain	Invert:	113.82 ft	Invert:	114.35 ft
From Node:	US CROSSDRAIN	Manning's N:	0.0120	Manning's N:	0.0120
To Node:	DS CROSSDRAIN	Geometry: Rectangular		Geometry: Rectangular	
Link Count:	1	Max Depth:	4.00 ft	Max Depth:	4.00 ft
Flow Direction:	Both	Max Width:	5.00 ft	Max Width:	5.00 ft
Damping:	0.0000 ft	Fillet:	0.00 ft	Fillet:	0.00 ft
Length:	66.00 ft	Bottom Clip			
FHWA Code:	9	Default:	0.00 ft	Default:	0.00 ft
Entr Loss Coef:	0.50	Op Table:		Op Table:	
Exit Loss Coef:	0.50	Ref Node:		Ref Node:	
Bend Loss Coef:	0.00	Manning's N:	0.0120	Manning's N:	0.0120
Bend Location:	0.00 ft	Top Clip			
Energy Switch:	Energy	Default:	0.00 ft	Default:	0.00 ft
		Op Table:		Op Table:	
		Ref Node:		Ref Node:	
		Manning's N:	0.0120	Manning's N:	0.0120

Comment:

Input Data

Custom Report (Link)

Link Min/Max Conditions [Cross Drain]

Link Name	Sim Name	Max Flow [cfs]	Min Flow [cfs]	Min/Max Delta Flow [cfs]	Max Us Velocity [fps]	Max Ds Velocity [fps]	Max Avg Velocity [fps]
CROSSDRAIN	025Y001H	8.06	0.00	-0.17	1.07	1.78	1.42
CROSSDRAIN	025Y002H	24.90	0.00	-0.11	2.19	3.32	2.75
CROSSDRAIN	025Y004H	53.55	0.00	0.09	3.34	5.05	4.20
CROSSDRAIN	025Y008H	71.00	0.00	-0.13	3.88	6.16	5.02
CROSSDRAIN	025Y024H	81.01	0.00	0.20	4.13	6.77	5.45
CROSSDRAIN	025Y072H	95.92	0.00	-0.98	4.80	7.65	6.23
CROSSDRAIN	025Y096H	187.65	0.00	0.98	9.38	10.65	10.02
CROSSDRAIN	025Y168H	103.28	0.00	-0.98	5.16	8.07	6.62
CROSSDRAIN	025Y240H	124.96	0.00	0.98	6.25	9.28	7.76

Link Min/Max Conditions

Custom Report (Channel Cross Section)

Channel Cross Section: CD CHANNEL

Scenario: Cross Drain
Lid: No
Conveyance Method: ICPRv3

Bottom Point Table

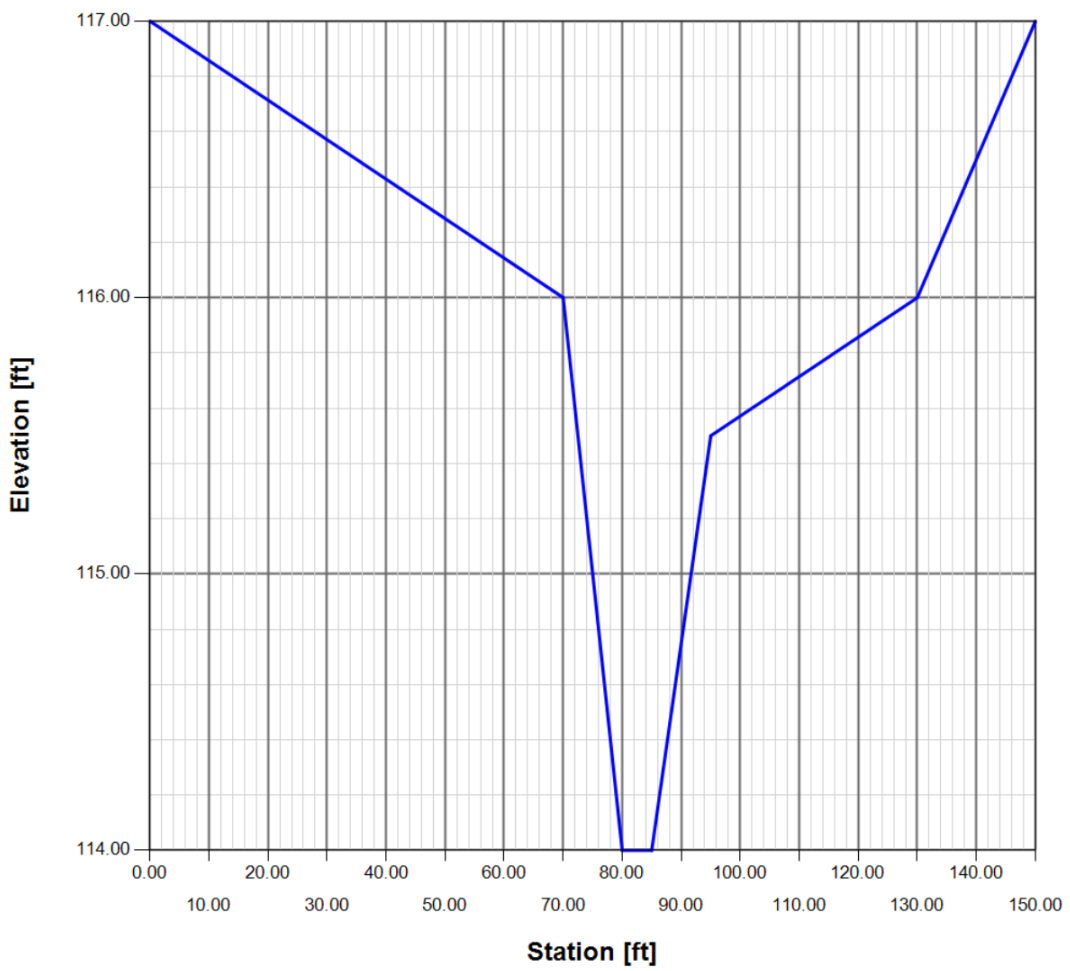
Order	Station [ft]	Elevation [ft]	Manning's N
0	0.00	117.00	0.0700
1	70.00	116.00	0.0700
2	80.00	114.00	0.0700
3	85.00	114.00	0.0700
4	95.00	115.50	0.0700
5	130.00	116.00	0.0700
6	150.00	117.00	0.0700

Comment:

Input Data

Custom Report (Channel Cross Section)

Channel Cross Section: CD CHANNEL — Scenario: CD CHANNEL

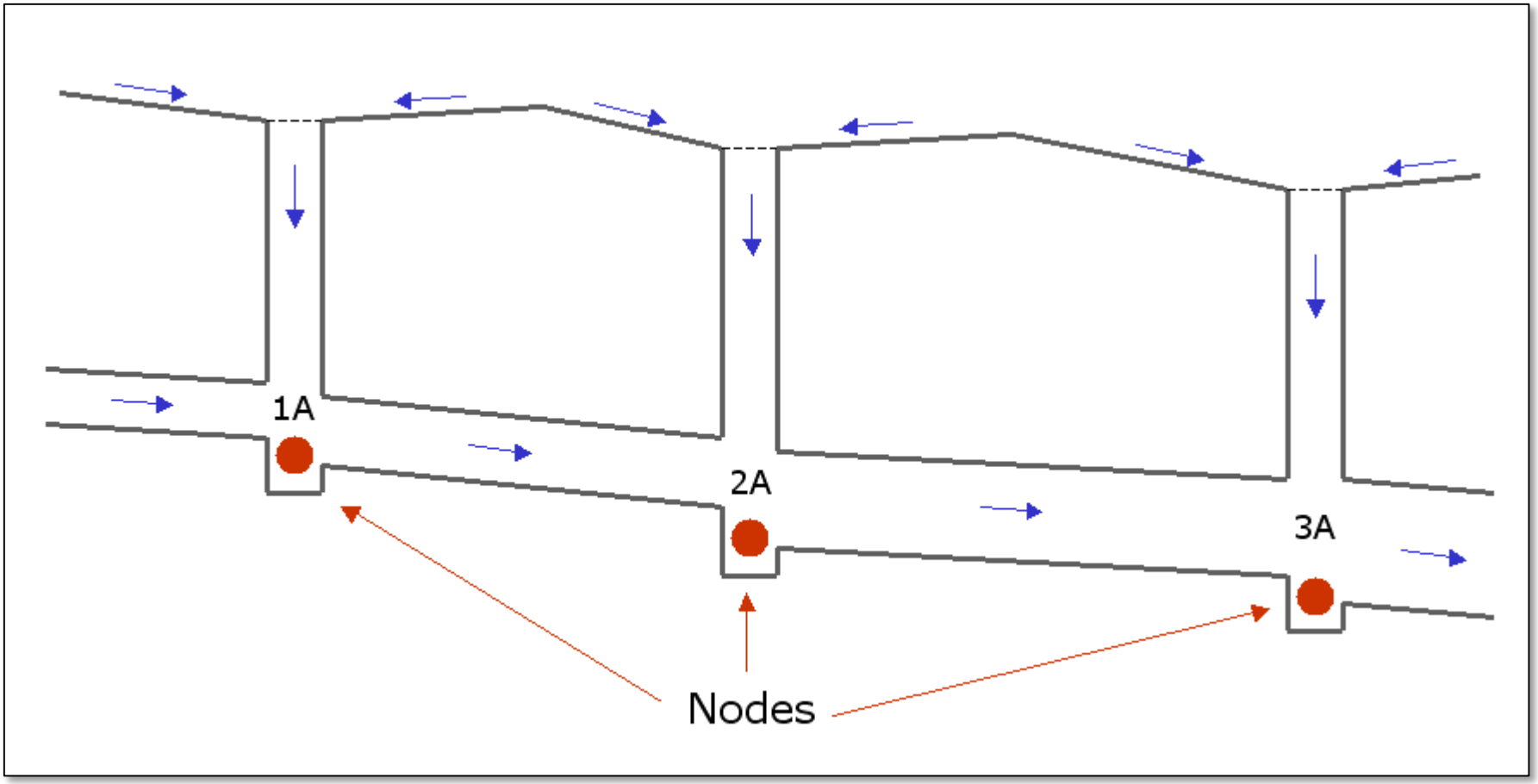


Cross Section Chart

Example #2

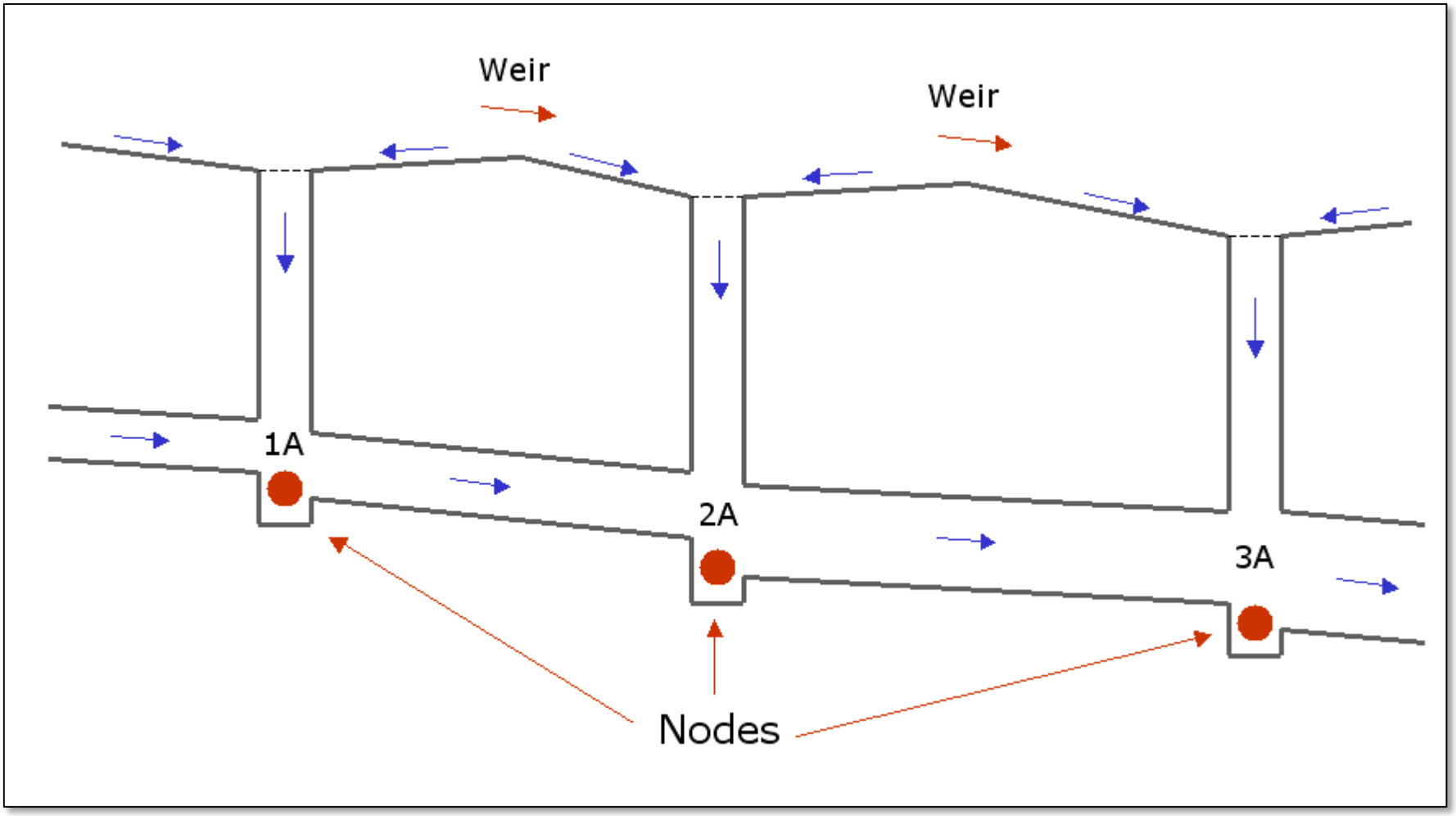
Integrated Storm Sewer Hydraulics and Pond Routing for a Commercial Site

Nodal Network Strategies for Storm Sewers



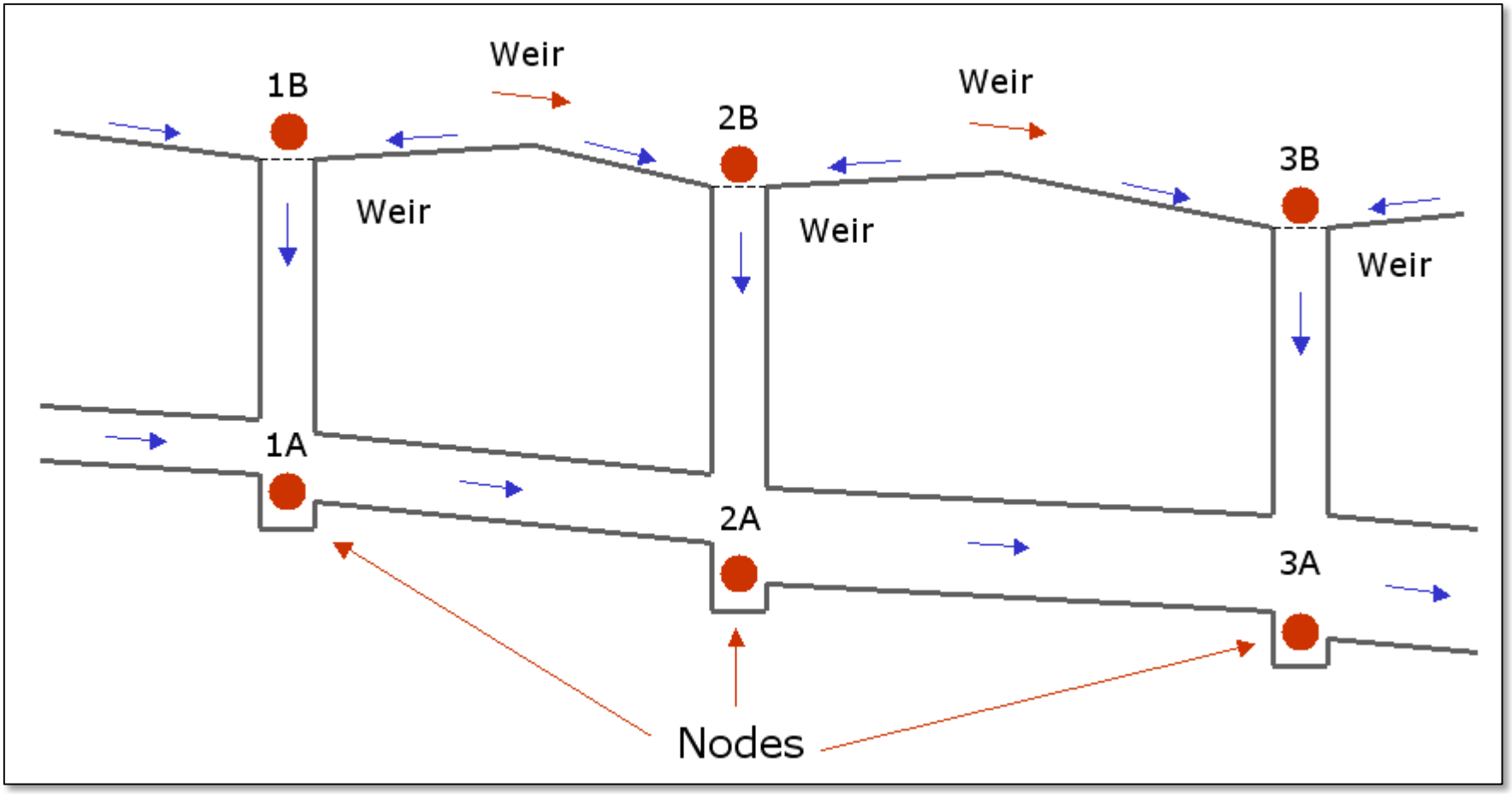
Option 1

Nodal Network Strategies for Storm Sewers



Option 2

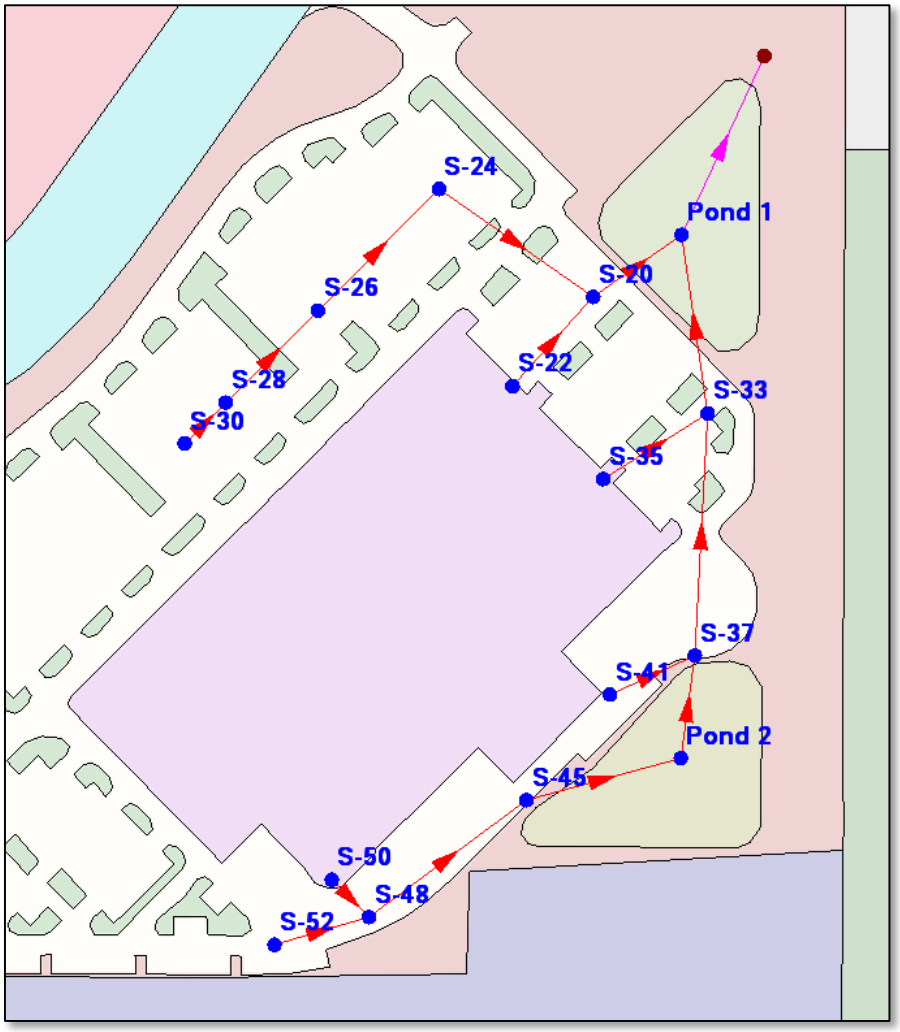
Nodal Network Strategies for Storm Sewers



Option 3

Integrated Storm Sewer Hydraulics and Pond Routing

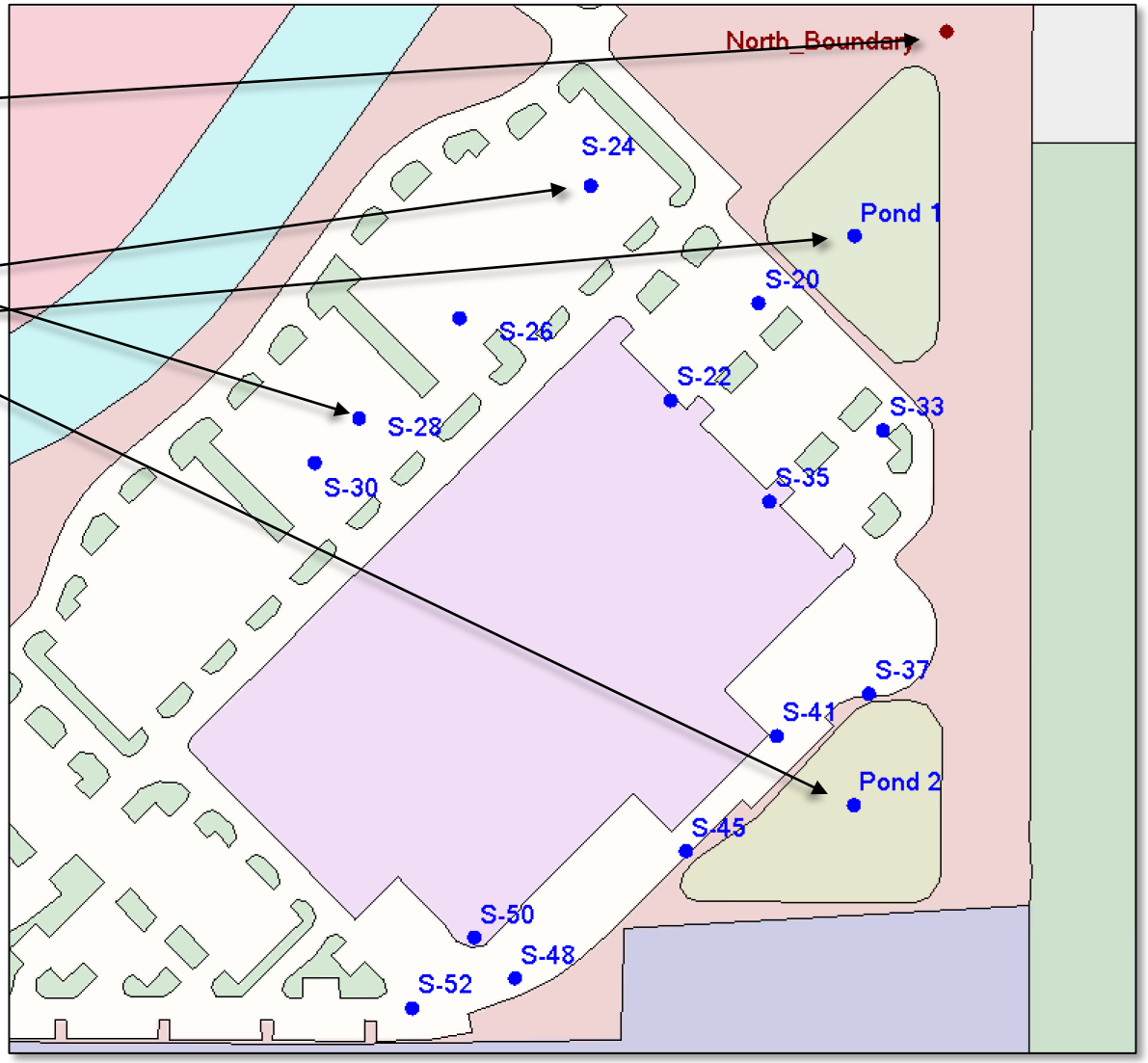
- This example includes a storm sewer system that drains part of a commercial site into 2 detention ponds
- A storm sewer is also used to connect the two ponds together
- "Option 1" from the previous slides is used for the nodal network strategy
- A control structure serves as the outfall for the system*
- The storm sewer hydraulics are integrated with the pond routing computations (dynamic tailwater condition)



* We will discuss control structures in Lesson 3

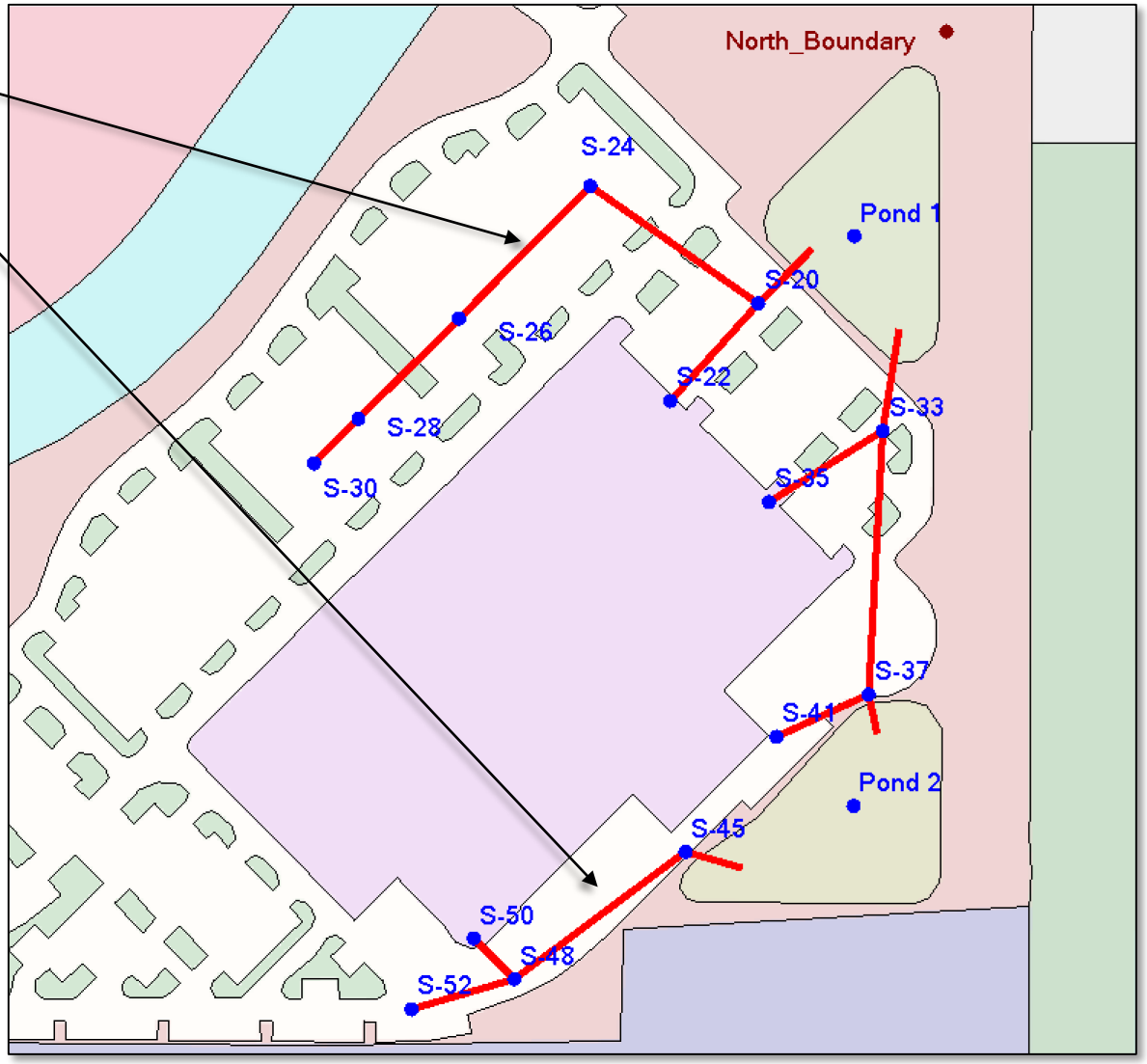
Integrated Storm Sewer Hydraulics and Pond Routing

- a time/stage node is place at the northern outlet
- stage/area nodes are placed at catch basins and at the ponds



Integrated Storm Sewer Hydraulics and Pond Routing

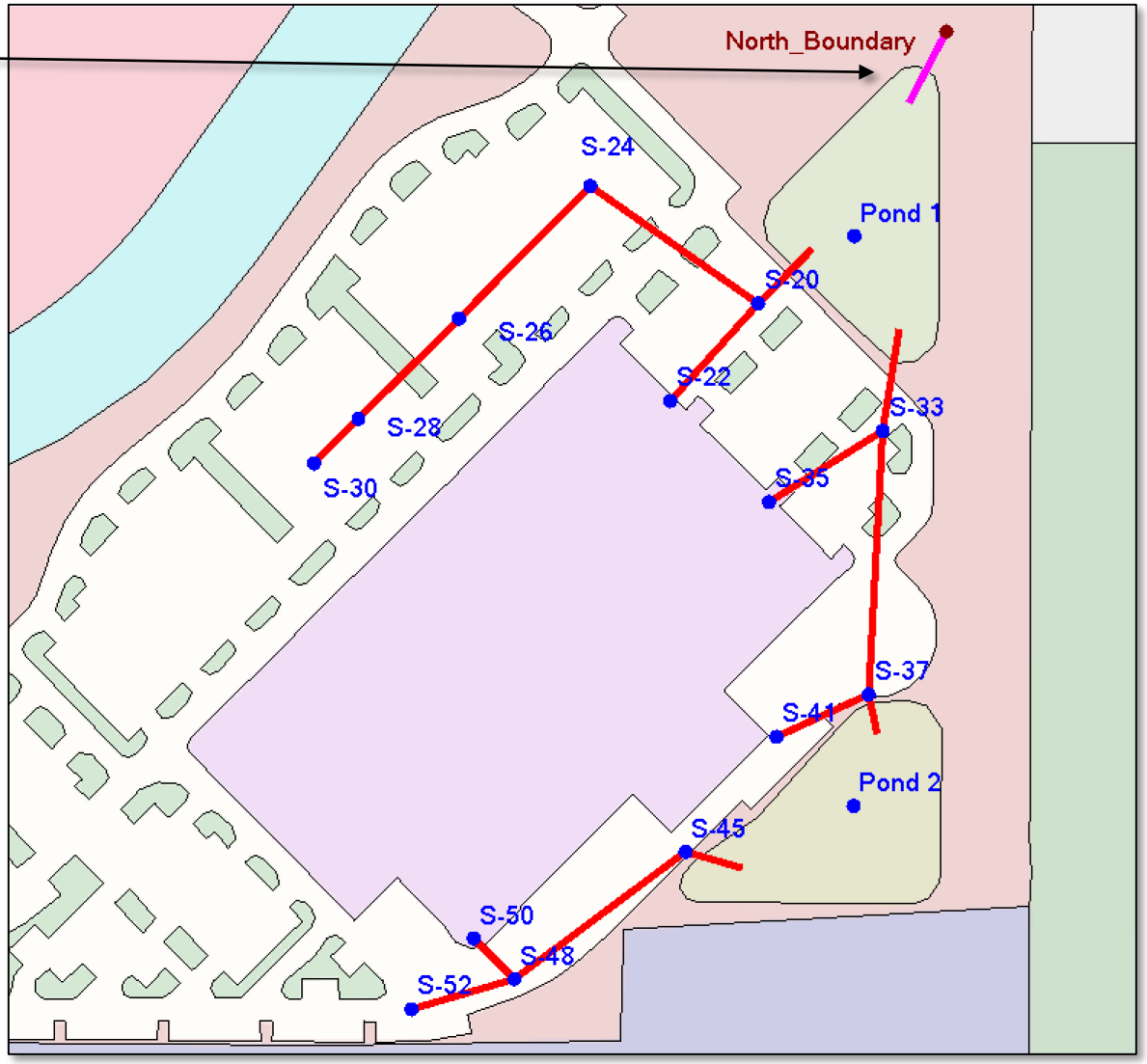
- add pipe links



Integrated Storm Sewer Hydraulics and Pond Routing

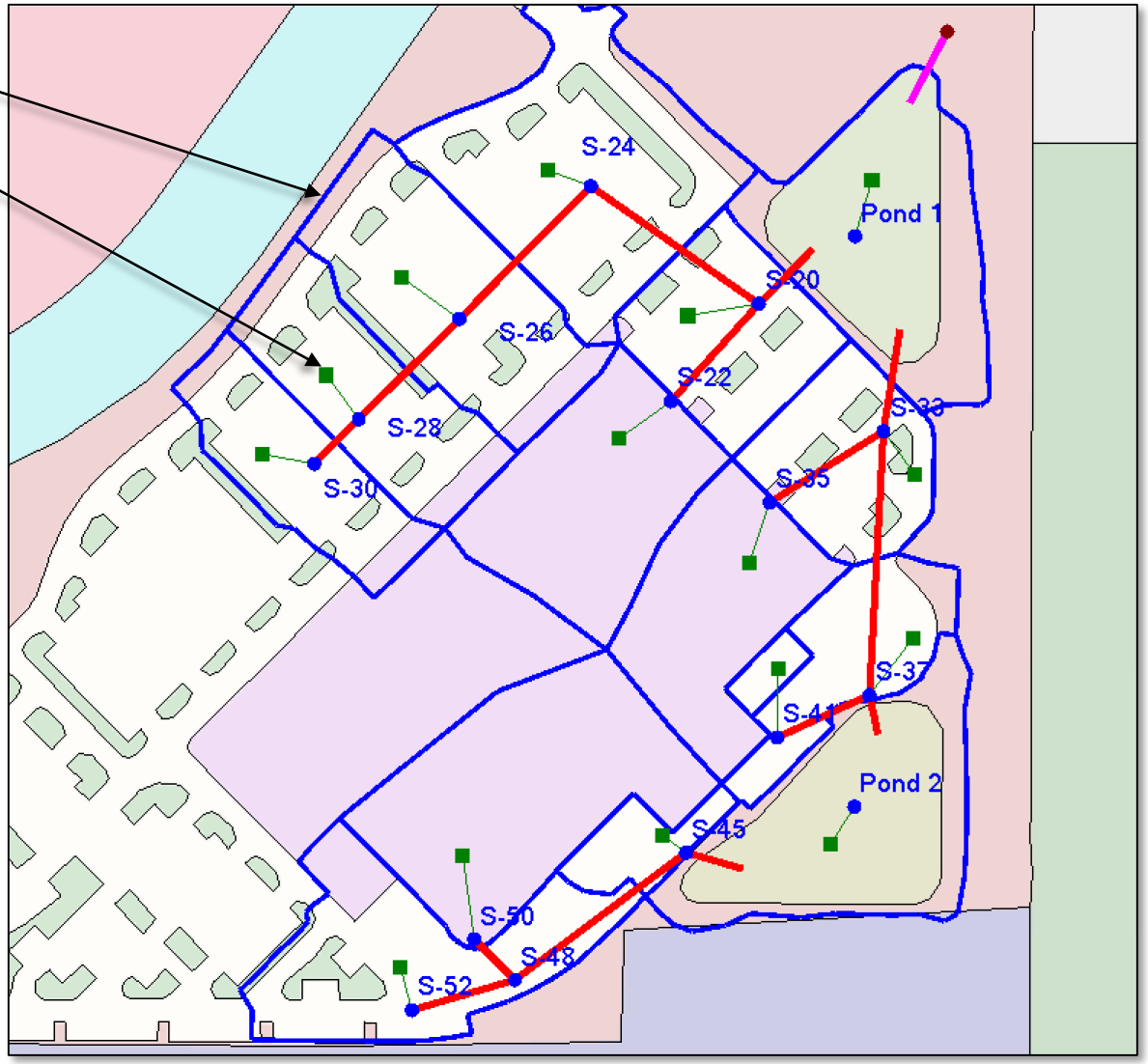
- add drop structure* link (control structure)

* to be discussed in Lesson 3

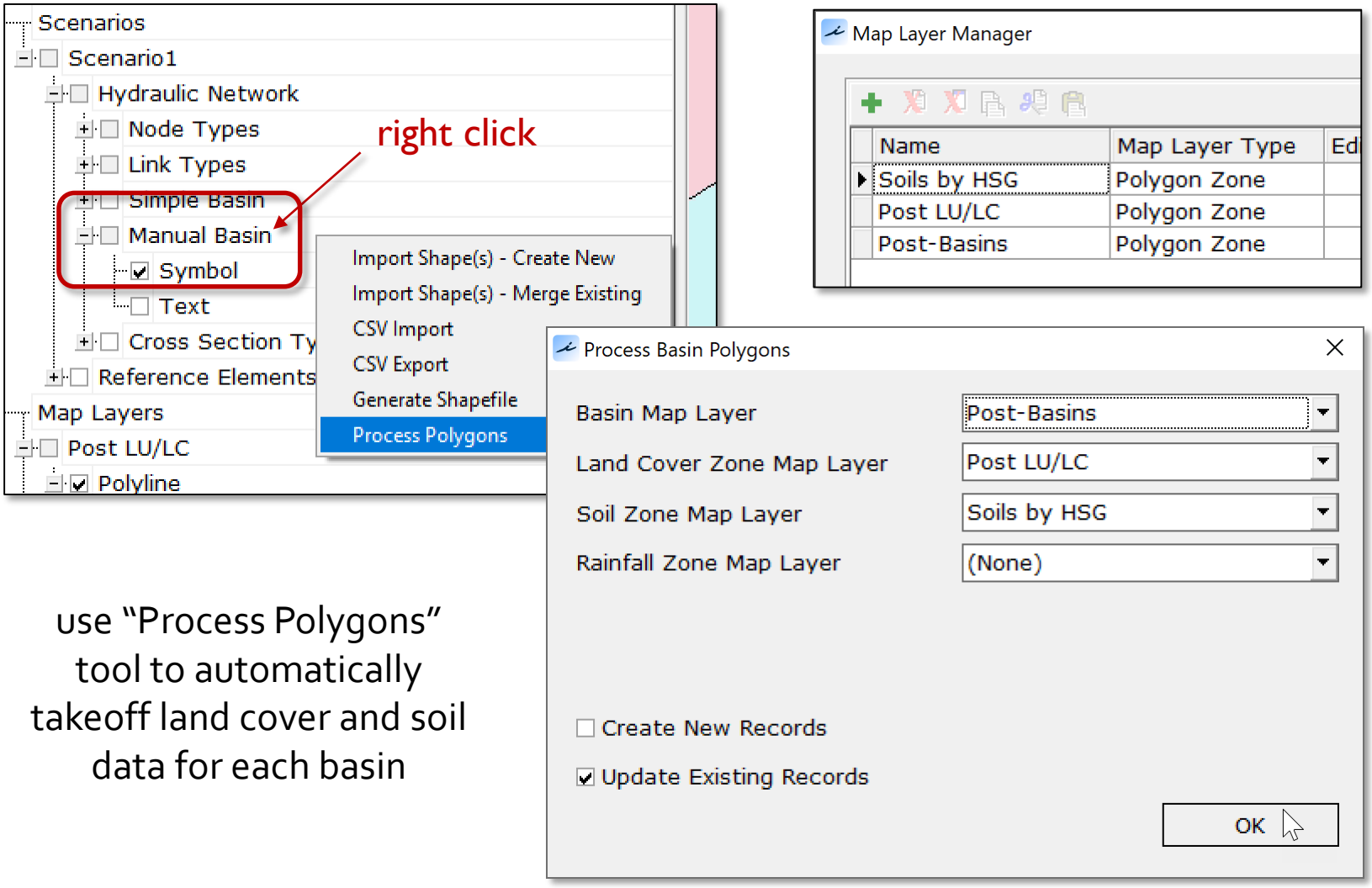


Integrated Storm Sewer Hydraulics and Pond Routing

- delineate "manual" basins
- assign basins to nodes

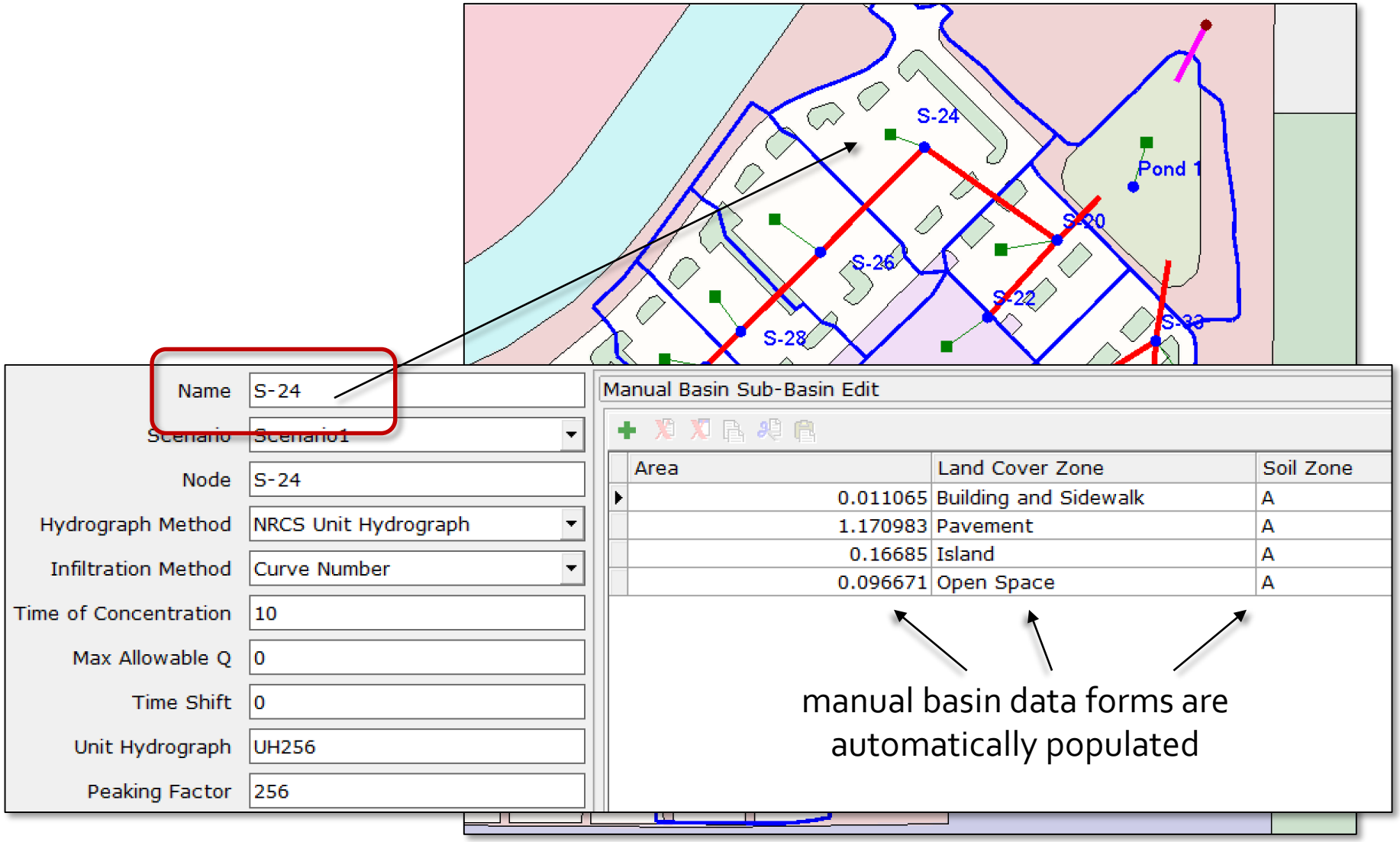


Integrated Storm Sewer Hydraulics and Pond Routing

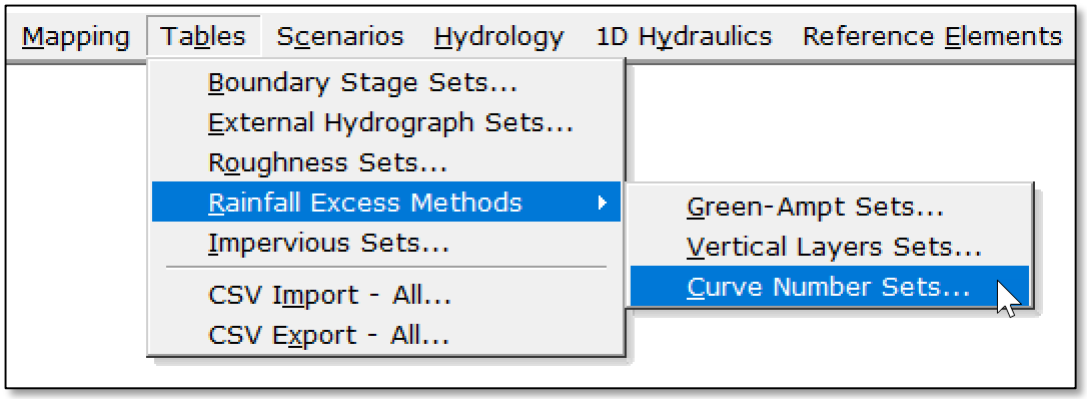


use "Process Polygons" tool to automatically takeoff land cover and soil data for each basin

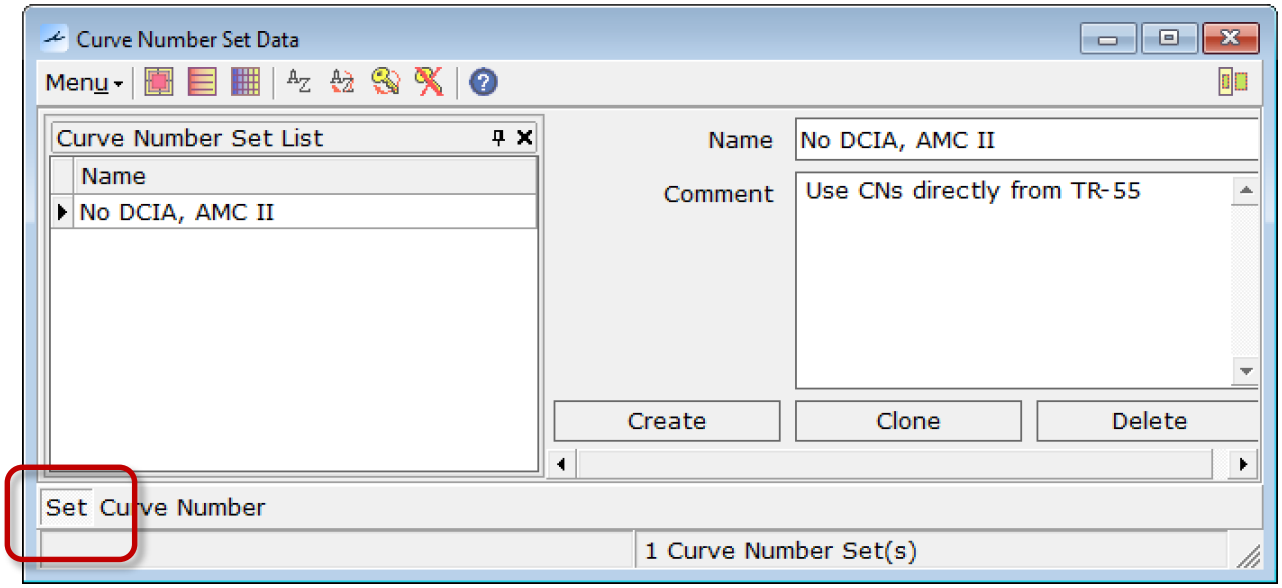
Integrated Storm Sewer Hydraulics and Pond Routing



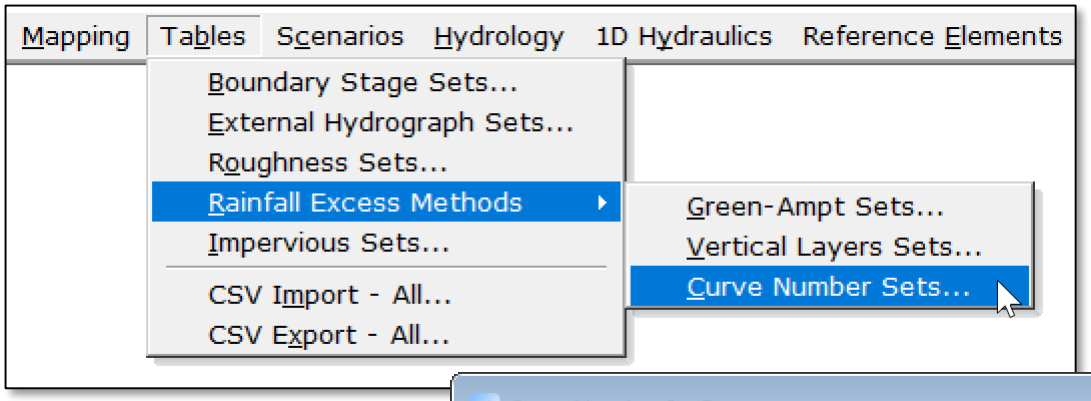
Integrated Storm Sewer Hydraulics and Pond Routing



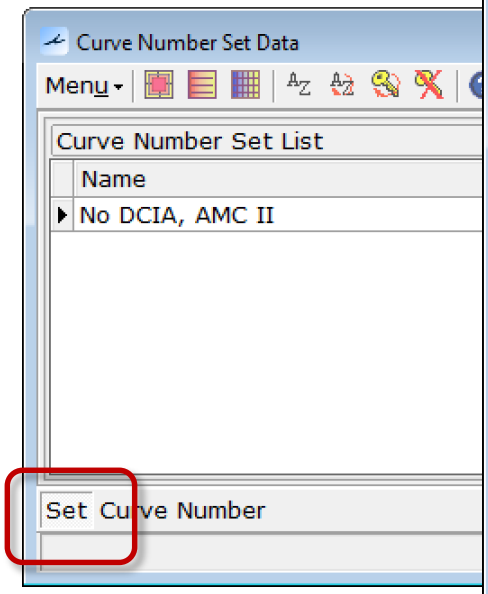
DCIA is not used in this example. The curve numbers include impervious areas.

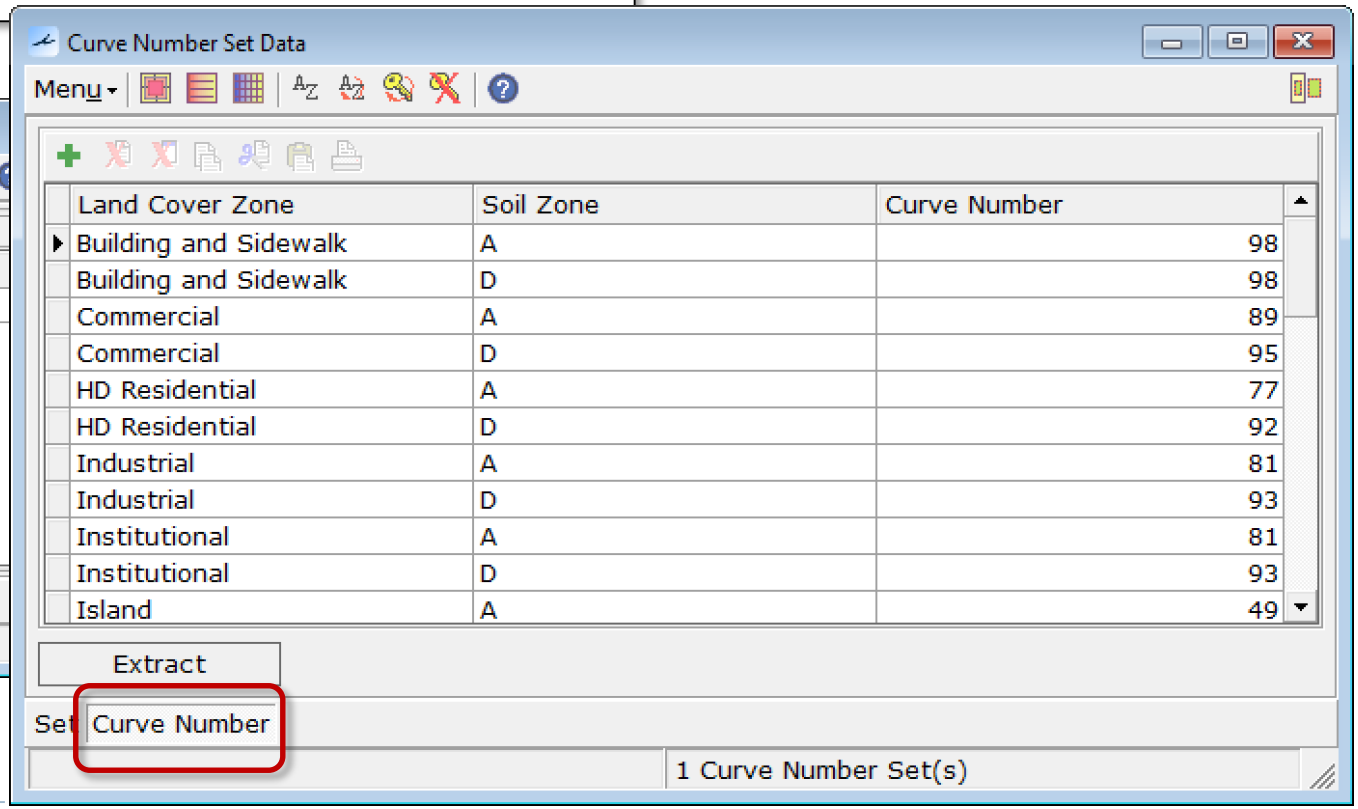


Integrated Storm Sewer Hydraulics and Pond Routing

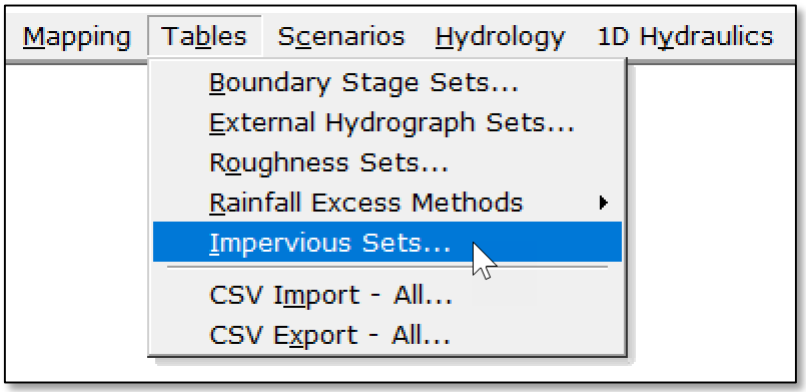


DCIA is not used in this example. The curve numbers include impervious areas.

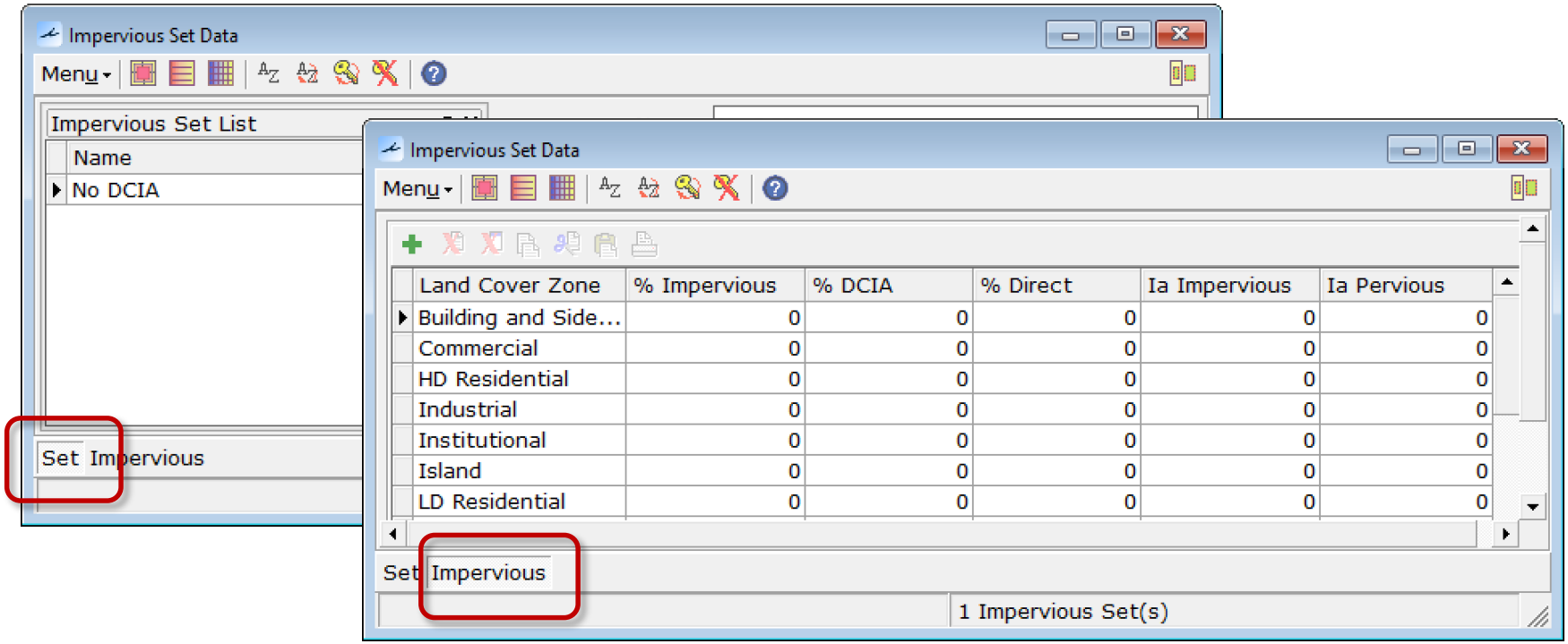




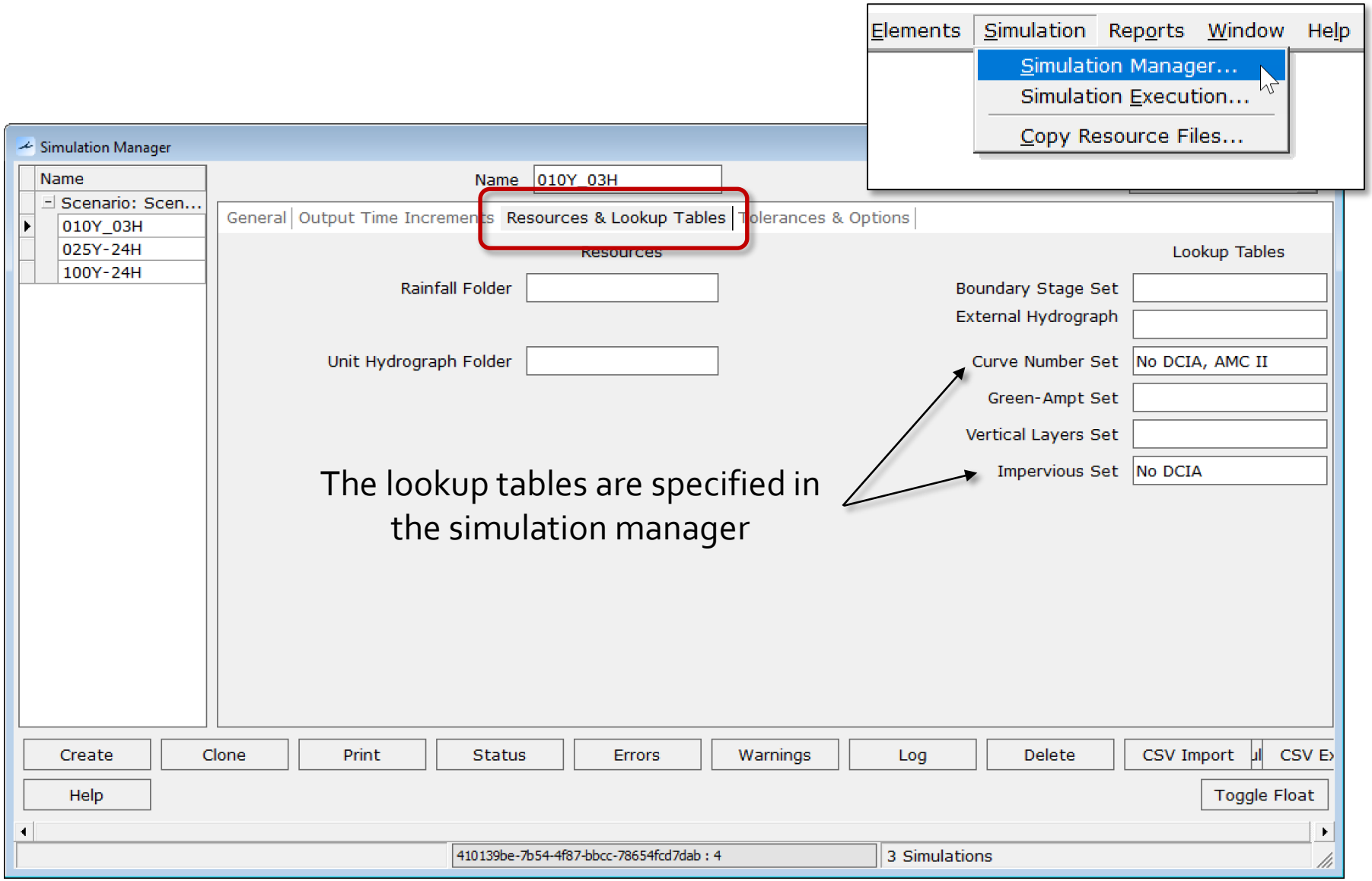
Integrated Storm Sewer Hydraulics and Pond Routing



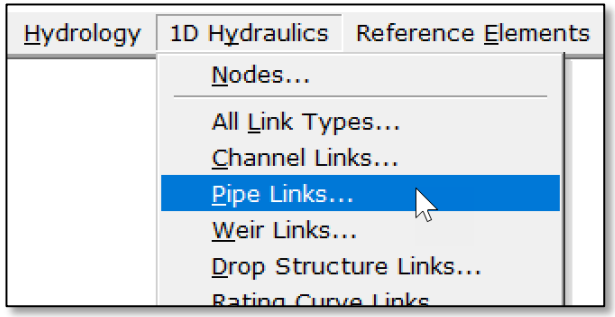
"% Impervious" is set to zero for all land covers because impervious areas are incorporated into the curve numbers



Integrated Storm Sewer Hydraulics and Pond Routing



Integrated Storm Sewer Hydraulics and Pond Routing



- Pipe Data -
Using the "grid" tab, columns can be moved and sorted for QC/QA purposes

Link Pipe Data

Menu

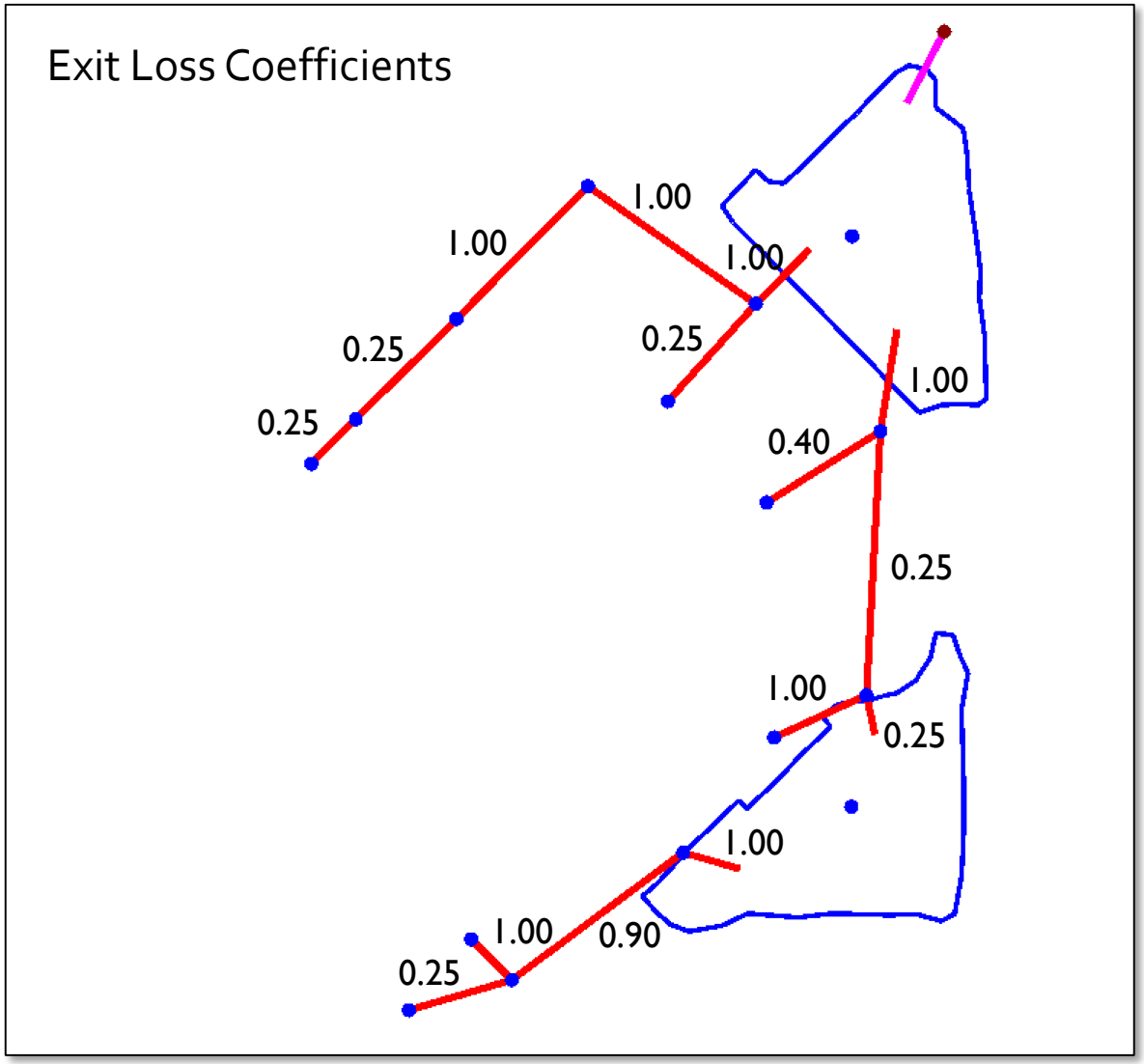
Name	From N...	To Node	Upstream Invert	Downstream Invert	Length	FHWA Culvert Code	Entrance Loss Coefficient	Exit Loss Coefficient
S-19	S-20	Pond 1	76.25	76	68	1	0.5	1
S-21	S-22	S-20	79	77.8	128	1	0.5	0.25
S-23	S-24	S-20	76.65	76.25	205	1	0.5	1
S-25	S-26	S-24	77.15	76.65	189	1	0.5	1
S-27	S-28	S-26	77.75	77.15	142	1	0.5	0.25
S-29	S-30	S-28	78.25	77.75	61	1	0.5	0.25
S-32	S-33	Pond 1	76.1	76	91	1	0.5	1
S-34	S-35	S-33	79	77.8	130	1	0.5	0.4
S-36	S-37	S-33	76	76.1	268	1	0.5	0.25
S-38	Pond 2	S-37	76	76	27	5	0.7	0.25
S-40	S-41	S-37	78.35	77.95	100	1	0.5	1
S-44	S-45	Pond 2	76.15	76	50	1	0.5	1
S-47	S-48	S-45	77	76.35	215	1	0.5	0.9
S-49	S-50	S-48	79	78.6	54	1	0.5	1
S-51	S-52	S-48	77.5	77	105	1	0.5	0.25

Main Grid

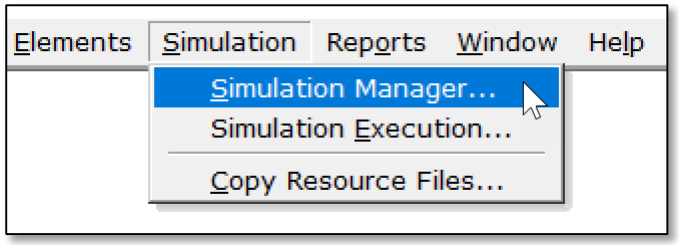
[ft] Enter 'Bend Location'

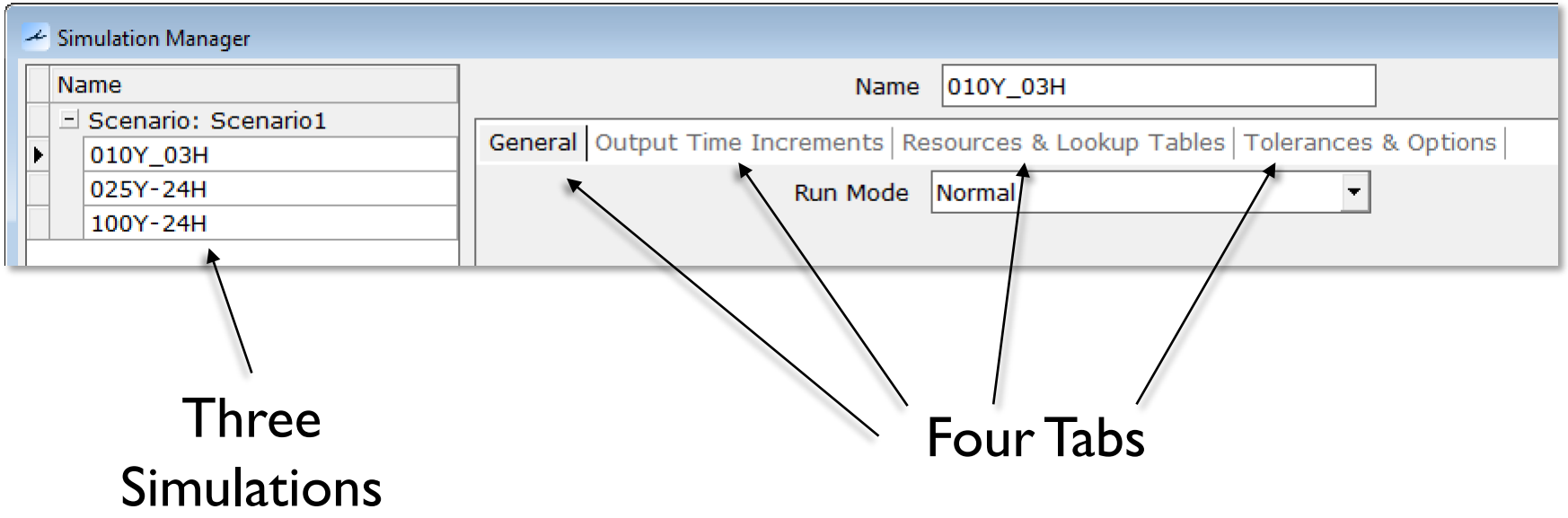
15 Pipe Link(s)

Integrated Storm Sewer Hydraulics and Pond Routing

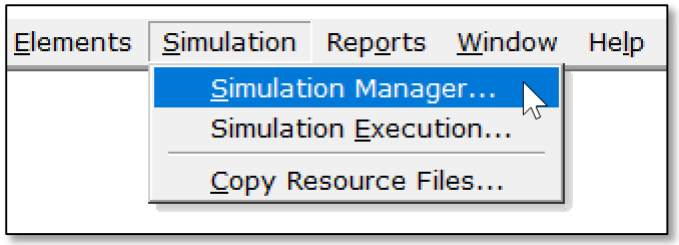


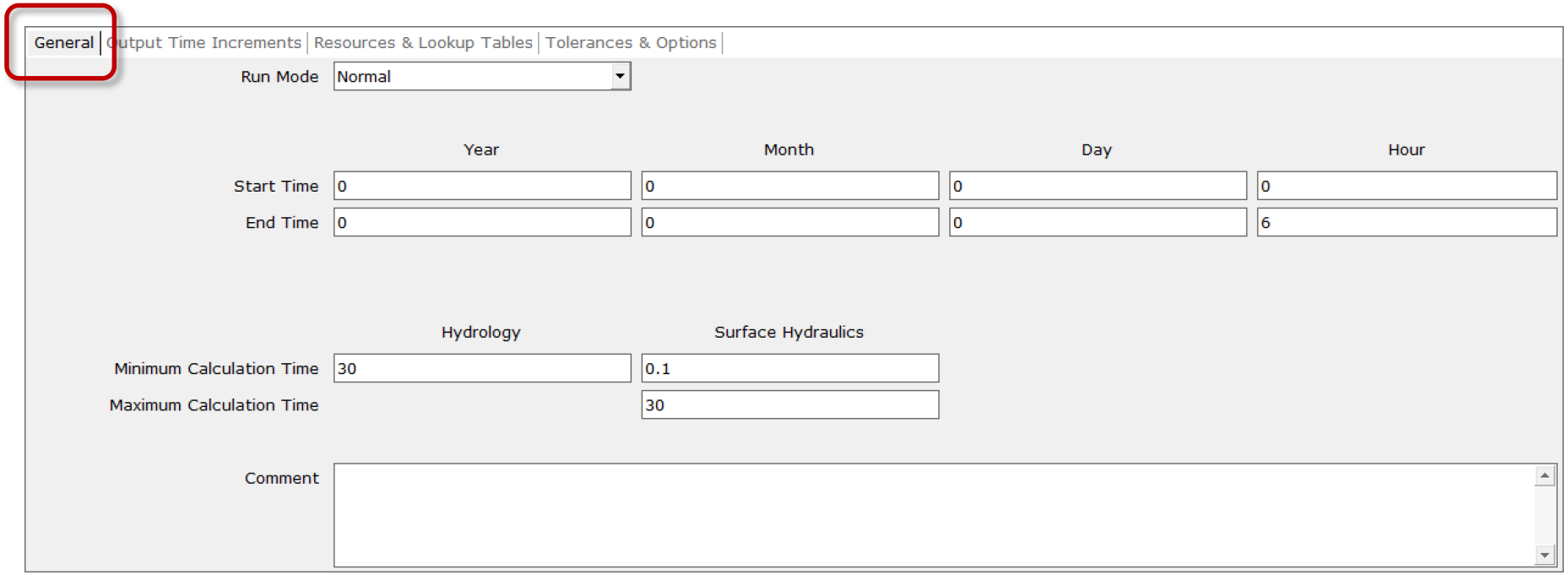
Integrated Storm Sewer Hydraulics and Pond Routing





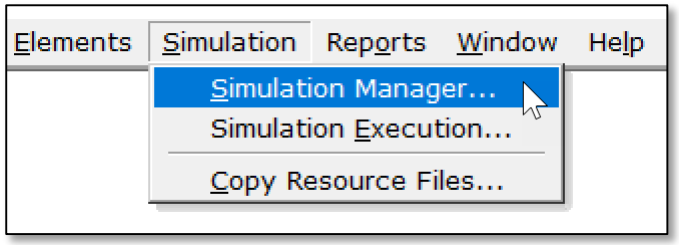
Integrated Storm Sewer Hydraulics and Pond Routing

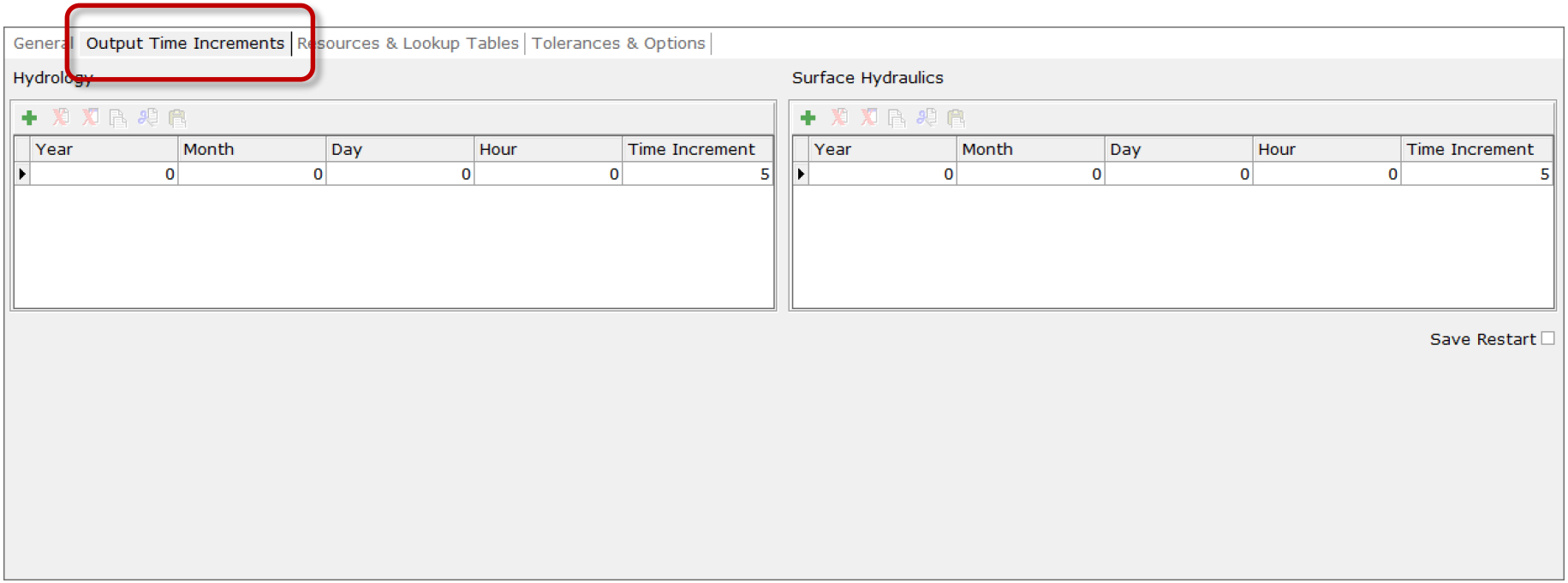




The "General" Tab

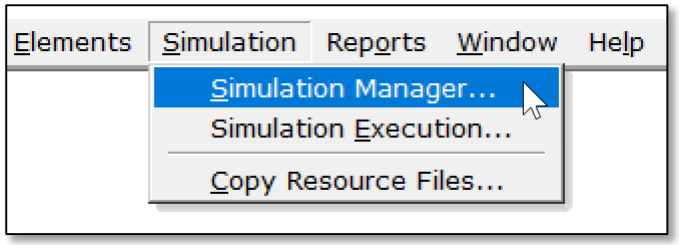
Integrated Storm Sewer Hydraulics and Pond Routing

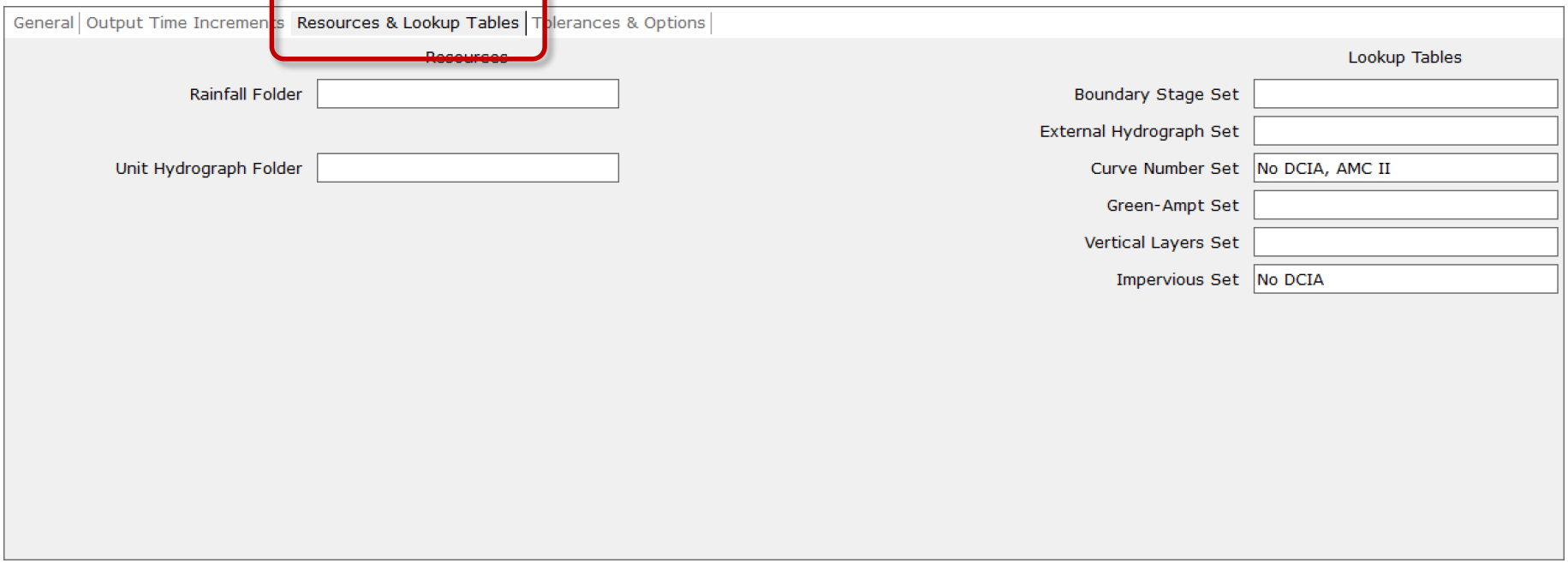




The "Output Time Increments" Tab

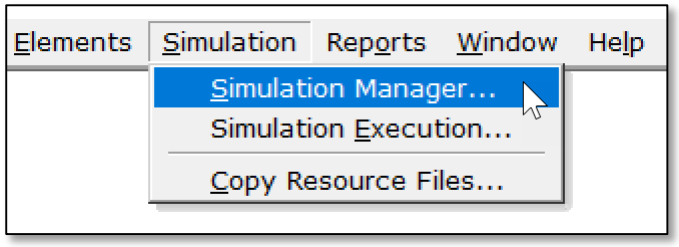
Integrated Storm Sewer Hydraulics and Pond Routing

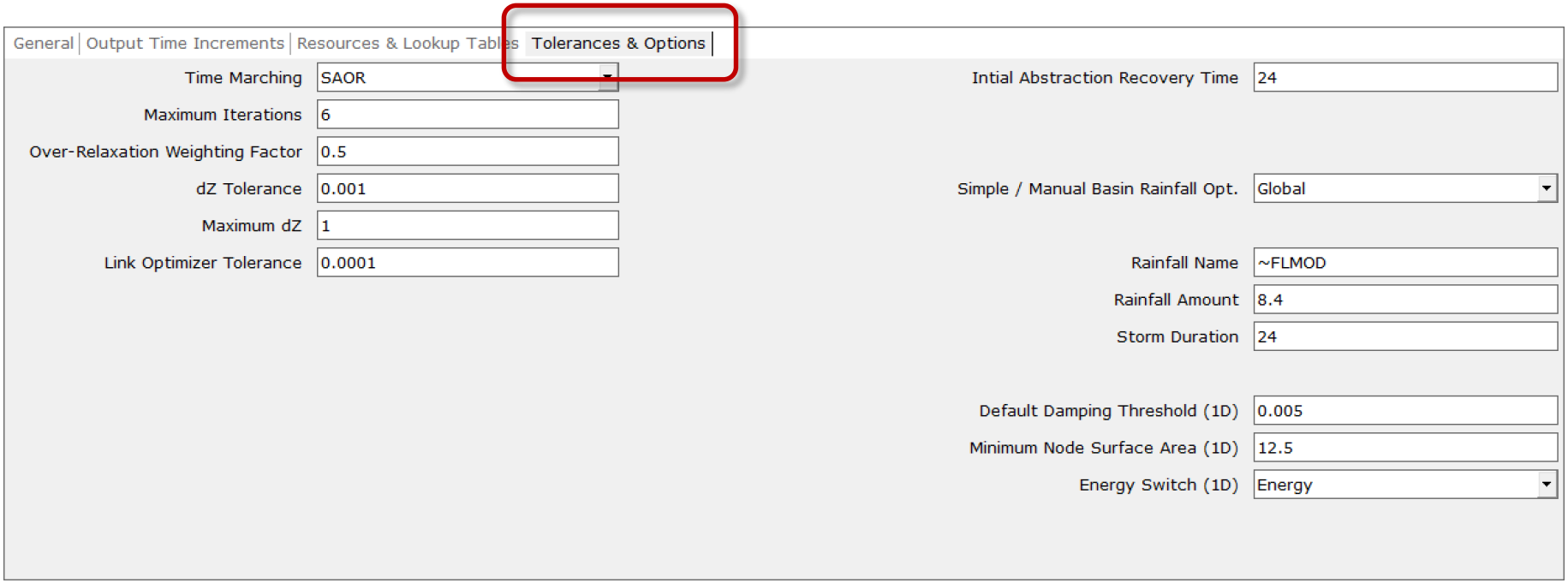




The "Resources & Lookup Tables" Tab

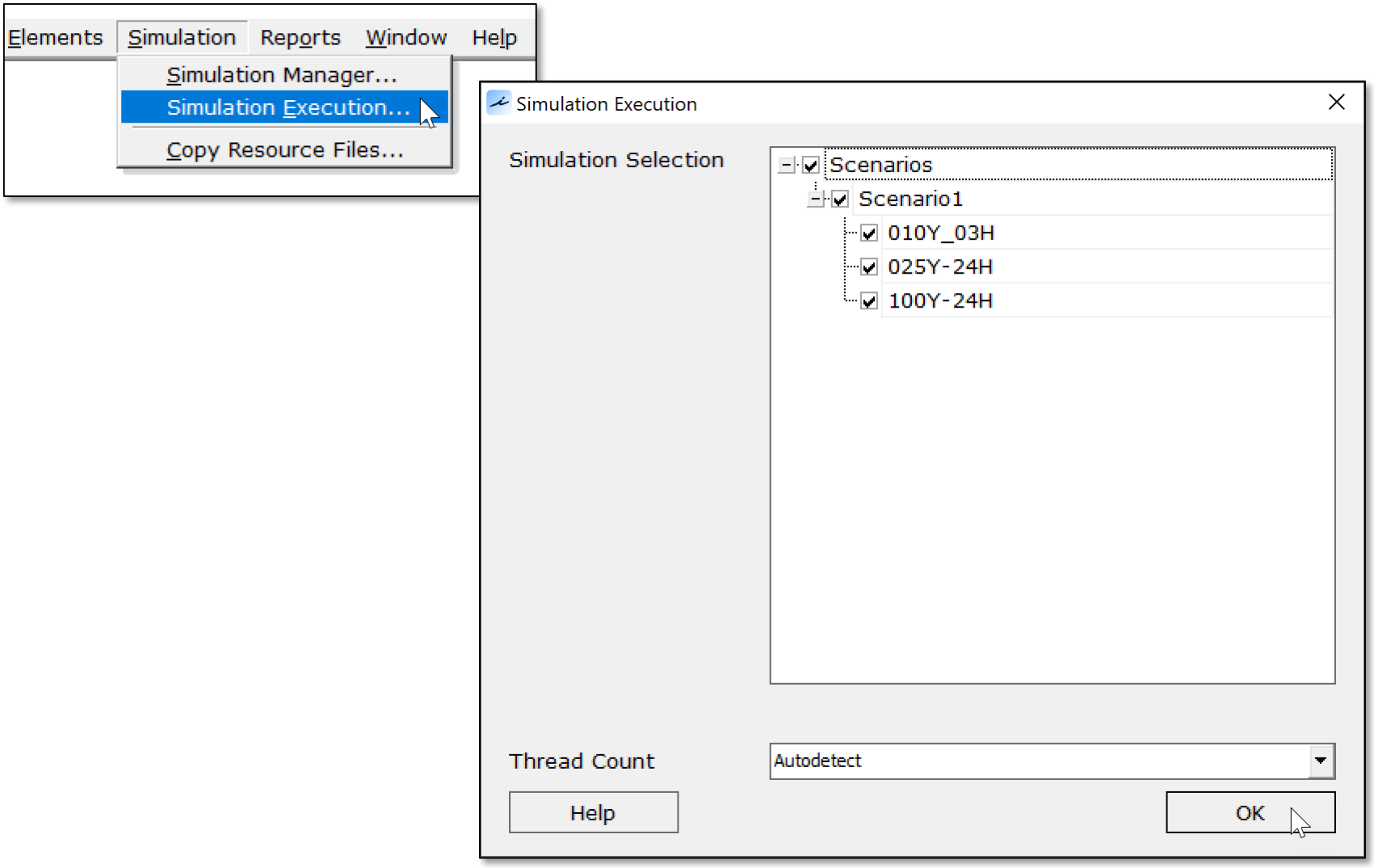
Integrated Storm Sewer Hydraulics and Pond Routing



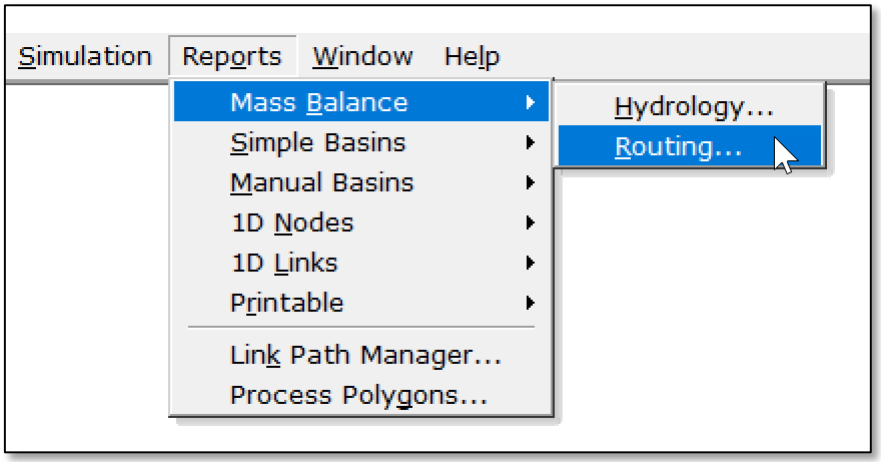


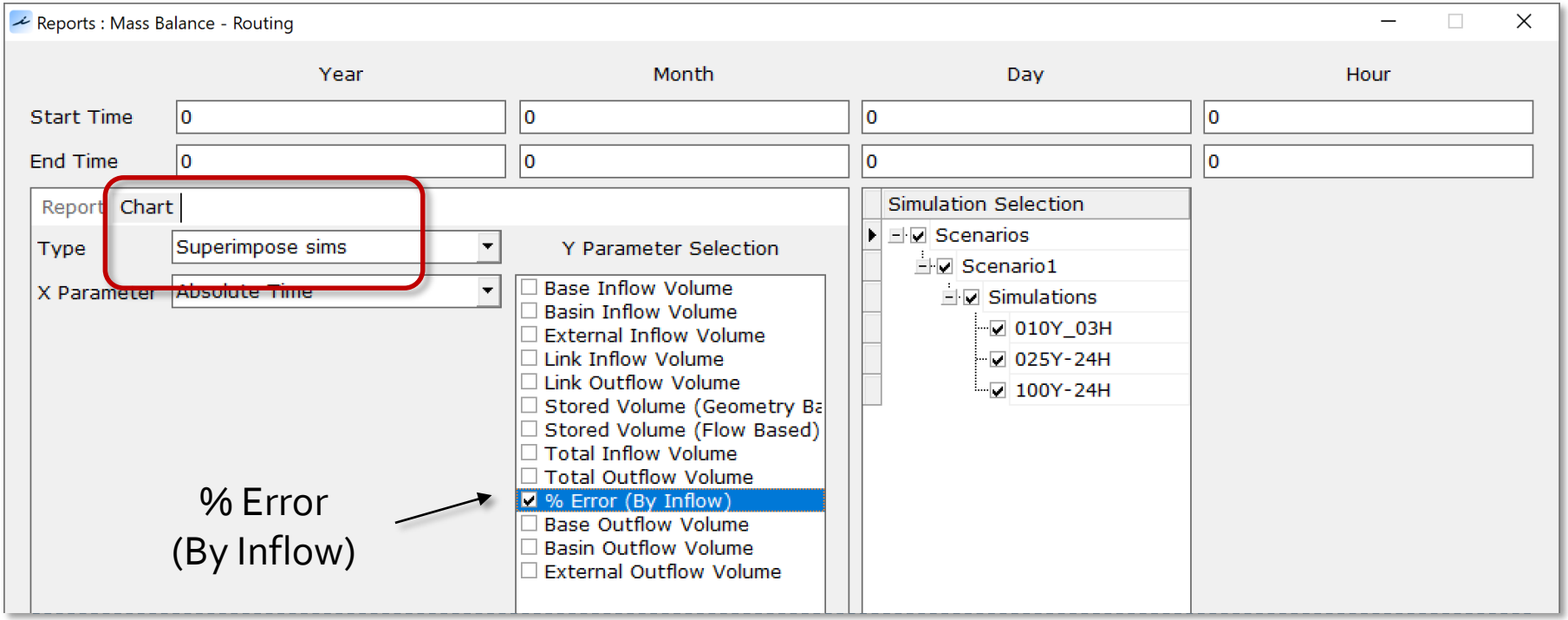
The "Tolerances & Options" Tab

Integrated Storm Sewer Hydraulics and Pond Routing

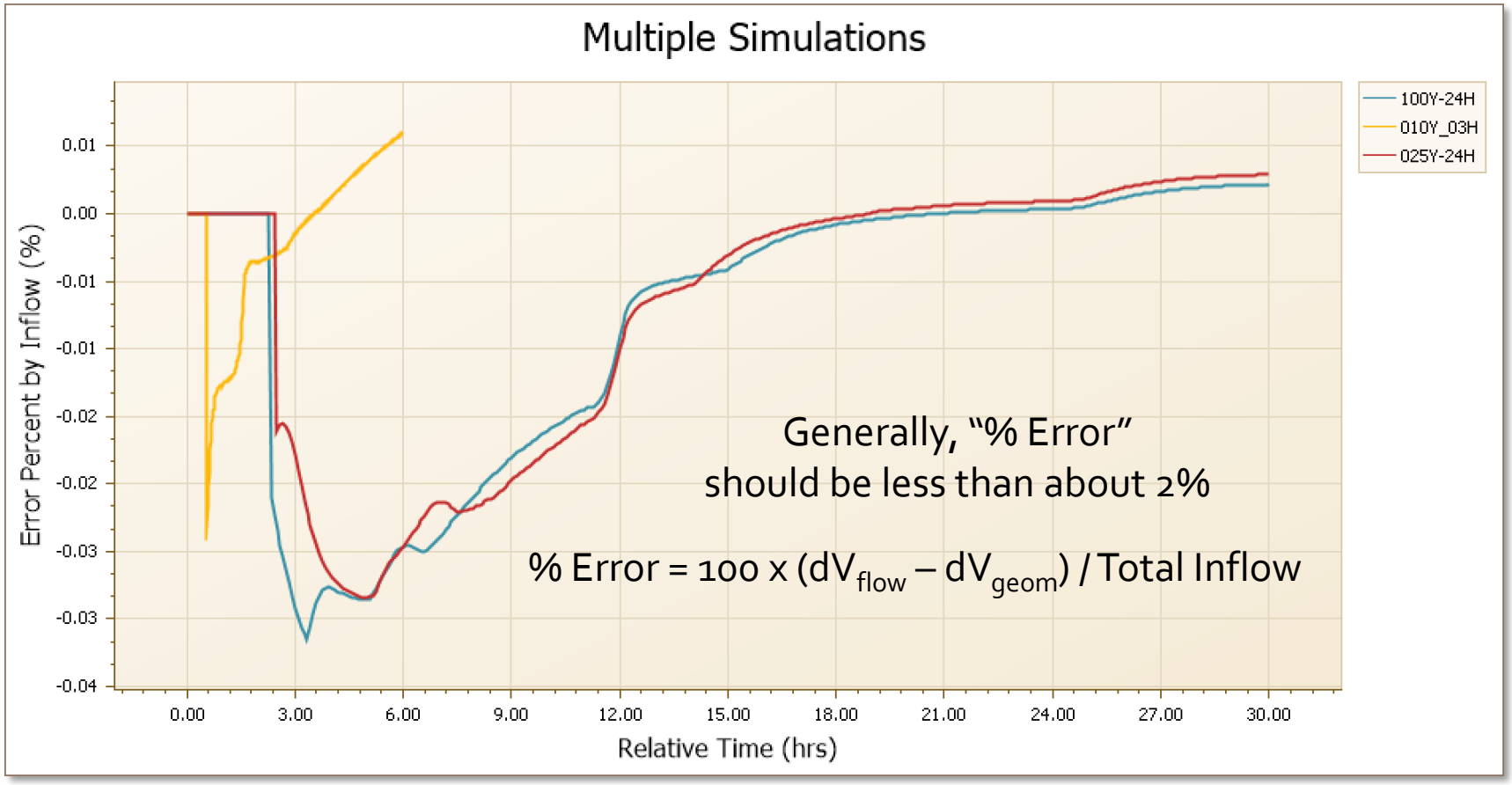


Integrated Storm Sewer Hydraulics and Pond Routing

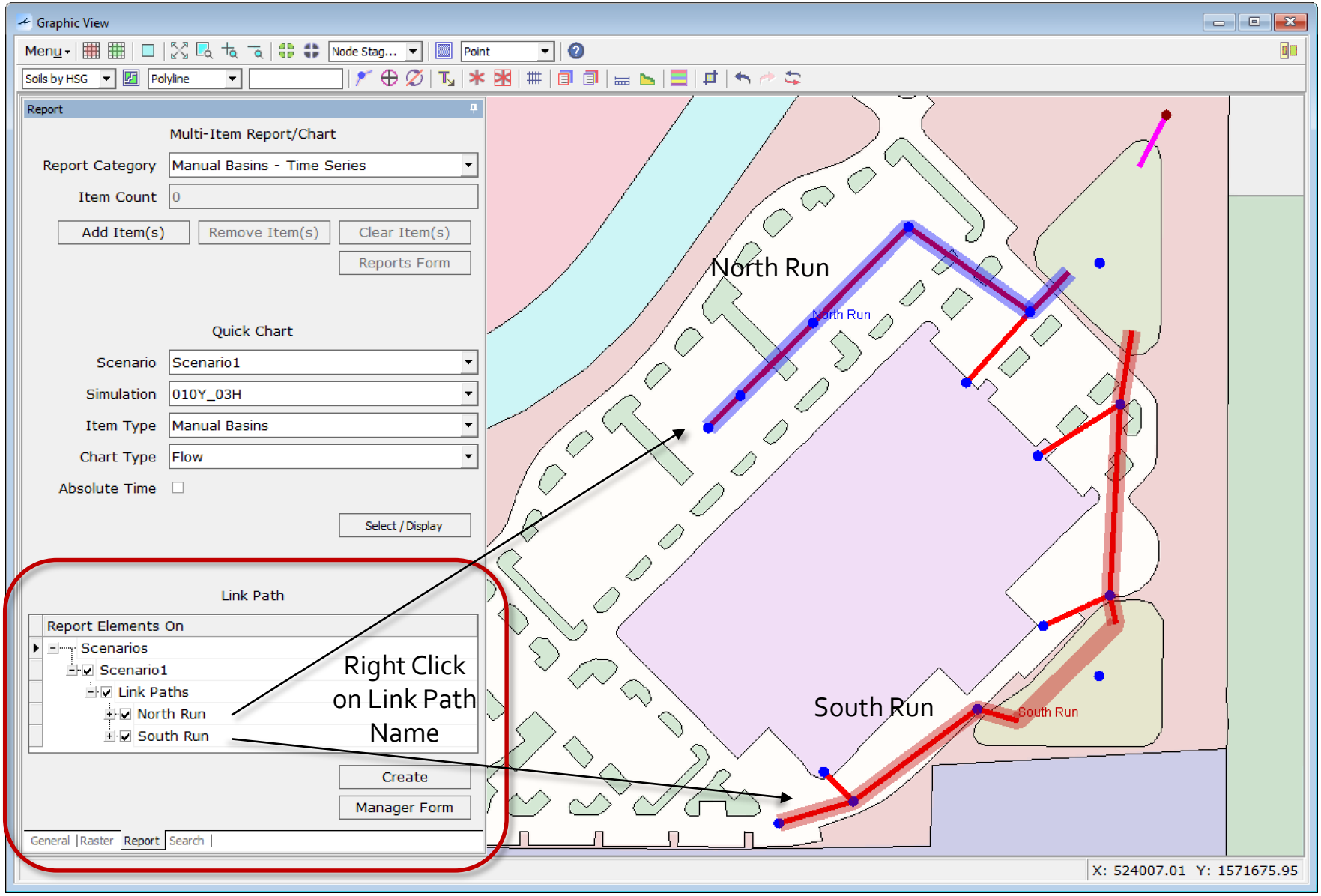




Integrated Storm Sewer Hydraulics and Pond Routing

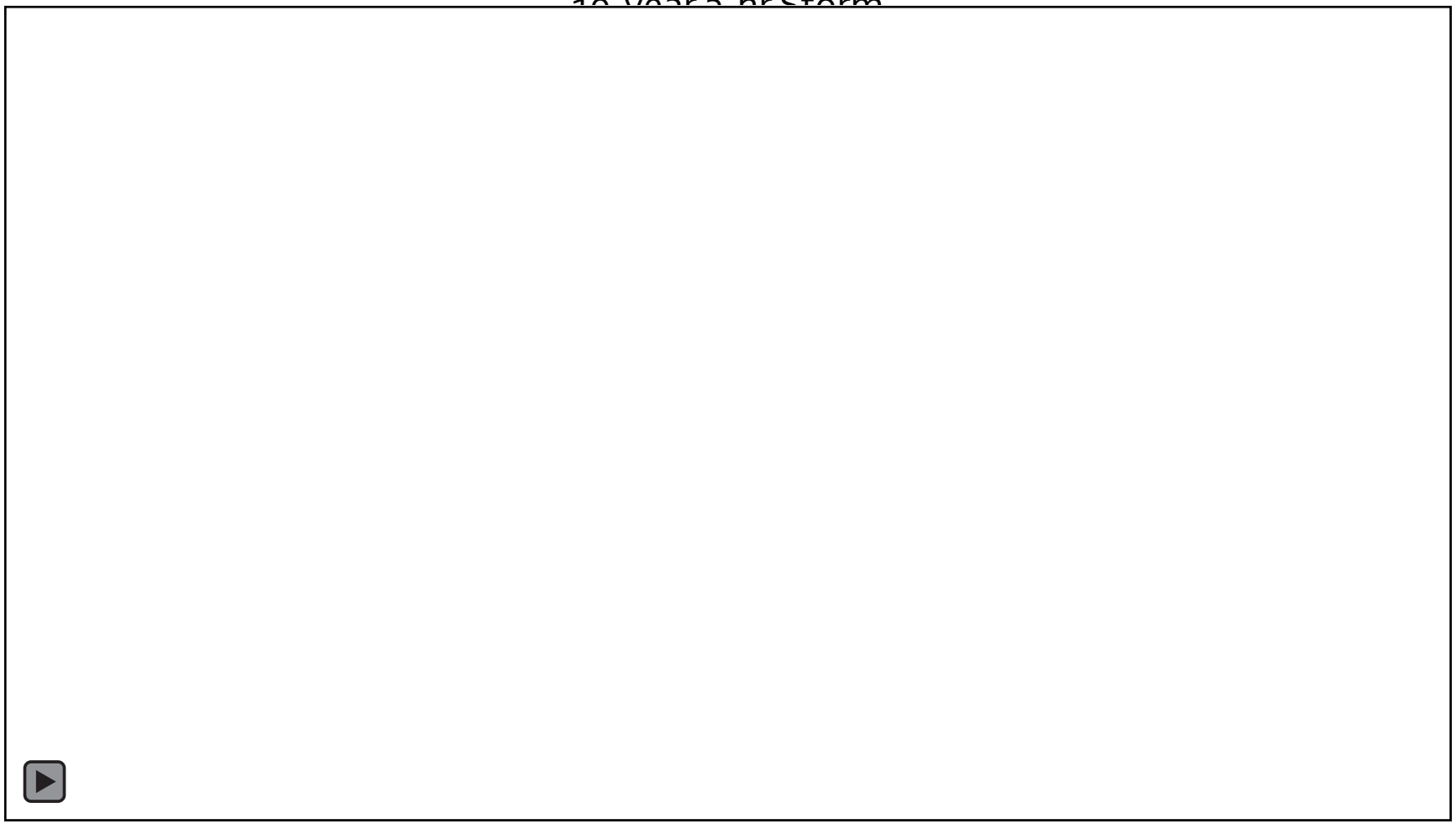


Integrated Storm Sewer Hydraulics and Pond Routing



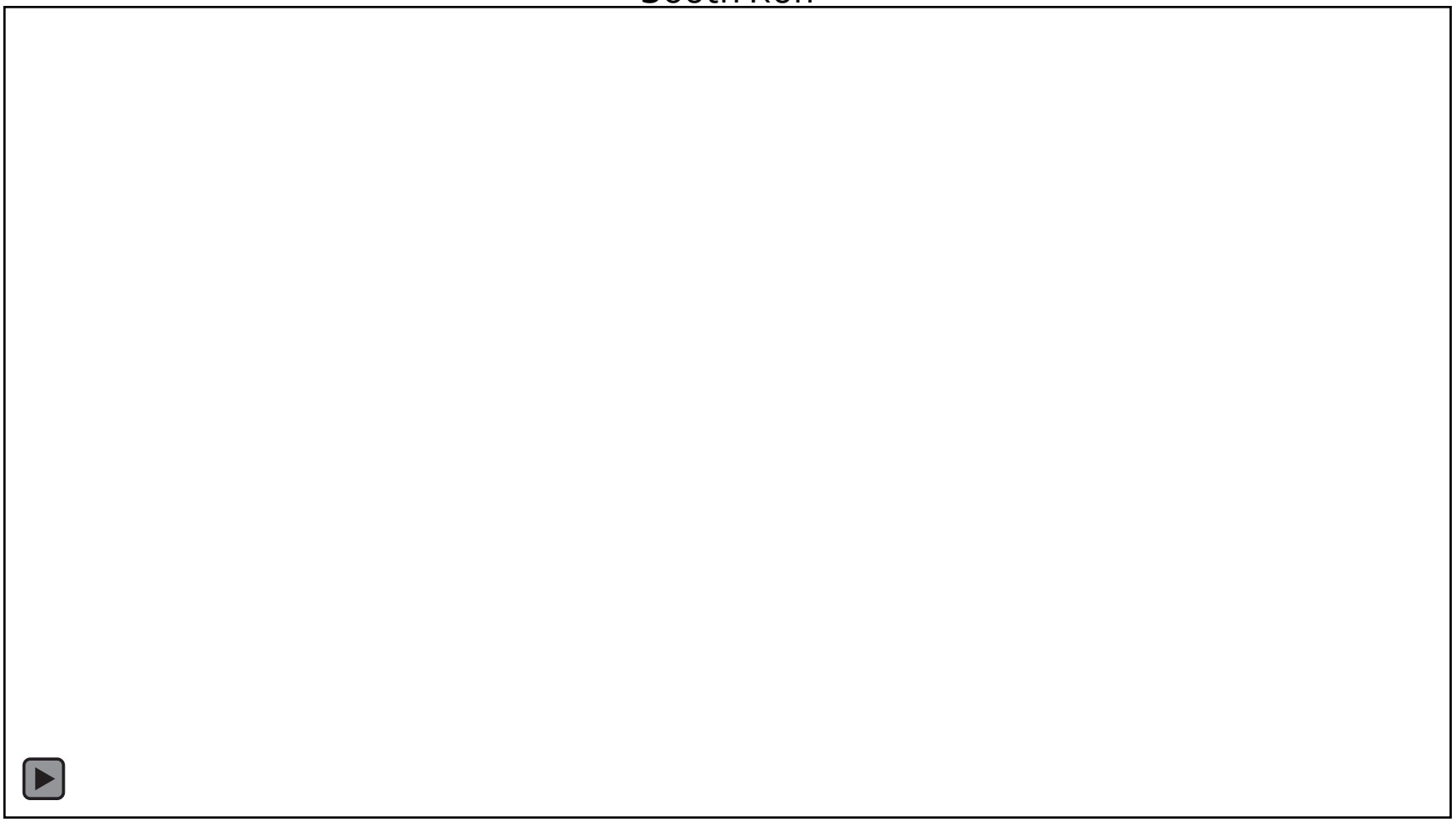
Integrated Storm Sewer Hydraulics and Pond Routing

North Run

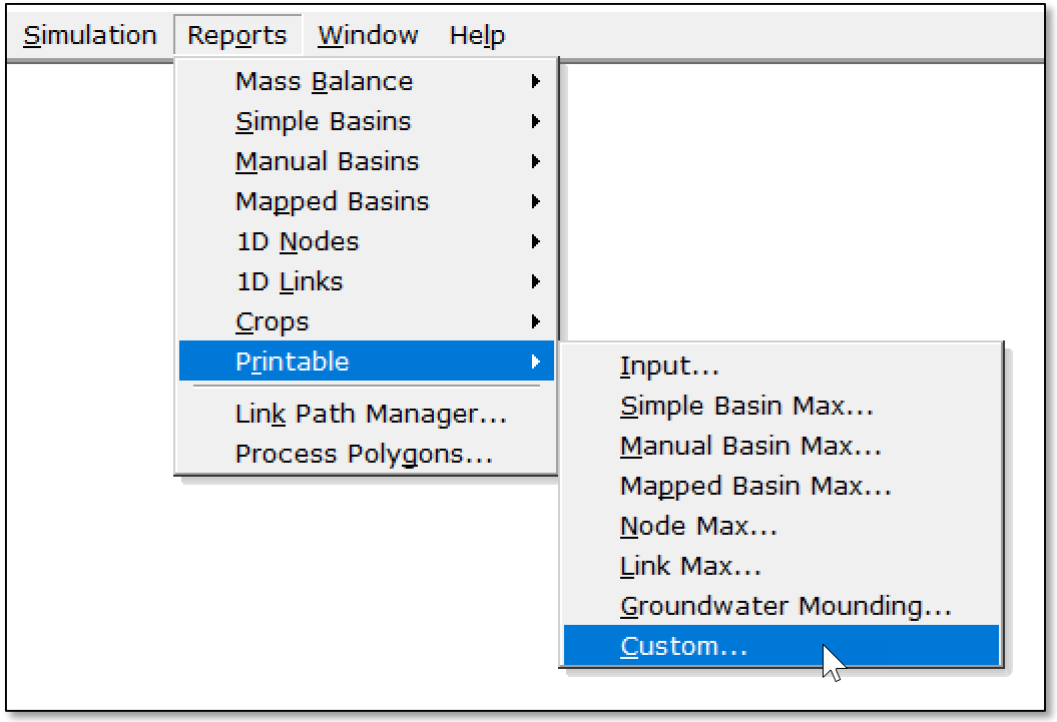


Integrated Storm Sewer Hydraulics and Pond Routing

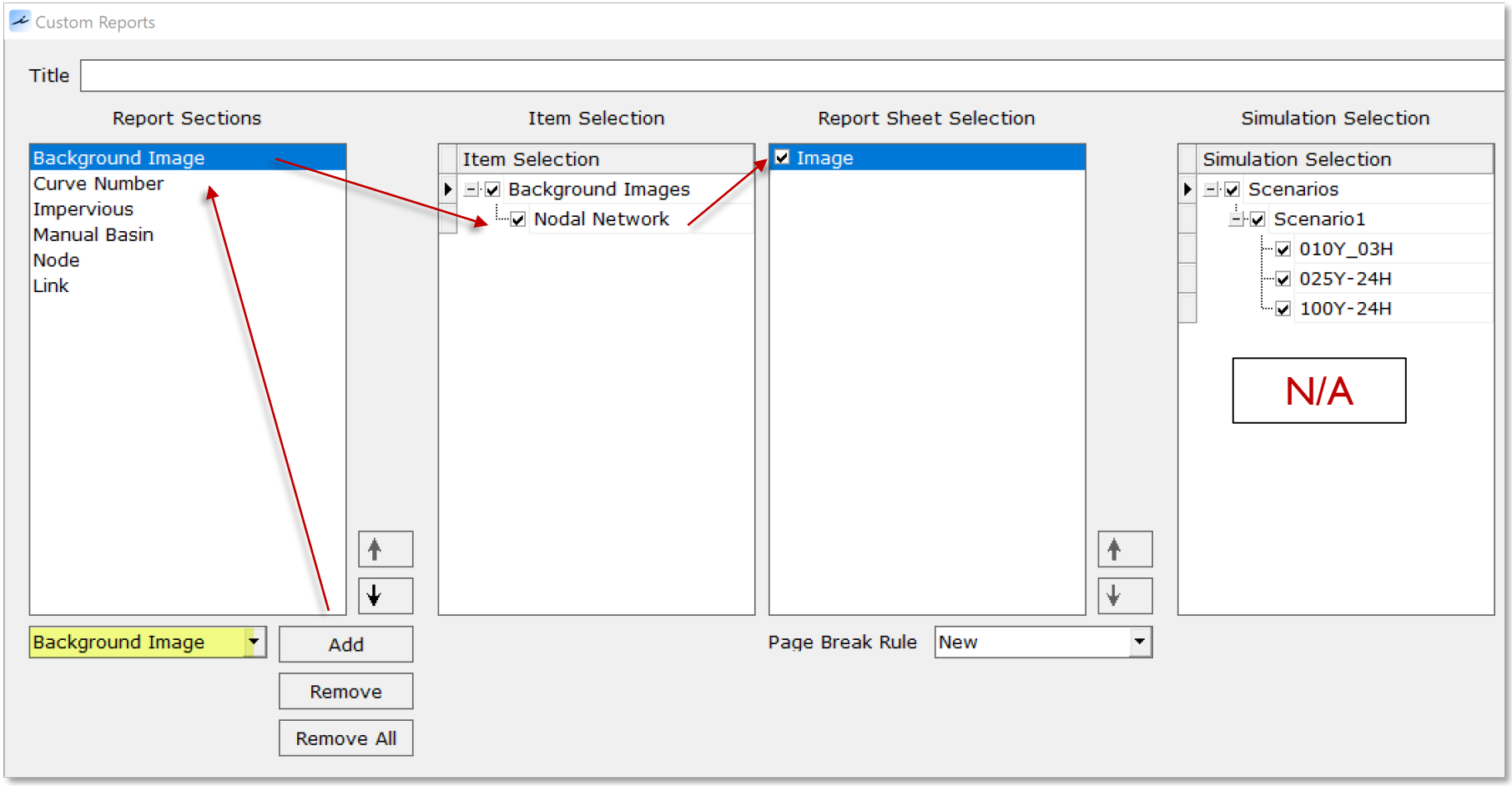
South Run



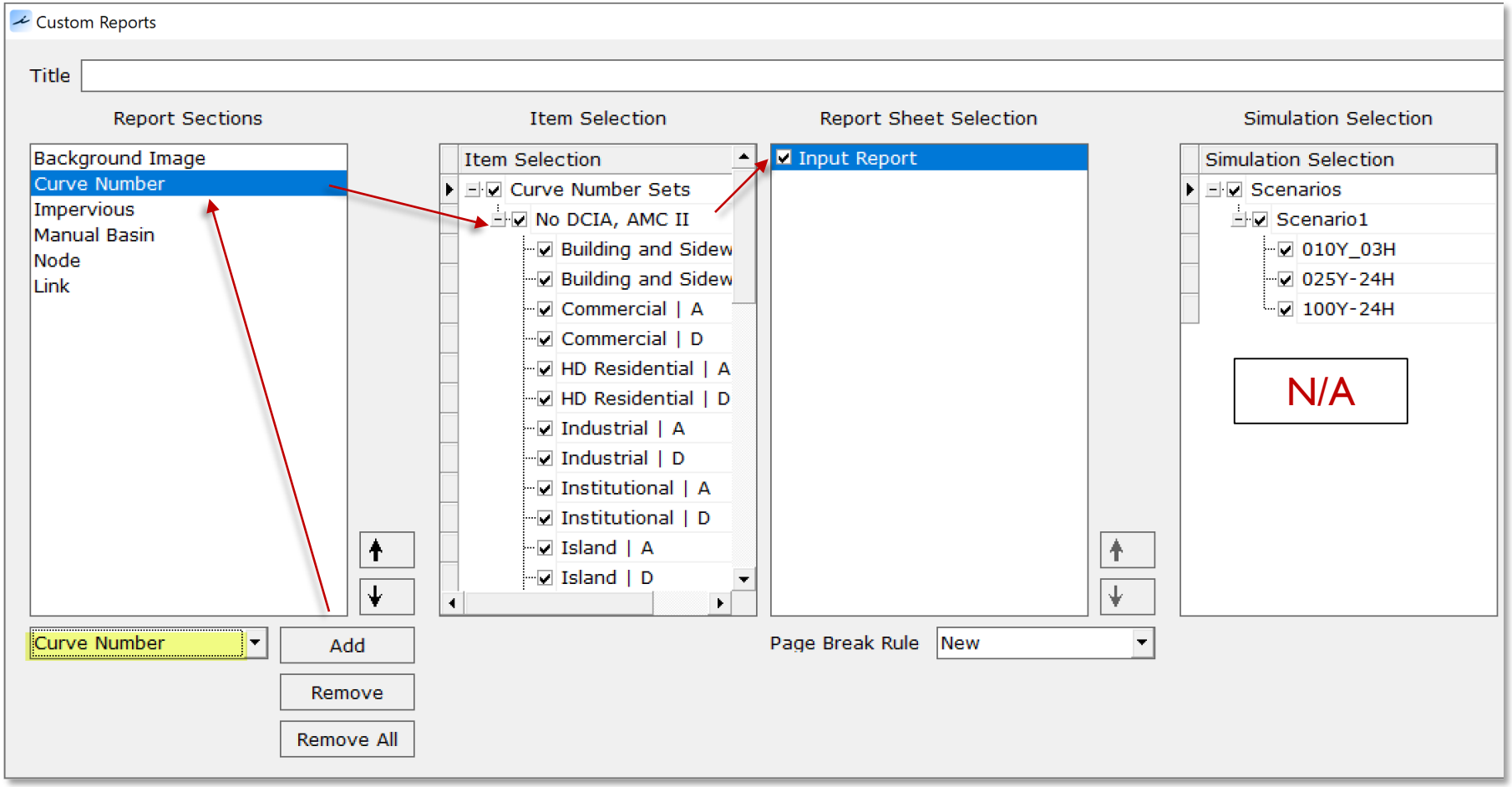
Integrated Storm Sewer Hydraulics and Pond Routing



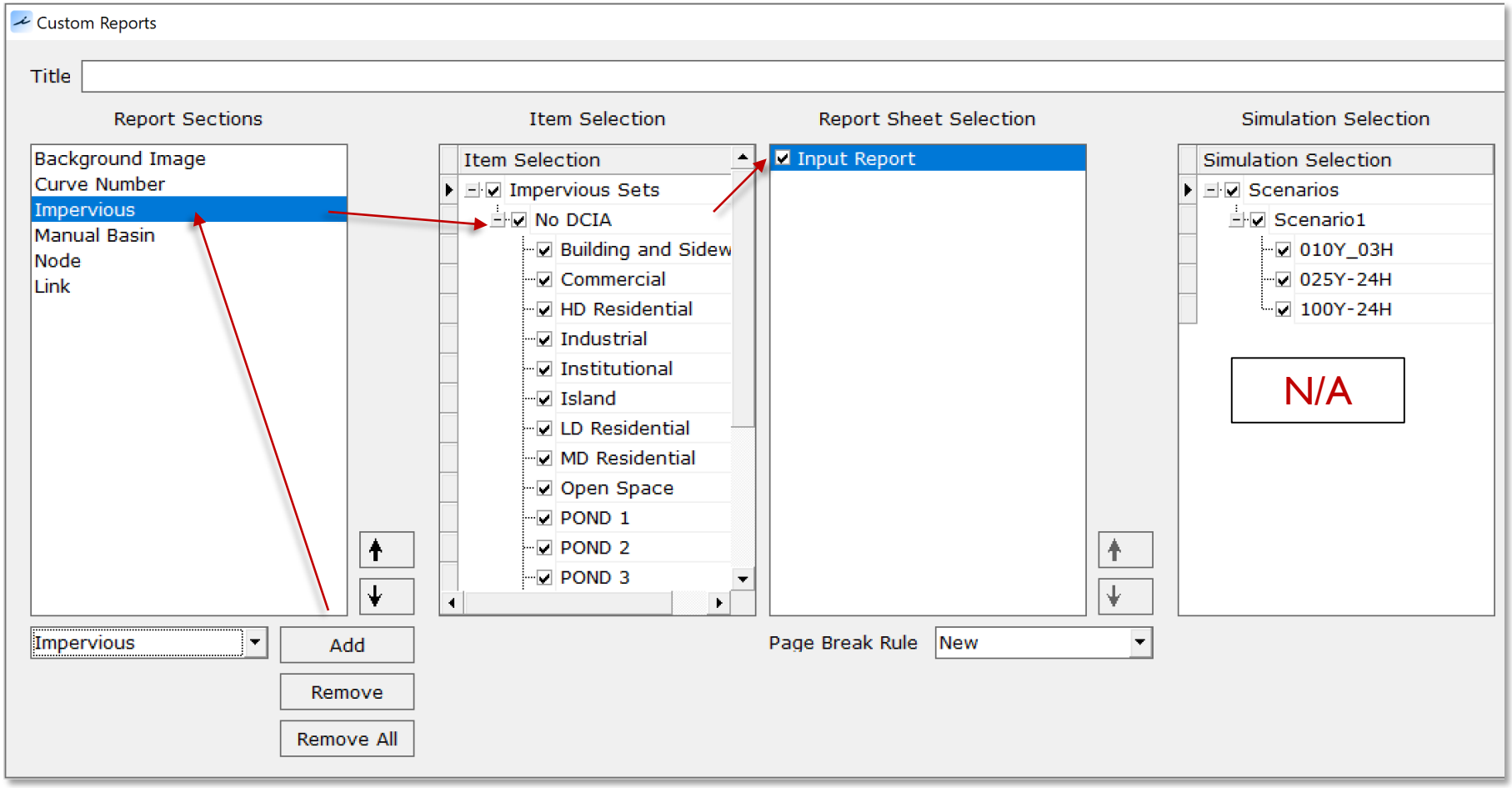
Integrated Storm Sewer Hydraulics and Pond Routing



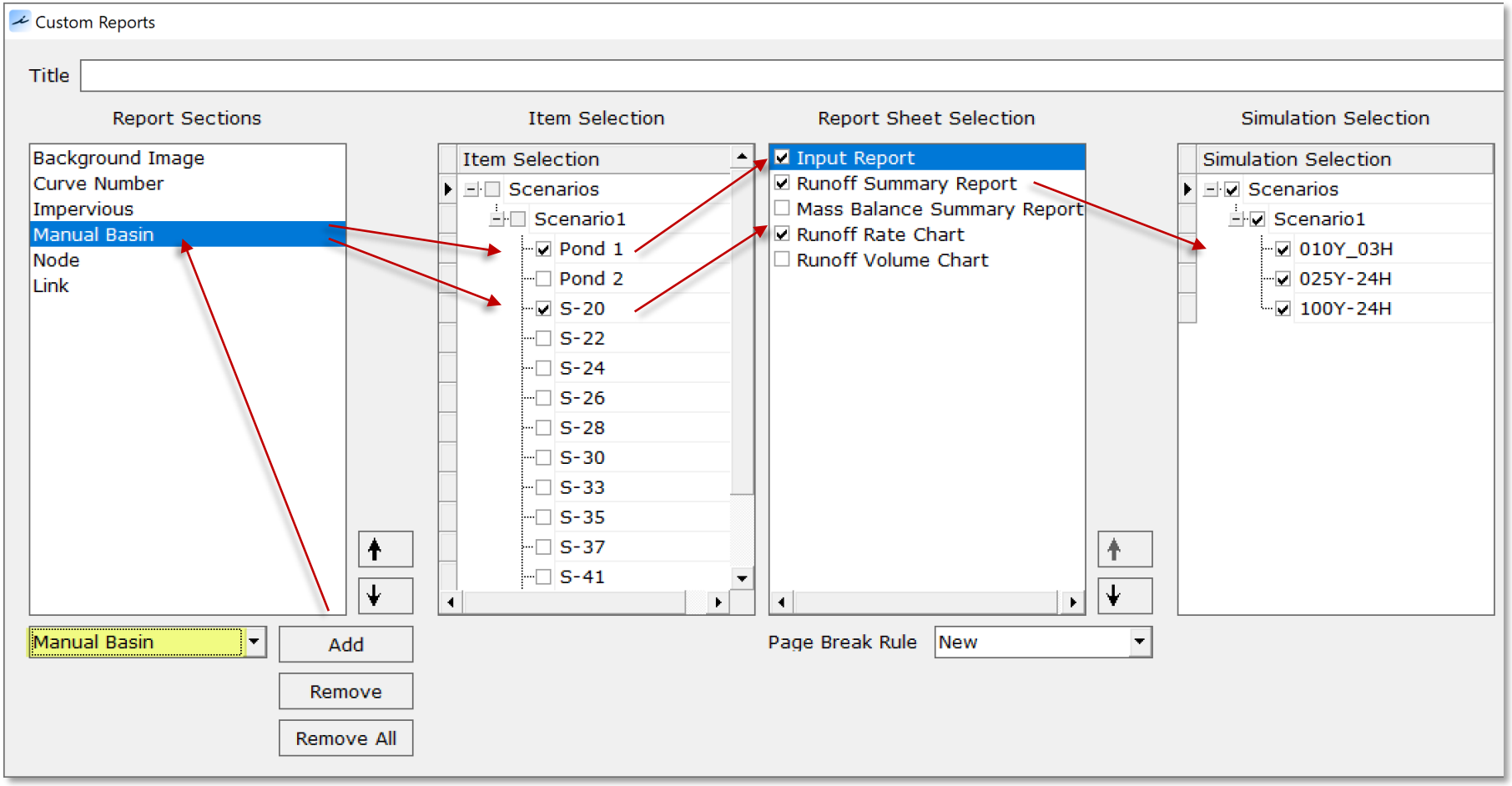
Integrated Storm Sewer Hydraulics and Pond Routing



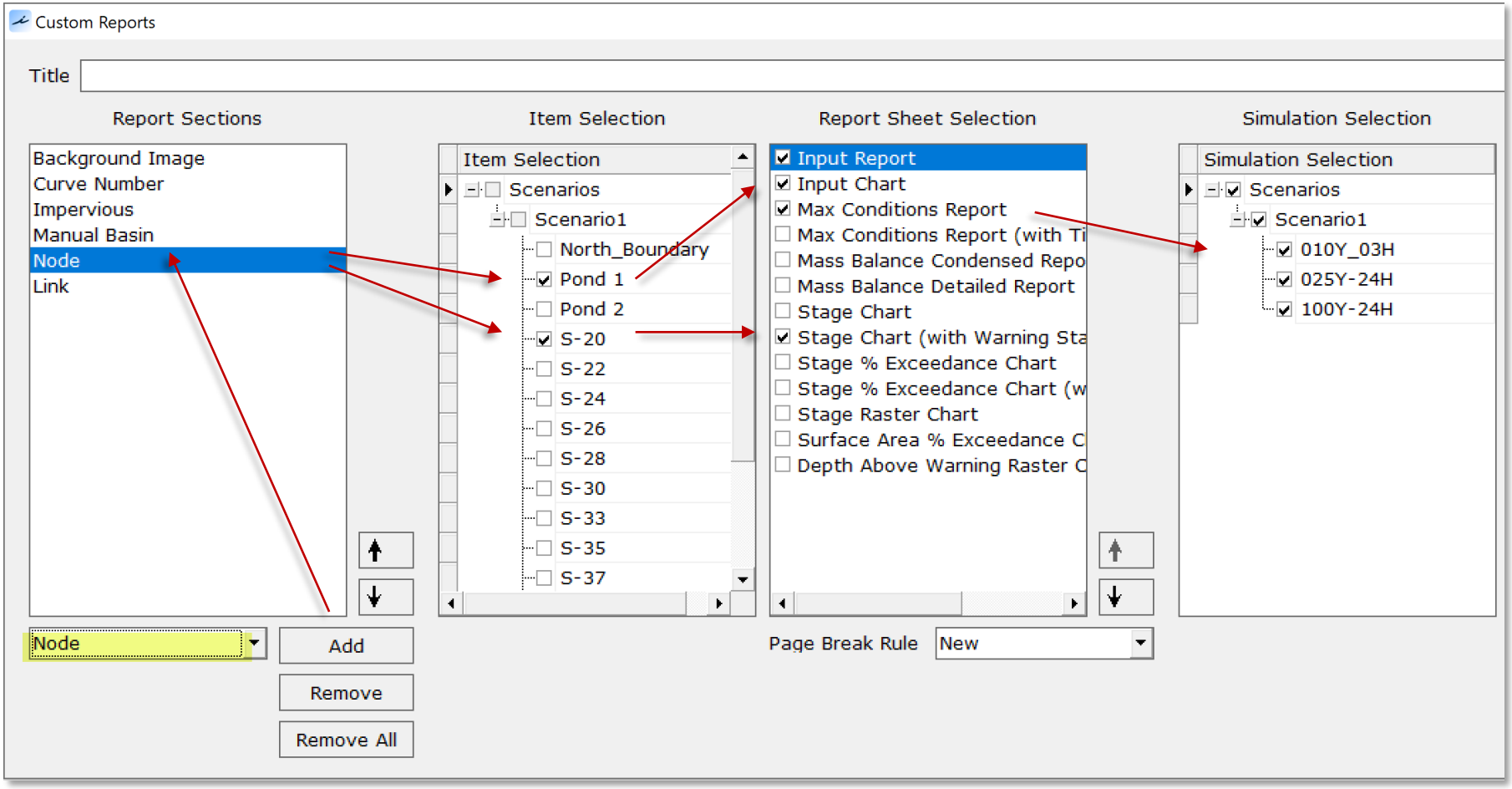
Integrated Storm Sewer Hydraulics and Pond Routing



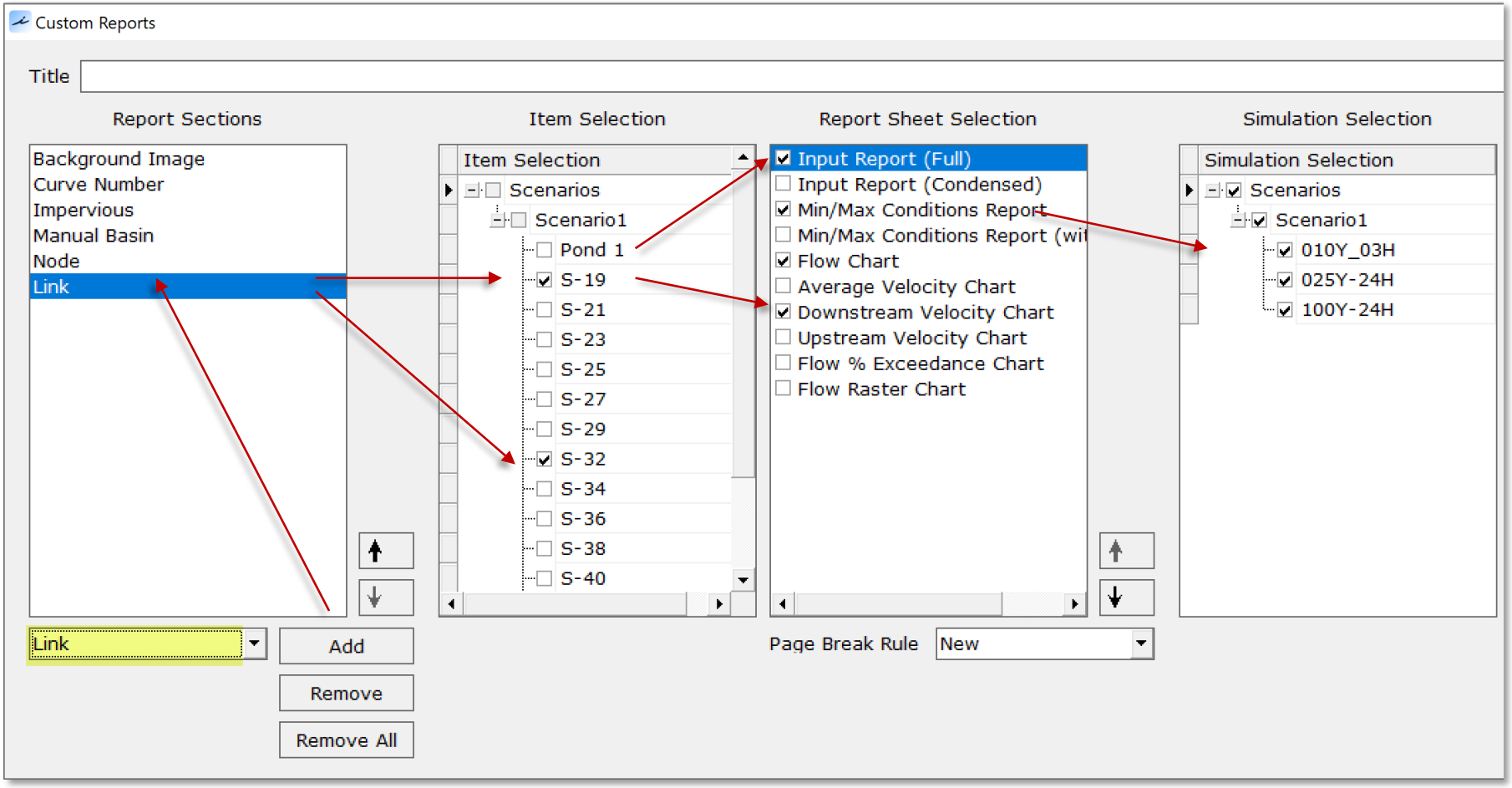
Integrated Storm Sewer Hydraulics and Pond Routing



Integrated Storm Sewer Hydraulics and Pond Routing

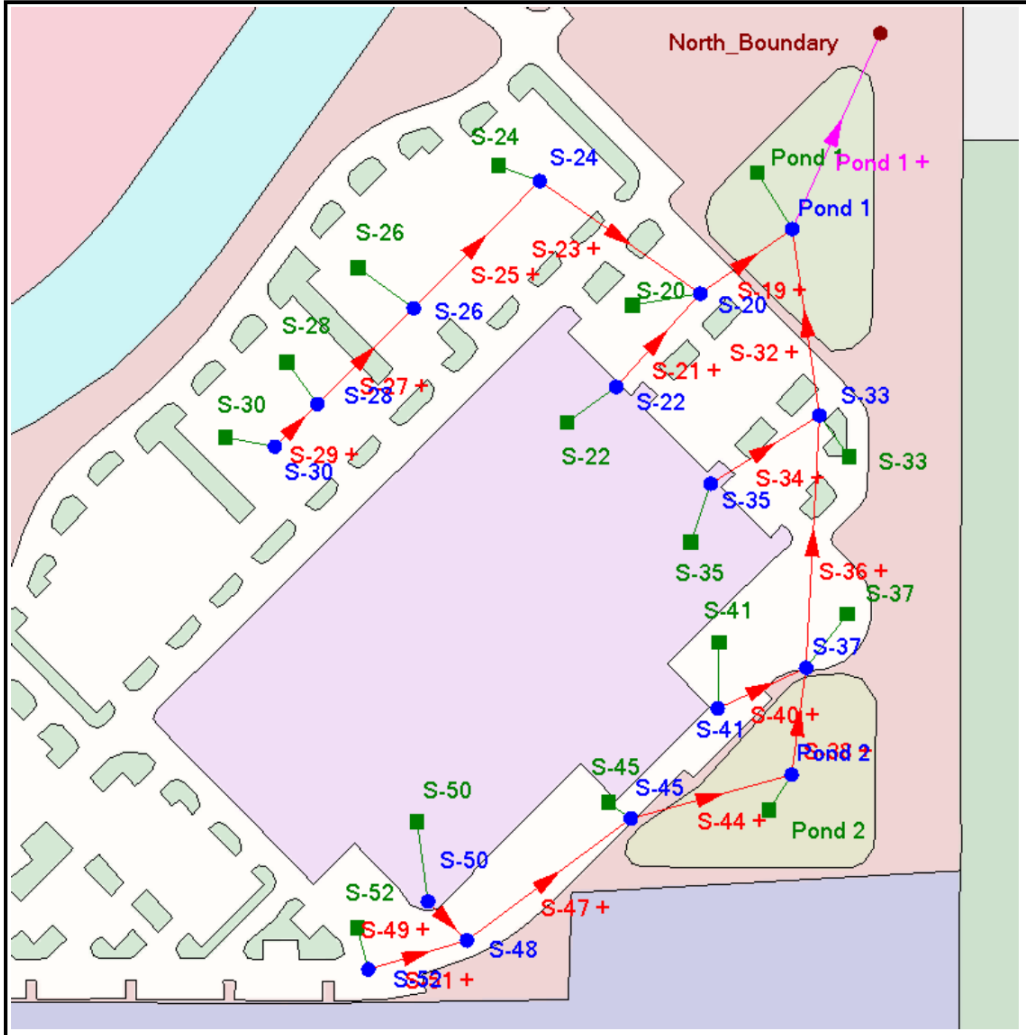


Integrated Storm Sewer Hydraulics and Pond Routing

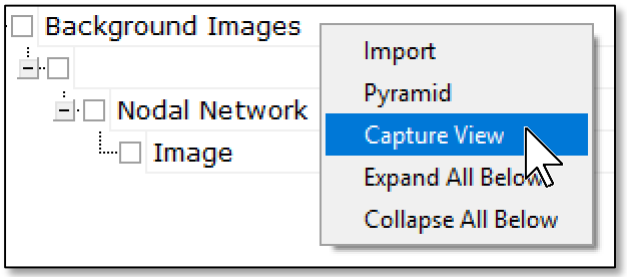


Custom Report (Background Image)

Background Image: Nodal Network



Nodal Network "captured" as a background image and included in report



Custom Report (Curve Number Lookup Table)

Curve Number: No DCIA, AMC II [Set]

Land Cover Zone	Soil Zone	Curve Number [dec]
Building and Sidewalk	A	98.0
Building and Sidewalk	D	98.0
Commercial	A	89.0
Commercial	D	95.0
HD Residential	A	77.0
HD Residential	D	92.0
Industrial	A	81.0
Industrial	D	93.0
Institutional	A	81.0
Institutional	D	93.0
Island	A	49.0
Island	D	84.0
LD Residential	A	57.0
LD Residential	D	86.0
MD Residential	A	61.0
MD Residential	D	87.0
Open Space	A	49.0
Open Space	D	49.0
POND 1	A	49.0
POND 1	D	84.0
POND 2	A	49.0
POND 2	D	84.0
POND 3	A	49.0
POND 3	D	84.0
Pavement	A	98.0
Pavement	D	98.0
ROW	A	83.0
ROW	D	93.0
Recreation	A	49.0
Recreation	D	84.0
Stream	A	95.0
Stream	D	98.0

Custom Report (Curve Number Lookup Table)

Land Cover Zone	Soil Zone	Curve Number [dec]
Trail	A	49.0
Trail	D	84.0
Wetland	A	95.0
Wetland	D	98.0

Custom Report (Impervious Lookup Table)

Impervious: No DCIA [Set]

Land Cover Zone	% Impervious	% DCIA	% Direct	Ia Impervious [in]	Ia Pervious [in]
Building and Sidewalk	0.00	0.00	0.00	0.000	0.000
Commercial	0.00	0.00	0.00	0.000	0.000
HD Residential	0.00	0.00	0.00	0.000	0.000
Industrial	0.00	0.00	0.00	0.000	0.000
Institutional	0.00	0.00	0.00	0.000	0.000
Island	0.00	0.00	0.00	0.000	0.000
LD Residential	0.00	0.00	0.00	0.000	0.000
MD Residential	0.00	0.00	0.00	0.000	0.000
Open Space	0.00	0.00	0.00	0.000	0.000
POND 1	0.00	0.00	0.00	0.000	0.000
POND 2	0.00	0.00	0.00	0.000	0.000
POND 3	0.00	0.00	0.00	0.000	0.000
Pavement	0.00	0.00	0.00	0.000	0.000
ROW	0.00	0.00	0.00	0.000	0.000
Recreation	0.00	0.00	0.00	0.000	0.000
Stream	0.00	0.00	0.00	0.000	0.000
Trail	0.00	0.00	0.00	0.000	0.000
Wetland	0.00	0.00	0.00	0.000	0.000

Custom Report (Manual Basin "Pond 1")

Manual Basin: Pond 1

Input Data

Scenario:	Scenario1
Node:	Pond 1
Hydrograph Method:	NRCS Unit Hydrograph
Infiltration Method:	Curve Number
Time of Concentration:	10.0000 min
Max Allowable Q:	0.00 cfs
Time Shift:	0.0000 hr
Unit Hydrograph:	UH256
Peaking Factor:	256.0
Area:	1.2373 ac

Area [ac]	Land Cover Zone	Soil Zone	Rainfall Name
0.0063	Pavement	A	
0.4262	Open Space	A	
0.8047	POND 1	A	

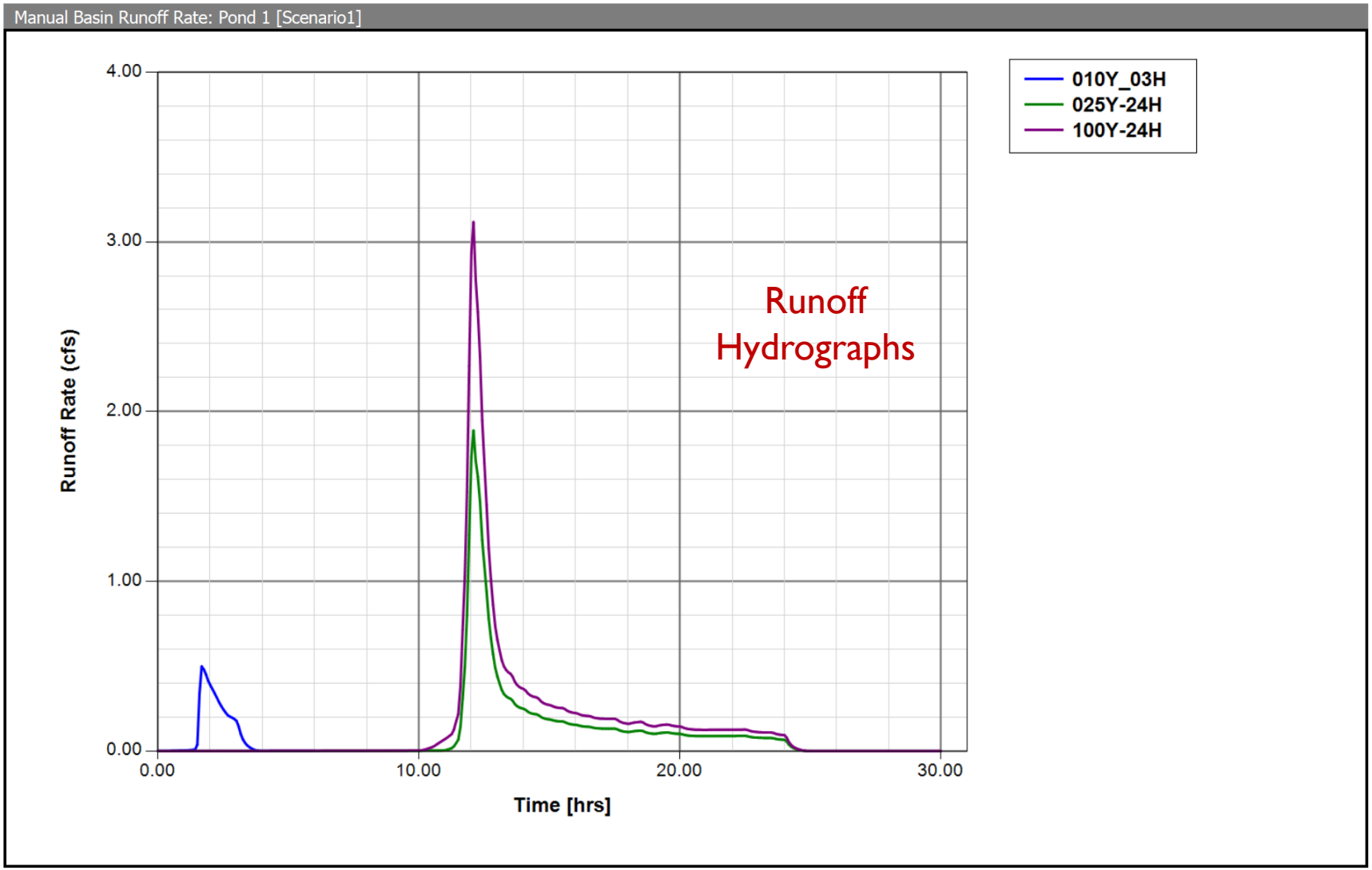
Comment:

Manual Basin Runoff Summary

Manual Basin Runoff Summary [Scenario1]

Basin Name	Sim Name	Max Flow [cfs]	Time to Max Flow [hrs]	Total Rainfall [in]	Total Runoff [in]	Area [ac]	Equivalent Curve Number	% Imperv	% DCIA
Pond 1	010Y_03H	0.50	1.6917	4.30	0.41	1.2373	49.5	0.00	0.00
Pond 1	025Y-24H	1.91	12.0750	8.40	2.42	1.2373	49.3	0.00	0.00
Pond 1	100Y-24H	3.17	12.0667	10.50	3.80	1.2373	49.2	0.00	0.00

Custom Report (Manual Basin "Pond 1")



Custom Report (Manual Basin "S-20")

Manual Basin: S-20

Input Data

Scenario:	Scenario1
Node:	S-20
Hydrograph Method:	NRCS Unit Hydrograph
Infiltration Method:	Curve Number
Time of Concentration:	10.0000 min
Max Allowable Q:	0.00 cfs
Time Shift:	0.0000 hr
Unit Hydrograph:	UH256
Peaking Factor:	256.0
Area:	0.7342 ac

Area [ac]	Land Cover Zone	Soil Zone	Rainfall Name
0.0176	Building and Sidewalk	A	
0.6341	Pavement	A	
0.0823	Island	A	
0.0002	Open Space	A	

Comment:

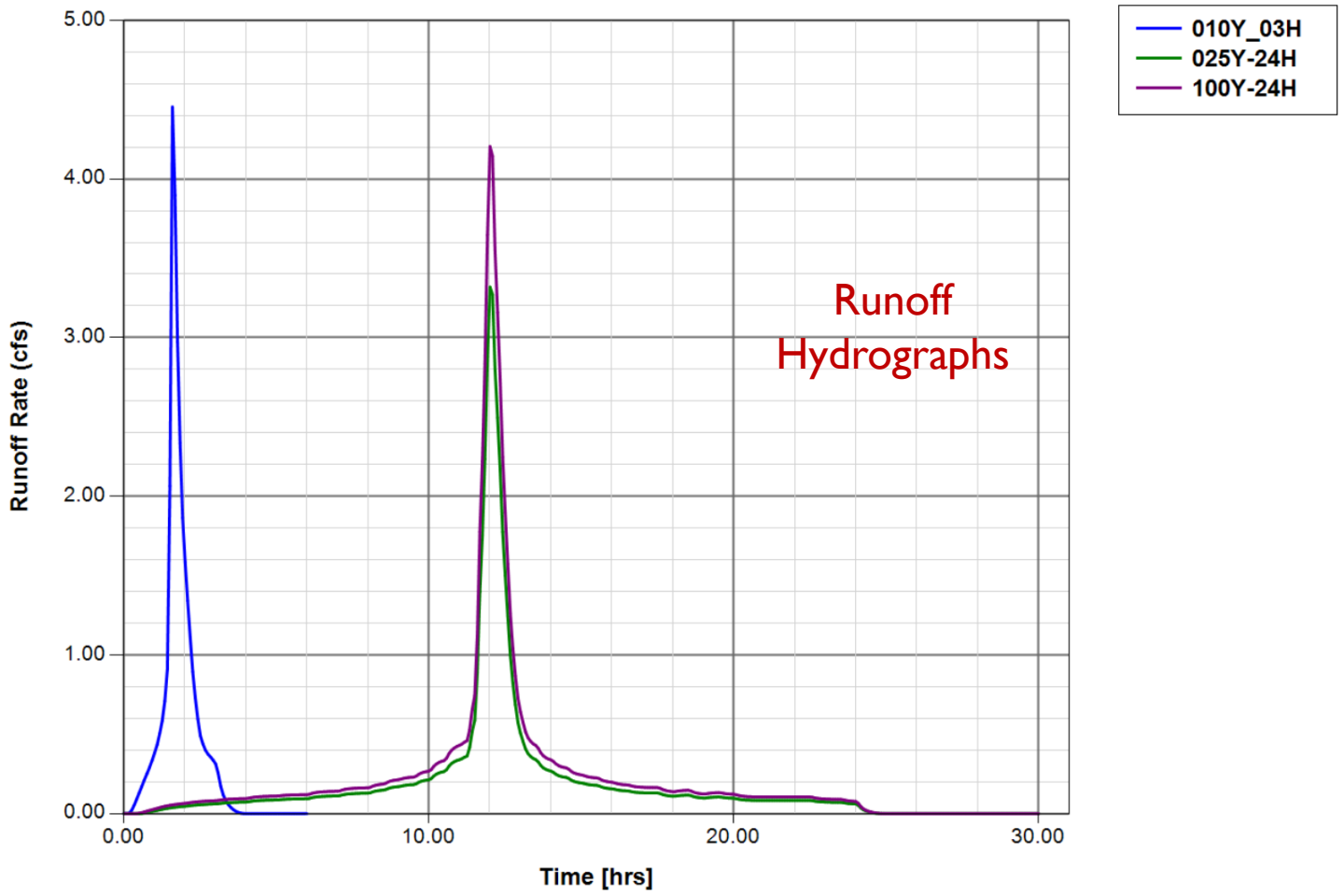
Manual Basin Runoff Summary

Manual Basin Runoff Summary [Scenario1]

Basin Name	Sim Name	Max Flow [cfs]	Time to Max Flow [hrs]	Total Rainfall [in]	Total Runoff [in]	Area [ac]	Equivalent Curve Number	% Imperv	% DCIA
S-20	010Y_03H	4.52	1.6083	4.30	3.65	0.7342	94.3	0.00	0.00
S-20	025Y-24H	3.40	12.0500	8.40	7.51	0.7342	92.6	0.00	0.00
S-20	100Y-24H	4.31	12.0500	10.50	9.52	0.7342	92.0	0.00	0.00

Custom Report (Manual Basin "S-20")

Manual Basin Runoff Rate: S-20 [Scenario1]



Custom Report (Node "Pond 1")

Node: Pond 1

Input Data

Scenario:	Scenario1
Type:	Stage/Area
Base Flow:	0.00 cfs
Initial Stage:	74.00 ft
Warning Stage:	80.50 ft

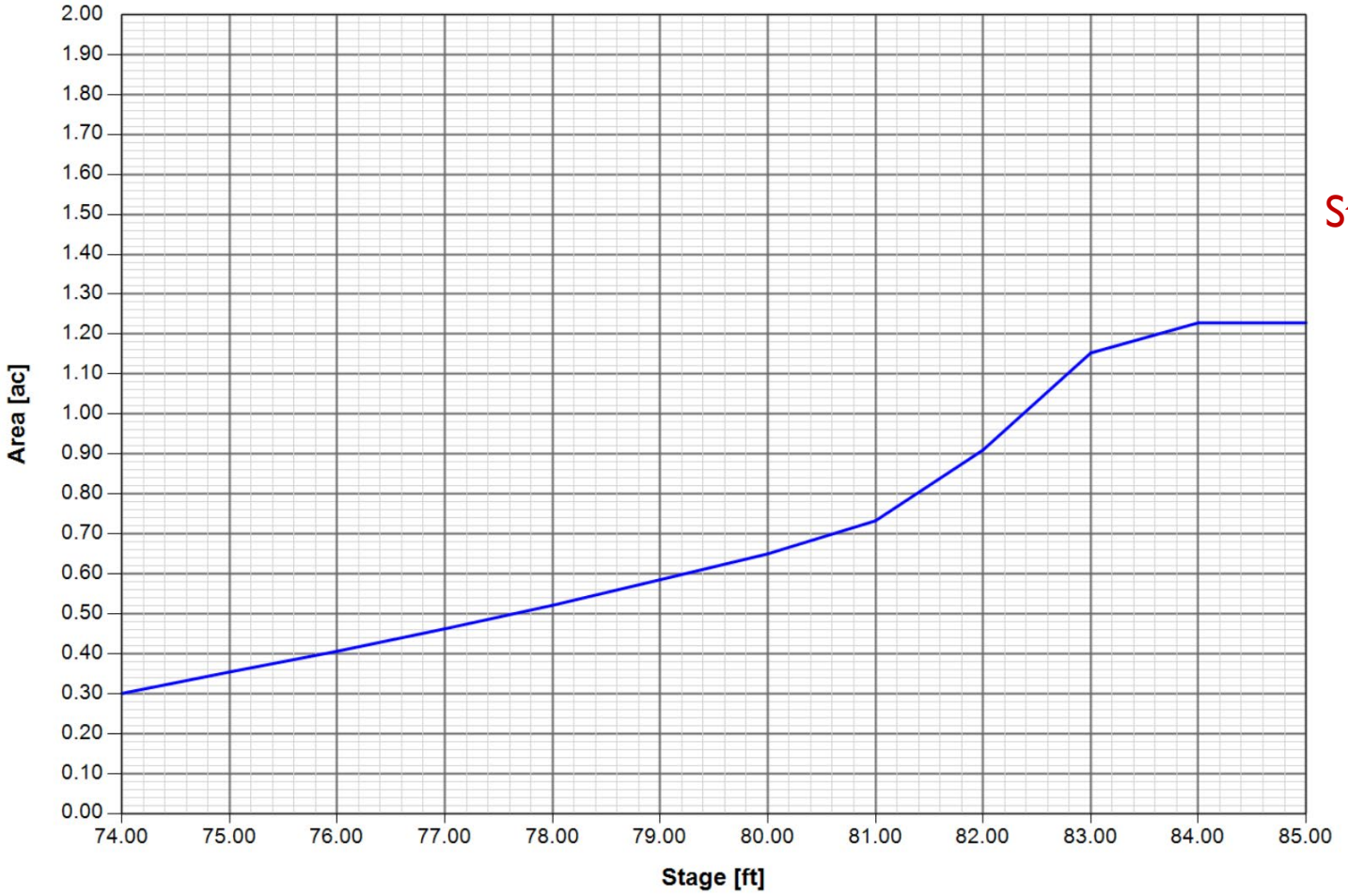
Stage/Area Table

Stage [ft]	Area [ac]	Area [ft2]
74.00	0.3006	13096
75.00	0.3544	15436
76.00	0.4062	17696
77.00	0.4624	20140
78.00	0.5212	22703
79.00	0.5853	25494
80.00	0.6500	28316
81.00	0.7327	31916
82.00	0.9101	39644
83.00	1.1530	50224
84.00	1.2284	53511
85.00	1.2284	53511

Comment:

Custom Report (Node "Pond 1")

Node: Pond 1 Scenario: Scenario1



Stage/Area Chart

Custom Report (Node "Pond 1")

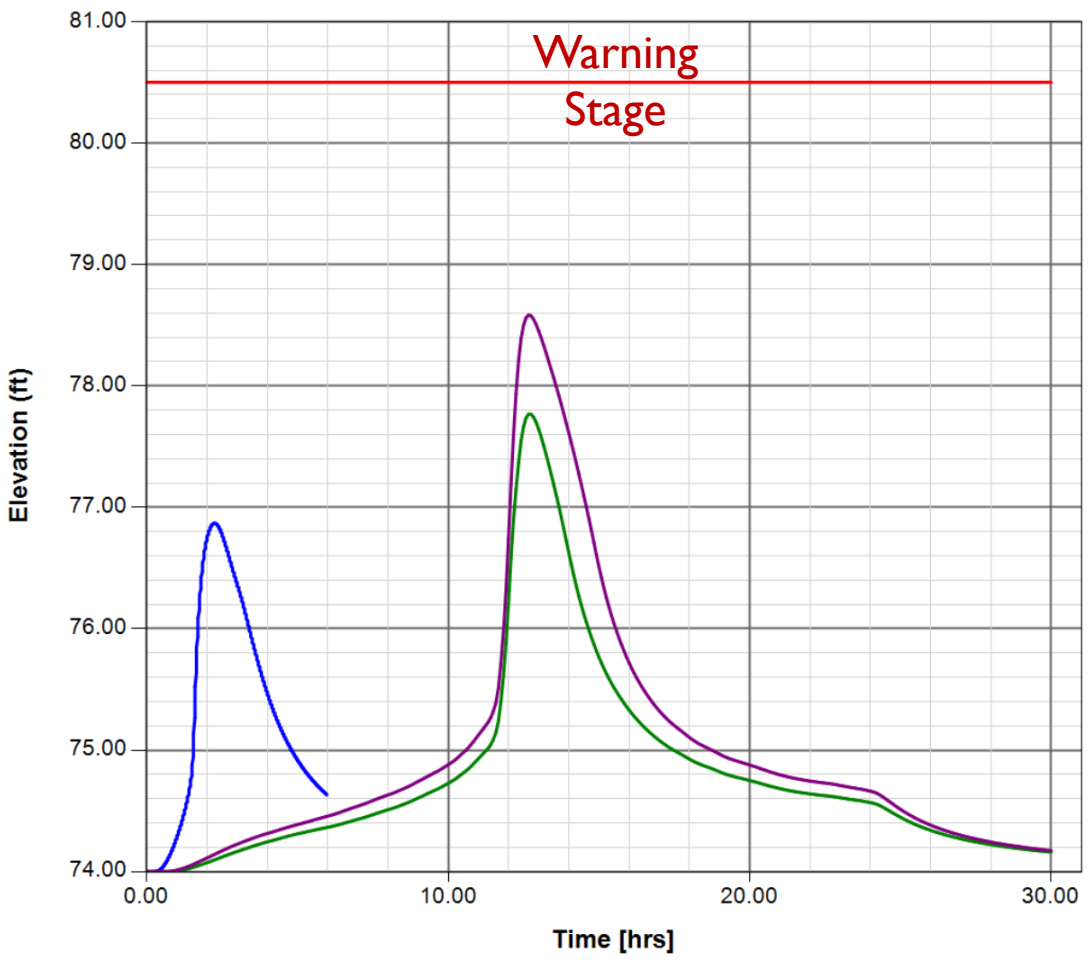
Node Max Conditions [Scenario1]

Node Max Conditions

Node Name	Sim Name	Warning Stage [ft]	Max Stage [ft]	Min/Max Delta Stage [ft]	Max Total Inflow [cfs]	Max Total Outflow [cfs]	Max Surface Area [ft2]
Pond 1	010Y_03H	80.50	76.87	0.0010	40.53	14.79	20027
Pond 1	025Y-24H	80.50	77.77	0.0010	36.01	17.61	22319
Pond 1	100Y-24H	80.50	78.59	0.0010	47.27	19.44	24412

Custom Report (Node "S-20")

Node Stage w/Warning Stage: Pond 1 [Scenario1]



Stage Hydrographs

Custom Report (Node "S-20")

Node: S-20

Input Data

Scenario:	Scenario1
Type:	Stage/Area
Base Flow:	0.00 cfs
Initial Stage:	76.25 ft
Warning Stage:	81.70 ft

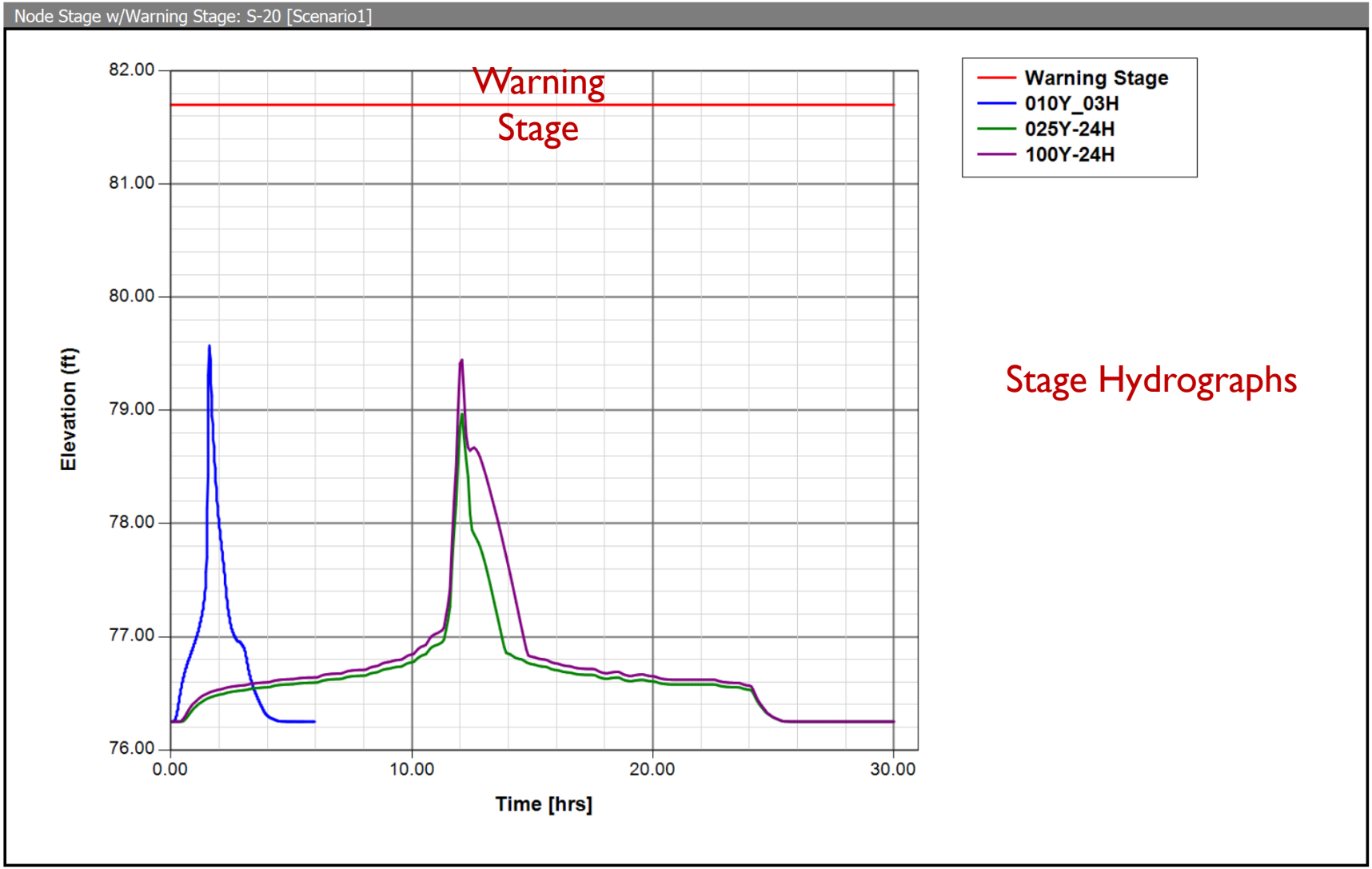
Comment:

Node Max Conditions

Node Max Conditions [Scenario1]

Node Name	Sim Name	Warning Stage [ft]	Max Stage [ft]	Min/Max Delta Stage [ft]	Max Total Inflow [cfs]	Max Total Outflow [cfs]	Max Surface Area [ft2]
S-20	010Y_03H	81.70	79.58	0.0019	34.07	34.05	603
S-20	025Y-24H	81.70	78.99	0.0010	25.85	25.84	601
S-20	100Y-24H	81.70	79.50	0.0010	32.93	32.96	602

Custom Report (Node "S-20")



Stage Hydrographs

Custom Report (Pipe Link "S-19")

Pipe Input Data

Pipe Link: S-19		Upstream		Downstream	
Scenario:	Scenario1	Invert:	76.25 ft	Invert:	76.00 ft
From Node:	S-20	Manning's N:	0.0130	Manning's N:	0.0130
To Node:	Pond 1	Geometry: Circular		Geometry: Circular	
Link Count:	1	Max Depth:	3.00 ft	Max Depth:	3.00 ft
Flow Direction:	Both	Bottom Clip			
Damping:	0.0000 ft	Default:	0.00 ft	Default:	0.00 ft
Length:	68.00 ft	Op Table:		Op Table:	
FHWA Code:	1	Ref Node:		Ref Node:	
Entr Loss Coef:	0.50	Manning's N:	0.0000	Manning's N:	0.0000
Exit Loss Coef:	1.00	Top Clip			
Bend Loss Coef:	0.00	Default:	0.00 ft	Default:	0.00 ft
Bend Location:	0.00 ft	Op Table:		Op Table:	
Energy Switch:	Energy	Ref Node:		Ref Node:	
		Manning's N:	0.0000	Manning's N:	0.0000

Comment:

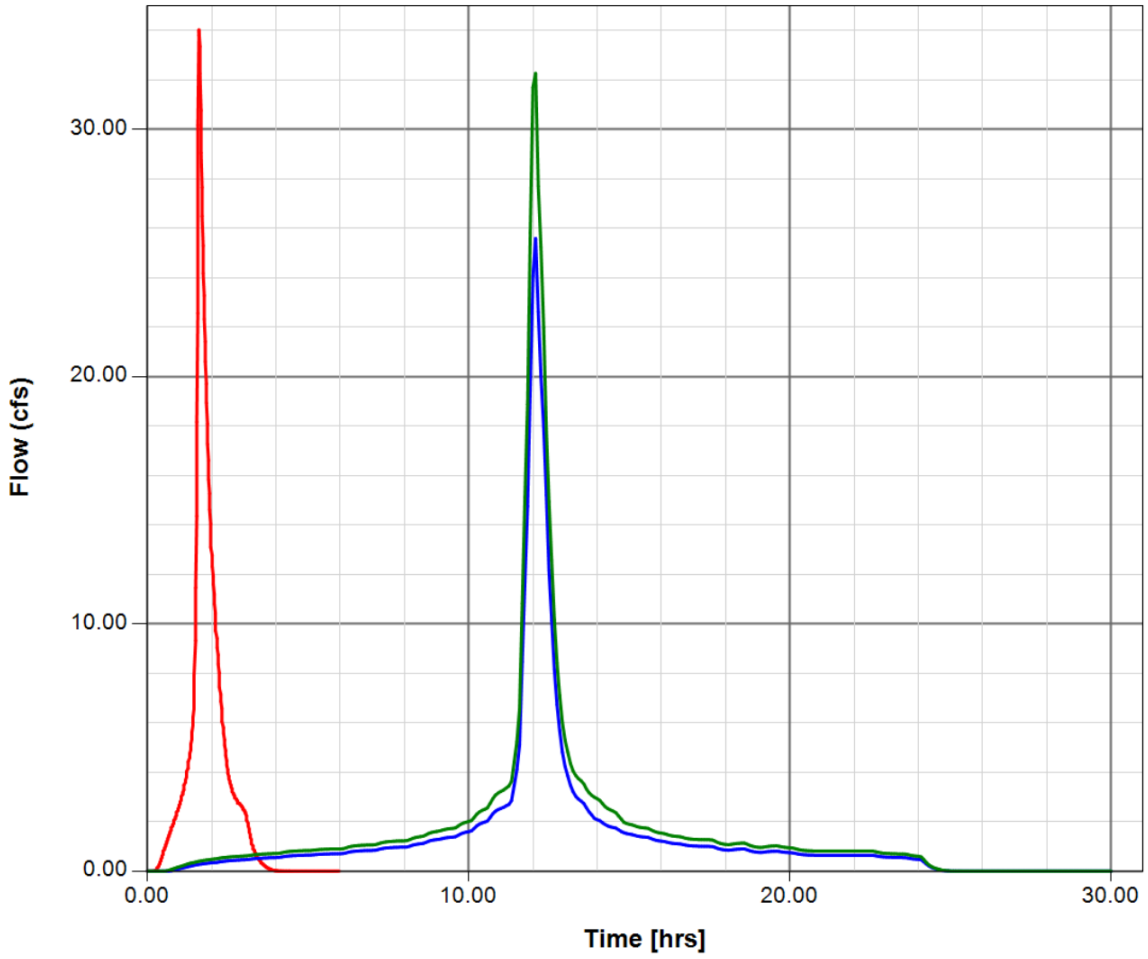
Link Min/Max Conditions

Link Min/Max Conditions [Scenario1]

Link Name	Sim Name	Max Flow [cfs]	Min Flow [cfs]	Min/Max Delta Flow [cfs]	Max Us Velocity [fps]	Max Ds Velocity [fps]	Max Avg Velocity [fps]
S-19	010Y_03H	34.05	0.00	0.13	4.82	7.24	6.03
S-19	025Y-24H	25.84	0.00	-0.09	3.82	6.50	5.16
S-19	100Y-24H	32.96	0.00	0.13	4.66	7.20	5.93

Custom Report (Pipe Link "S-19")

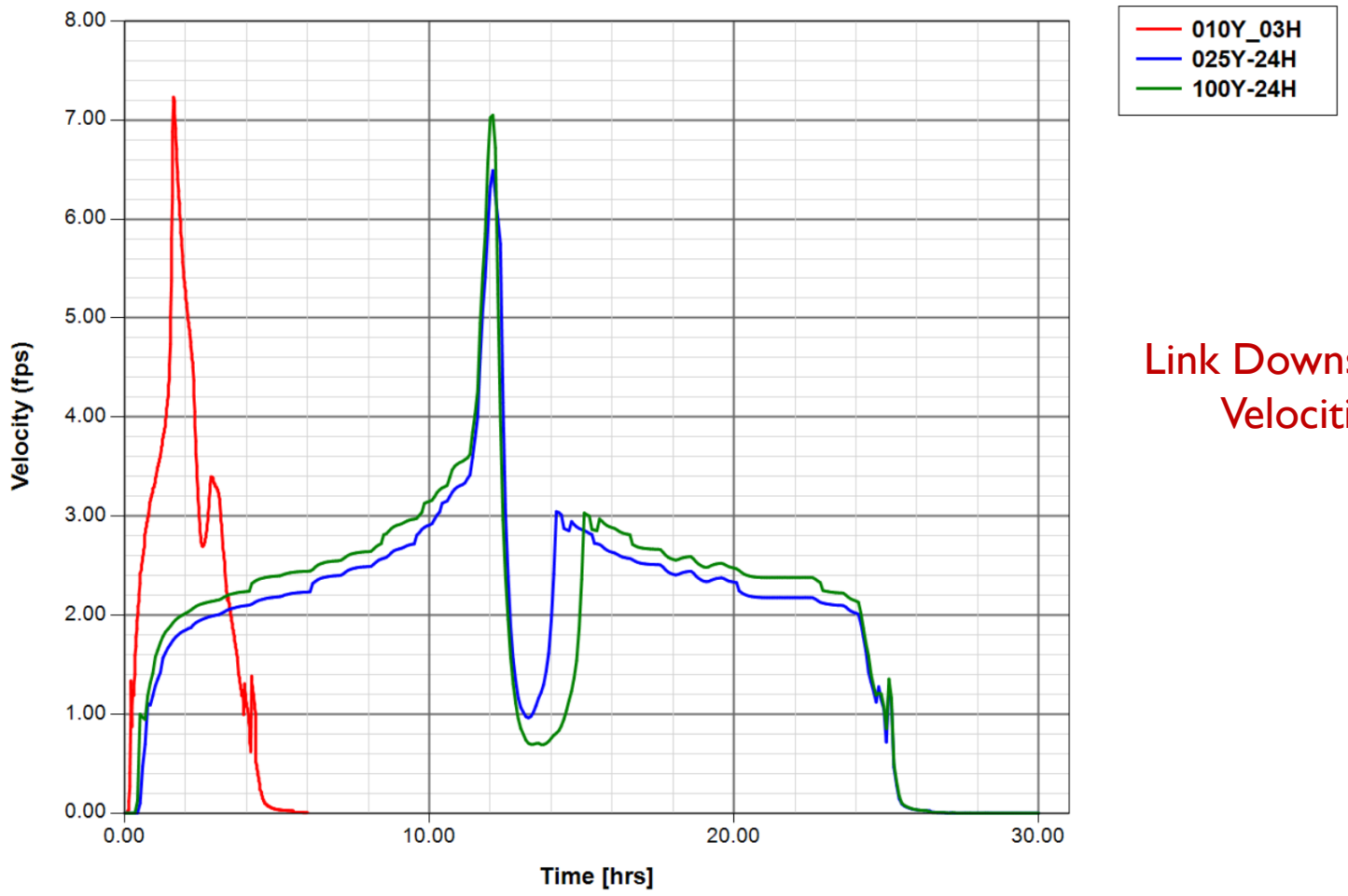
Link Flow: S-19 [Scenario1]



Link Discharge Hydrographs

Custom Report (Pipe Link "S-19")

Link Downstream Velocity: S-19 [Scenario1]



Link Downstream Velocities

Custom Report (Pipe Link "S-32")

Pipe Input Data

Pipe Link: S-32		Upstream		Downstream	
Scenario:	Scenario1	Invert:	76.10 ft	Invert:	76.00 ft
From Node:	S-33	Manning's N:	0.0130	Manning's N:	0.0130
To Node:	Pond 1	Geometry: Circular		Geometry: Circular	
Link Count:	1	Max Depth:	2.50 ft	Max Depth:	2.50 ft
Flow Direction:	Both	Bottom Clip			
Damping:	0.0000 ft	Default:	0.00 ft	Default:	0.00 ft
Length:	91.00 ft	Op Table:		Op Table:	
FHWA Code:	1	Ref Node:		Ref Node:	
Entr Loss Coef:	0.50	Manning's N:	0.0000	Manning's N:	0.0000
Exit Loss Coef:	1.00	Top Clip			
Bend Loss Coef:	0.00	Default:	0.00 ft	Default:	0.00 ft
Bend Location:	0.00 ft	Op Table:		Op Table:	
Energy Switch:	Energy	Ref Node:		Ref Node:	
		Manning's N:	0.0000	Manning's N:	0.0000

Comment:

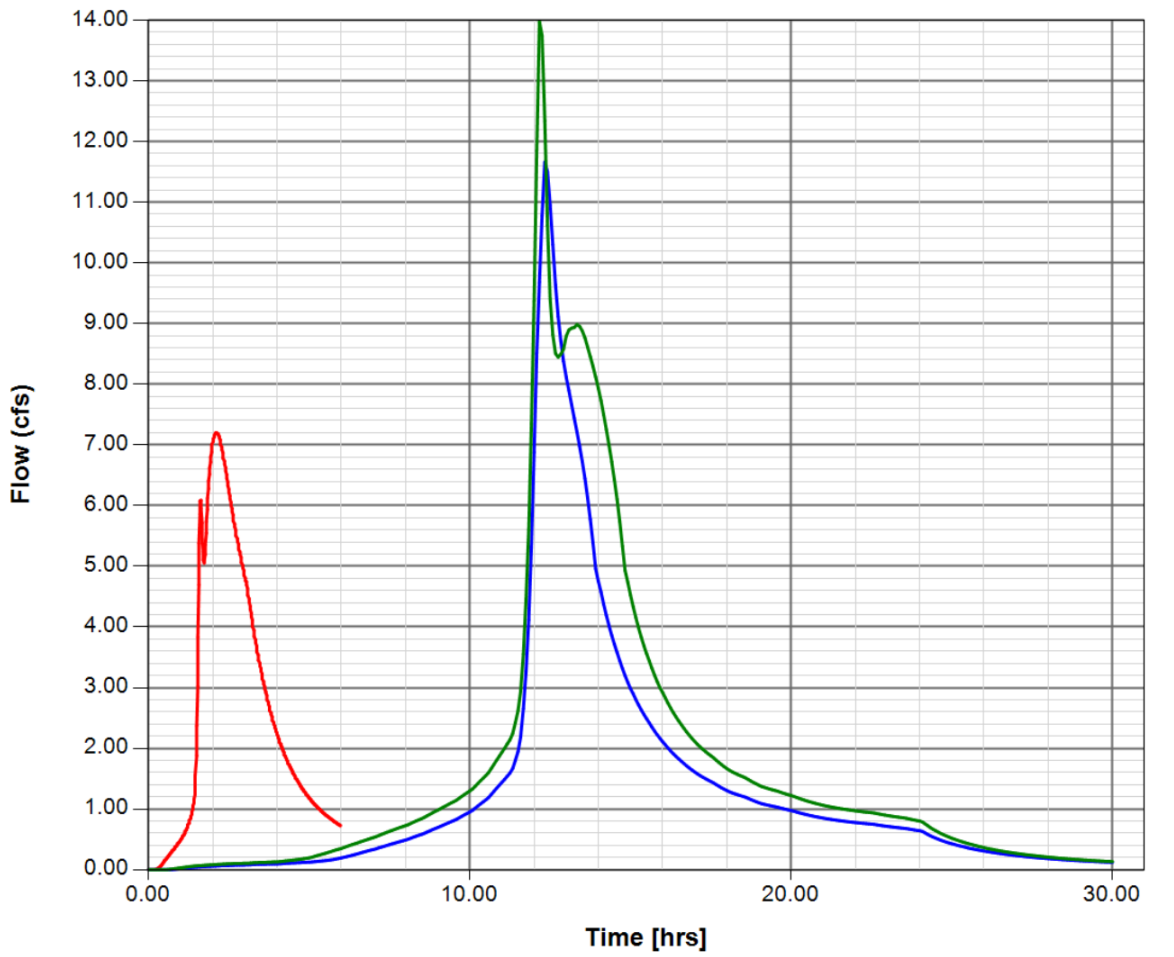
Link Min/Max Conditions

Link Min/Max Conditions [Scenario1]

Link Name	Sim Name	Max Flow [cfs]	Min Flow [cfs]	Min/Max Delta Flow [cfs]	Max Us Velocity [fps]	Max Ds Velocity [fps]	Max Avg Velocity [fps]
S-32	010Y_03H	7.20	0.00	-0.02	2.33	4.56	3.45
S-32	025Y-24H	11.70	0.00	-0.04	2.94	5.12	3.88
S-32	100Y-24H	14.09	0.00	-0.04	3.17	5.28	4.02

Custom Report (Pipe Link "S-32")

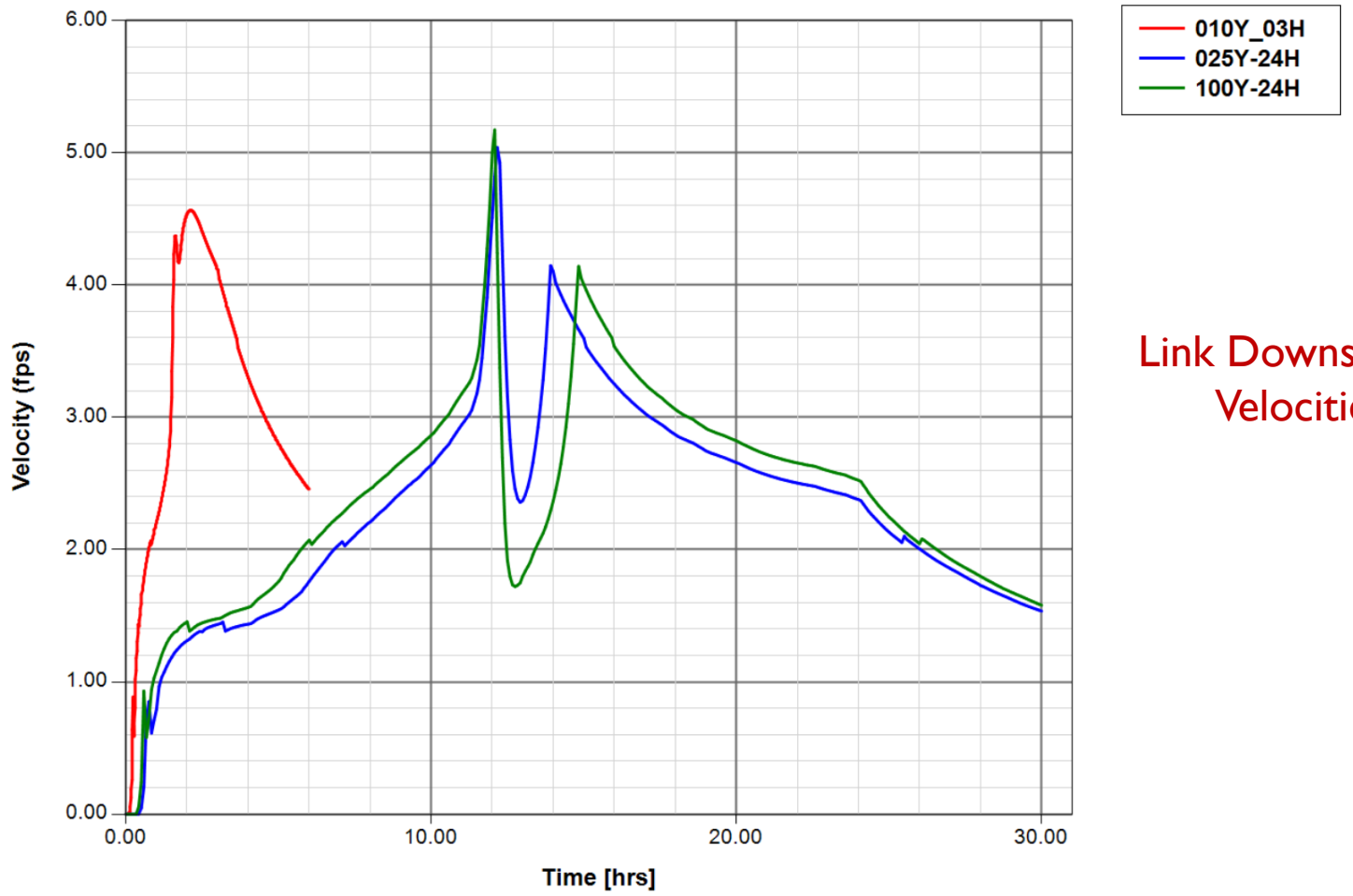
Link Flow: S-32 [Scenario1]



Link Discharge Hydrographs

Custom Report (Pipe Link "S-32")

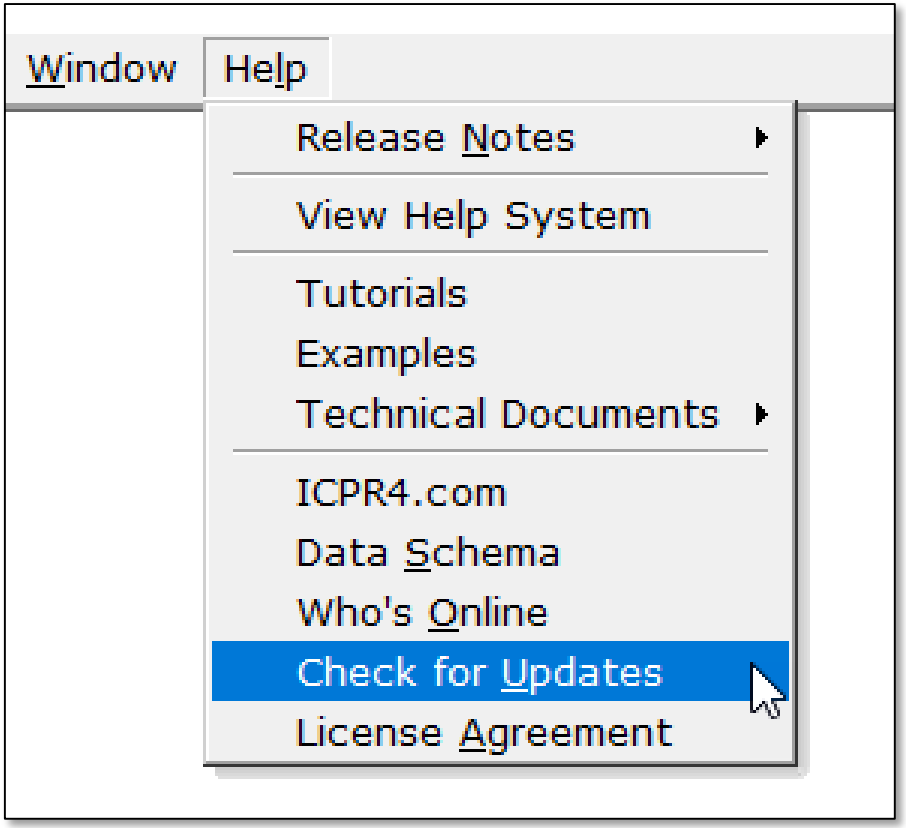
Link Downstream Velocity: S-32 [Scenario1]



Link Downstream Velocities

Next Webinar – Lesson 3: Hydraulics, Part 2

Tuesday October 29, 2019
11:30 – 1:30 (EDT)



We will try to post a recording of this webinar and/or the presentation material as soon as we can.

To find them:
"Check for Updates"
sometime tomorrow.

support@icpr4.com