Regulatory Review Webinar Series

Lesson 1
Building Blocks & Hydrology

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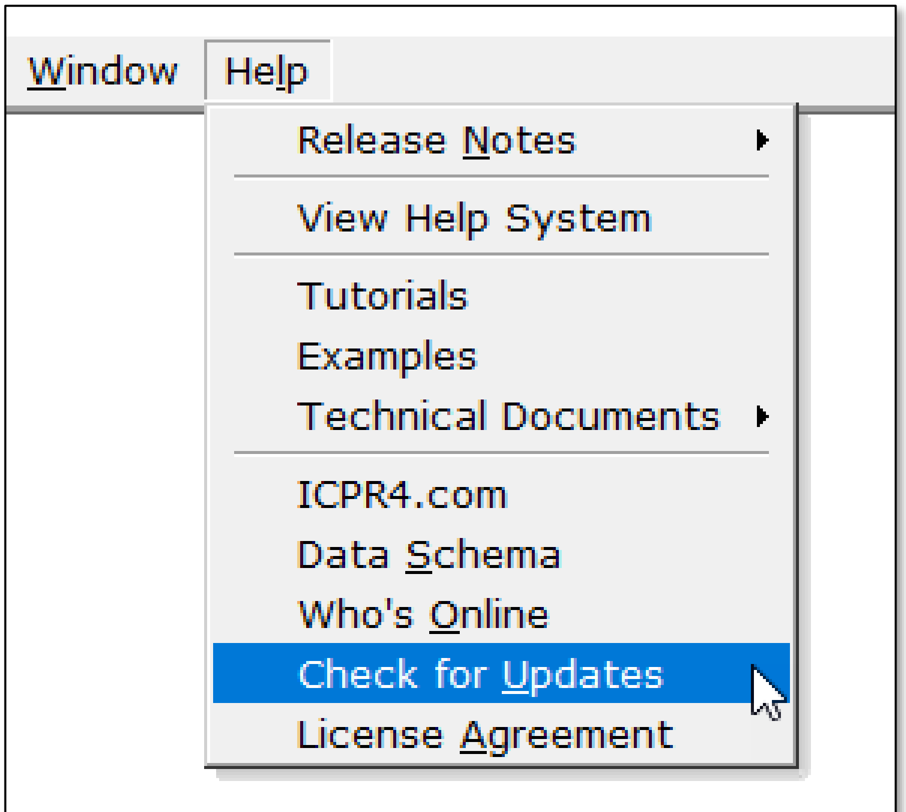
Streamline Technologies, Inc.

Monday – October 21, 2019

Next Webinar – Lesson 2: Hydraulics, Part 1

Wednesday October 23, 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"
in about a week or so.

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

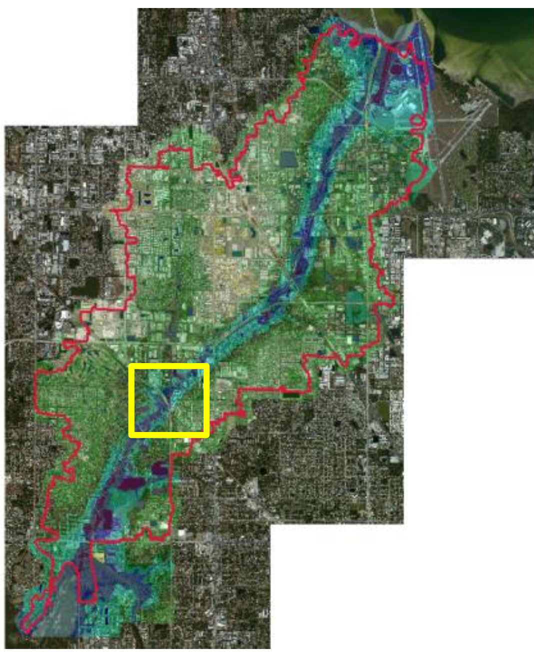
Lesson 1 Topics

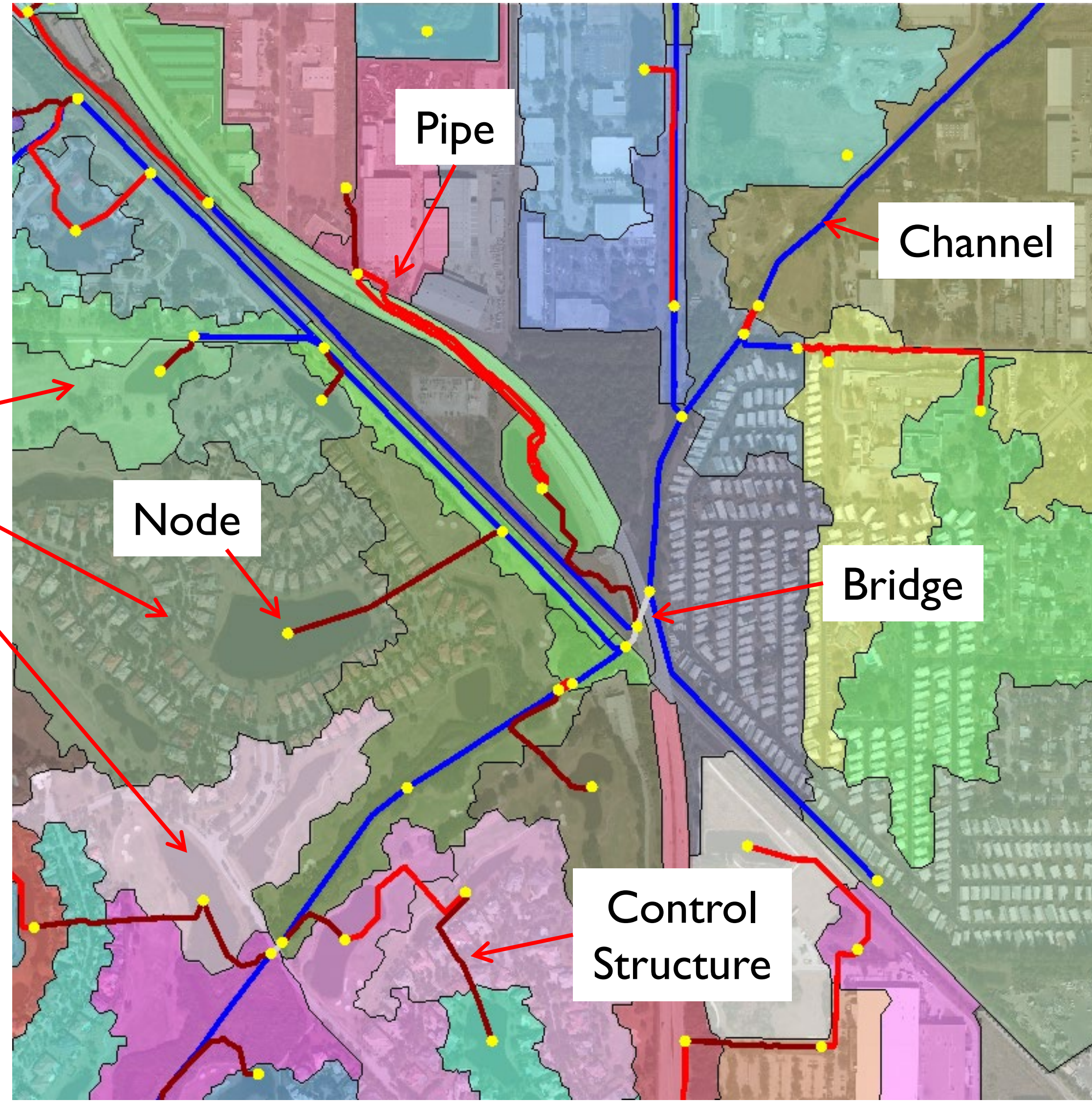
- ICPR4 Building Blocks
- Hydrology
  - Curve Number Method
  - NRCS Unit Hydrograph Method
  - SBUH Method
  - Working with Rainfall Data
- Examples & Reports
  - Land-Locked System
  - FDOT Critical Storm Analysis using the NOAA Atlas 14 Precipitation Data

ICPR Building Blocks

- Nodes, Links, Basins -

Catchment Areas





ICPR Building Blocks

- Nodes, Links, Basins -

- Runoff hydrographs from Basins are assigned to Nodes

- Stages are calculated at Nodes

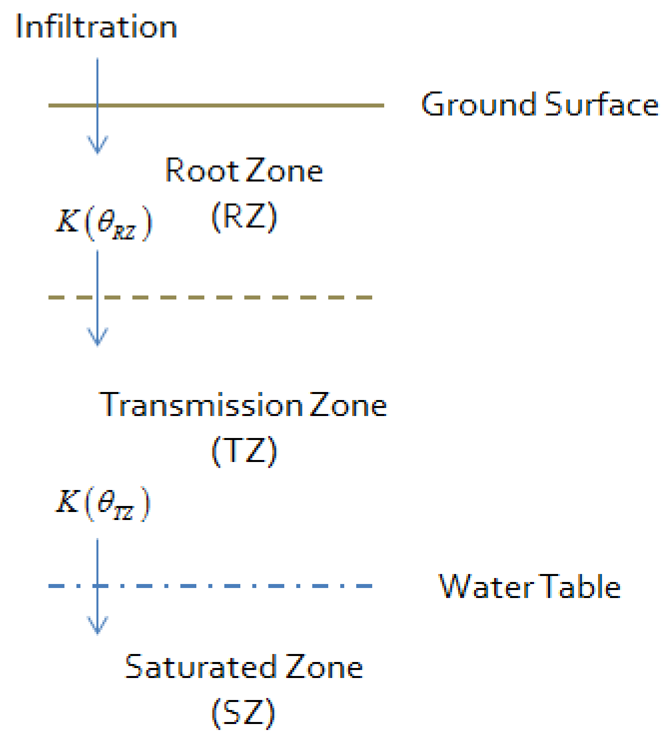
- Flows are calculated for Links based on the stages at the connecting nodes

ICPR Building Blocks

- Nodes, Links, Basins -

Infiltration & Rainfall Excess Methods

- Curve Number Method
- Green-Ampt Method
- Vertically Layered Kinematic Method



2-Layer Green-Ampt Schematic

Curve Number (CN) Method

(from NRCS TR-55)

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \quad \text{[eq. 2-3]}$$

non-linear relationship between rainfall and runoff

$$S = \frac{1000}{CN} - 10 \quad \text{[eq. 2-4]}$$

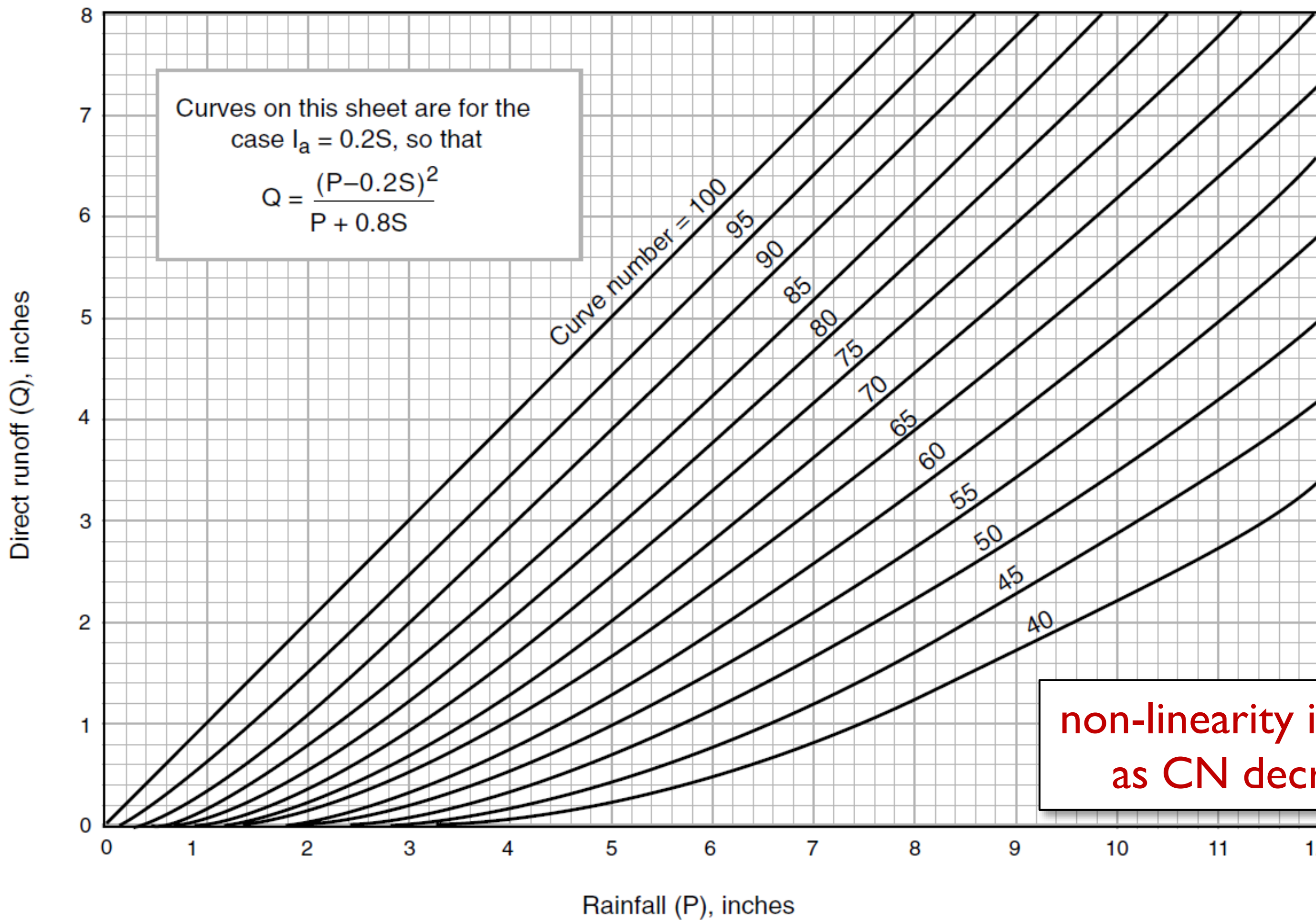
$$I_a = 0.2S \quad \text{[eq. 2-2]}$$

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in)
I_a = initial abstraction (in)

Curve Number (CN) Method

(from NRCS TR-55)

Figure 2-1 Solution of runoff equation.



non-linearity increases as CN decreases

Curve Number (CN) Method

(from NRCS TR-55)

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover type and hydrologic condition (Cover description)	Average percent impervious area [2/]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]	77	86	91	94	

Curve numbers for hydrologic soil group: A, B, C, D.

Curve Number (CN) Method

(from NRCS TR-55)

Table 2-2a Runoff curve numbers for urban areas 1/

Cover description: Cover type and hydrologic condition	Average percent impervious area 2/	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc.					
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) 5/	77	86	91	94	

Average percent impervious area 2/

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows:

1. impervious areas are directly connected to the drainage system
2. impervious areas have a CN of 98
3. pervious areas are considered equivalent to open space in good hydrologic condition

Curve Number (CN) Method

(from NRCS TR-55)

	% IMP	A	B	C	D
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

Curve Number (CN) Method

Example: Calculating "Lumped" CN

Land Cover:	Residential ¼-ac lots
Hydrologic Soil Group:	A
Average Impervious:	38%

Lumped CN (a.k.a., area weighted average)

$CN_{impervious}$ = 98 (38%)

$CN_{pervious}$ = 39 (62%, open space good condition)

CN_{lumped} = (0.38 x 98) + (0.62 x 39)

= 61.4 say 61

Curve Number (CN) Method

Runoff Example (Lumped CN Approach)

Land Cover:	Residential ¼-ac lots
Hydrologic Soil Group:	A
Rainfall:	6 inches

$CN = 61$

$S = (1000/CN) - 10 = 6.39''$

$I_a = 0.2S = 1.28''$ ←

$Q = (P - 0.2S)^2 / (P + 0.8S) = \underline{2.01''}$

Curve Number (CN) Method

Runoff Example (Distributed CN Approach)

Land Cover:	Residential ¼-ac lots
Hydrologic Soil Group:	A
Impervious Area:	38% (CN = 98)
Pervious Area:	62% (CN = 39)
Rainfall:	6 inches

% impervious = 38%

$CN_{impervious}$ = 98

S = (1000/CN) – 10 = 0.20”

Q_{imp} = $(P - 0.2S)^2 / (P + 0.8S)$ = 5.76”

% pervious = 62%

$CN_{impervious}$ = 39

S = (1000/CN) – 10 = 15.64”

Q_{perv} = $(P - 0.2S)^2 / (P + 0.8S)$ = 0.45”

$Q_{distributed}$ = (%imp x Q_{imp}) + (%perv x Q_{perv})

= (0.38 x 5.76) + (0.62 x 0.45)

= 2.47”

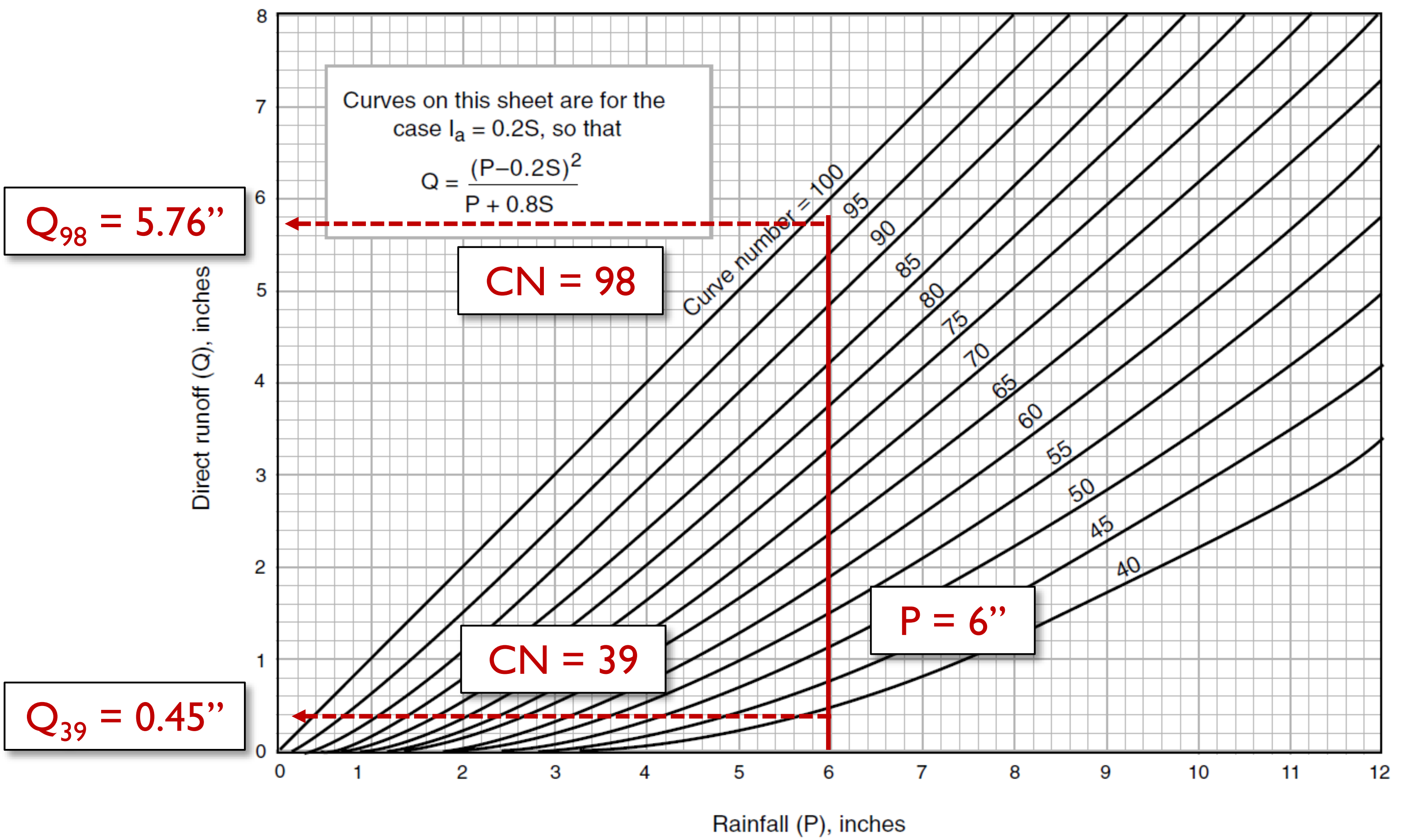
Q_{lumped} = 2.01”

$Q_{distributed}$ = 2.47”

Curve Number (CN) Method

(from NRCS TR-55)

Figure 2-1 Solution of runoff equation.

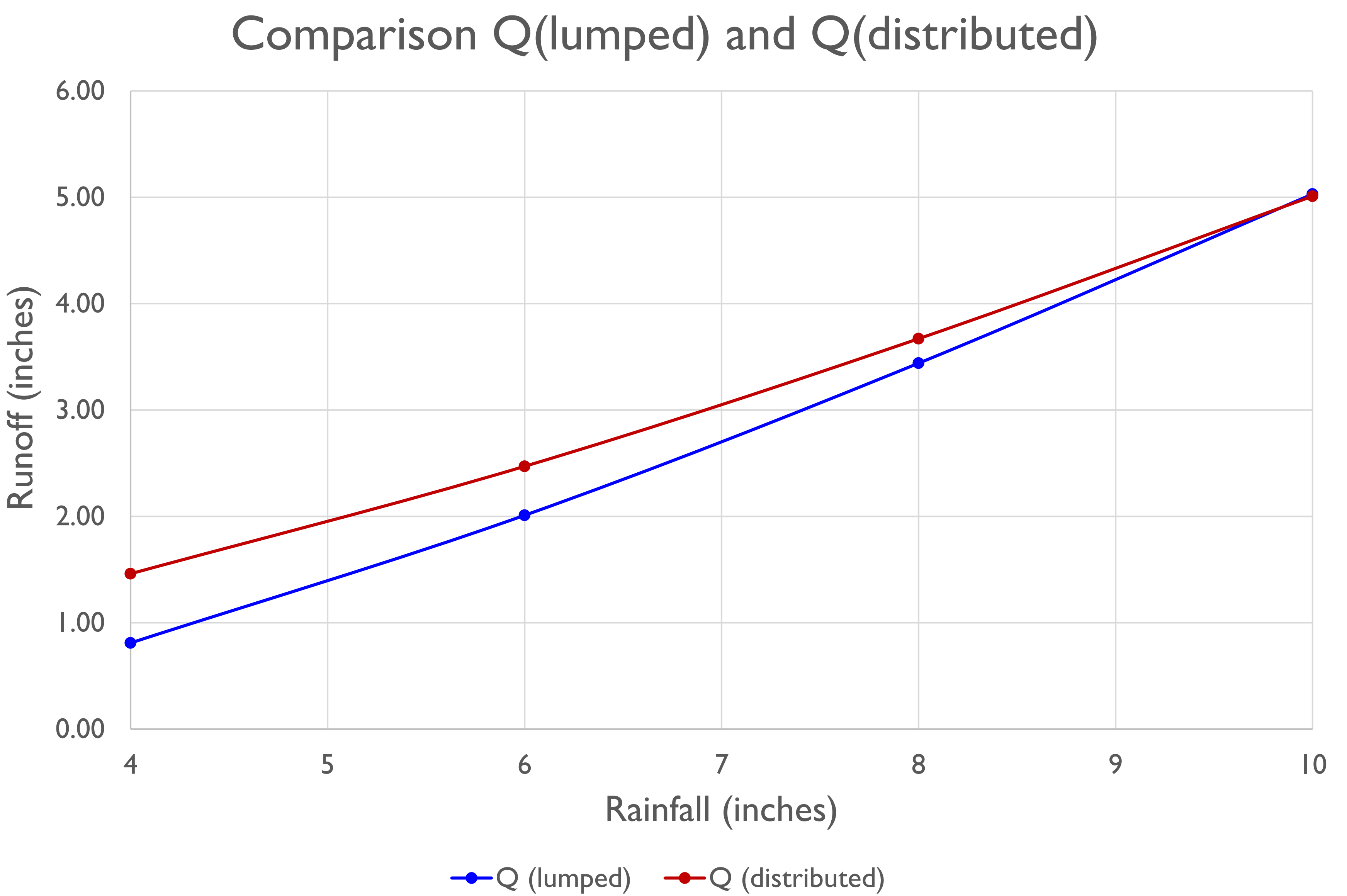


Curve Number (CN) Method

Runoff Comparison Lumped & Distributed Approaches

Land Cover:	Residential ¼-ac lots
Hydrologic Soil Group:	A
Impervious Area:	38% (CN = 98)
Pervious Area:	62% (CN = 39)
Rainfall (varies):	4, 6, 8 & 10 inches

Method	P = 4”	P = 6”	P = 8”	P = 10”
Lumped	0.81”	2.01”	3.44”	5.03”
Distributed	1.46”	2.47”	3.67”	5.01”
% Diff	+80%	+23%	+7%	-0.4%


Comparison Q(lumped) and Q(distributed)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Runoff (inches)
4
5
6
7
8
9
10
Rainfall (inches)
Q (lumped)
Q (distributed)

Curve Number (CN) Method

Summary: Lumped & Distributed Approaches

- Lumped approach: runoff volume based on a single "area weighted average" CN – assumes linear relationship between CN and runoff

Curve Number (CN) Method

Summary: Lumped & Distributed Approaches

- Lumped approach: runoff volume based on a single "area weighted average" CN – assumes linear relationship between CN and runoff
- Distributed approach: total runoff volume based on summation of runoff volumes for each unique land cover/HSG combination – assumes non-linear relationship between CN and runoff

Curve Number (CN) Method

Summary: Lumped & Distributed Approaches

- Lumped approach: runoff volume based on a single "area weighted average" CN – assumes linear relationship between CN and runoff
- Distributed approach: total runoff volume based on summation of runoff volumes for each unique land cover/HSG combination – assumes non-linear relationship between CN and runoff
- Lumped approach simpler to implement but less accurate, especially for lower rainfalls

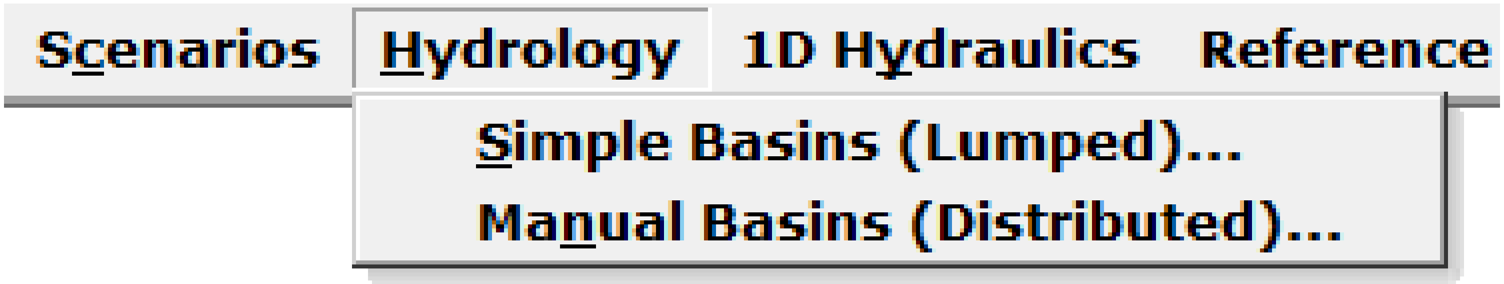
Curve Number (CN) Method

Summary: Lumped & Distributed Approaches

- Lumped approach: runoff volume based on a single "area weighted average" CN – assumes linear relationship between CN and runoff
- Distributed approach: runoff volume based on summation of runoff volumes for each unique land cover/HSG combination – assumes non-linear relationship between CN and runoff
- Lumped approach simpler to implement but less accurate, especially for lower rainfalls
- Distributed approach more complicated to implement but also more accurate

Curve Number (CN) Method

Implementation of Lumped & Distributed Approaches in ICPR4



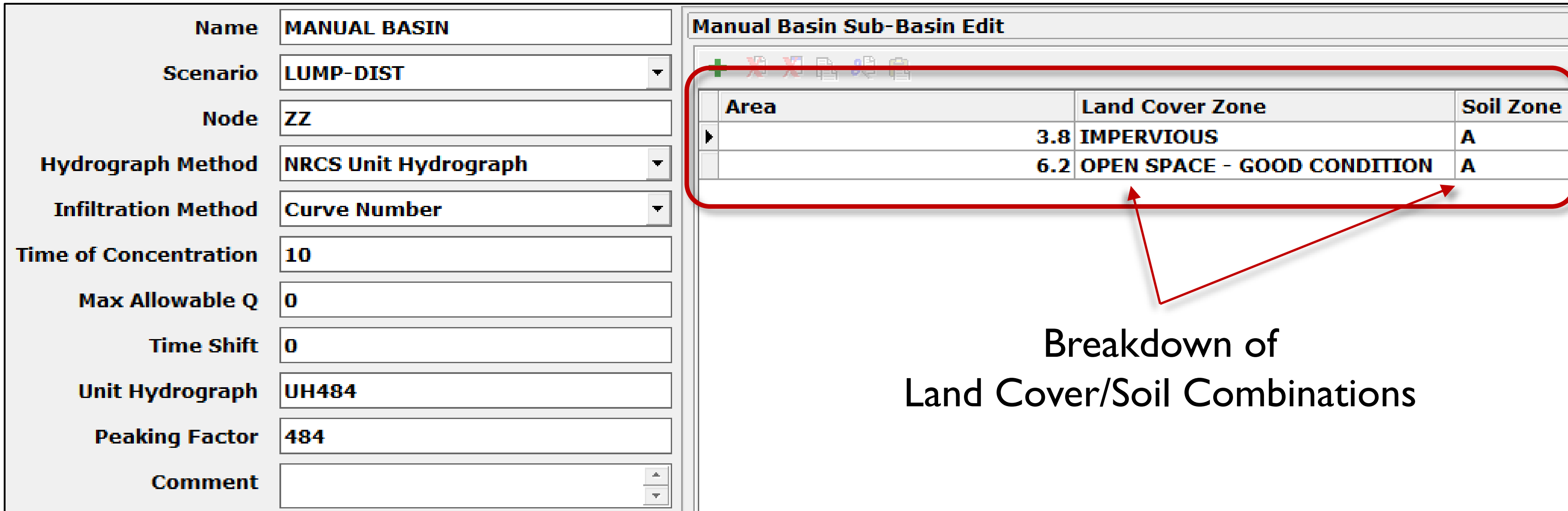
Curve Number (CN) Method

“Simple Basin” uses a Lumped Approach

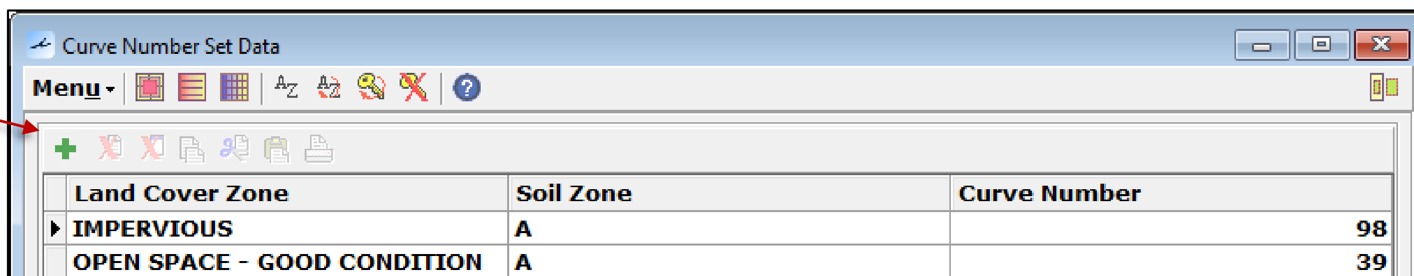
Name	SIMPLE BASIN		
Scenario	LUMP-DIST		
Node	ZZ	Area	10
Hydrograph Method	NRCS Unit Hydrograph	Curve Number	61
Infiltration Method	Curve Number	% Impervious	0
Time of Concentration	10	% DCIA	0
Max Allowable Q	0	% Direct	0
Time Shift	0	Rainfall Name	
Unit Hydrograph	UH484		
Peaking Factor	484		
Comment	SFR 1/4 AC LOTS - TYPE A SOILS		

Curve Number (CN) Method

"Manual Basin" uses a Distributed Approach



Requires a CN lookup table



Curve Number (CN) Method

We will discuss reports in greater depth later. For now, this is a runoff summary "custom" report for 4 simulations of 4", 6", 8" and 10", respectively.

1

Simple Basin (Lumped Method)

Simple Basin Runoff Summary [LUMP-DIST]

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
SIMPLE BASIN	04-INCH	10.38	12.0500	4.000	0.814	10.0000	61.0	0.00	0.00
SIMPLE BASIN	06-INCH	27.48	12.0333	6.000	2.010	10.0000	61.0	0.00	0.00
SIMPLE BASIN	08-INCH	47.54	12.0333	8.000	3.453	10.0000	61.0	0.00	0.00
SIMPLE BASIN	10-INCH	69.06	12.0333	10.000	5.045	10.0000	61.0	0.00	0.00

Manual Basin (Distributed Method)

Manual Basin Runoff Summary [LUMP-DIST]

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
MANUAL BASIN	04-INCH	16.54	12.0167	4.000	1.463	10.0000	72.0	0.00	0.00
MANUAL BASIN	06-INCH	26.12	12.0333	6.000	2.472	10.0000	66.3	0.00	0.00
MANUAL BASIN	08-INCH	40.85	12.0333	8.000	3.675	10.0000	63.0	0.00	0.00
MANUAL BASIN	10-INCH	57.85	12.0333	10.000	5.021	10.0000	60.8	0.00	0.00

Curve Number (CN) Method

Simple Basin Runoff Summary [LUMP-DIST]

Basin Name	Sim Name	Max Flow [cfs]
SIMPLE BASIN	04-INCH	10.38
SIMPLE BASIN	06-INCH	27.48
SIMPLE BASIN	08-INCH	47.54
SIMPLE BASIN	10-INCH	69.06

Lumped

Manual Basin Runoff Summary [LUMP-DIST]

Basin Name	Sim Name	Max Flow [cfs]
MANUAL BASIN	04-INCH	16.54
MANUAL BASIN	06-INCH	26.12
MANUAL BASIN	08-INCH	40.85
MANUAL BASIN	10-INCH	57.85

Distributed

Maximum flow rates can vary significantly between lumped and distributed approaches.

Curve Number (CN) Method

Equivalent CNs – what are they?

Total Rainfall [in]	Total Runoff [in]	Area [ac]	Equivalent Curve Number
4.000	1.463	10.0000	72.0
6.000	2.472	10.0000	66.3
8.000	3.675	10.0000	63.0
10.000	5.021	10.0000	60.8

Equivalent CNs vary with rainfall when using Manual Basins (distributed method)

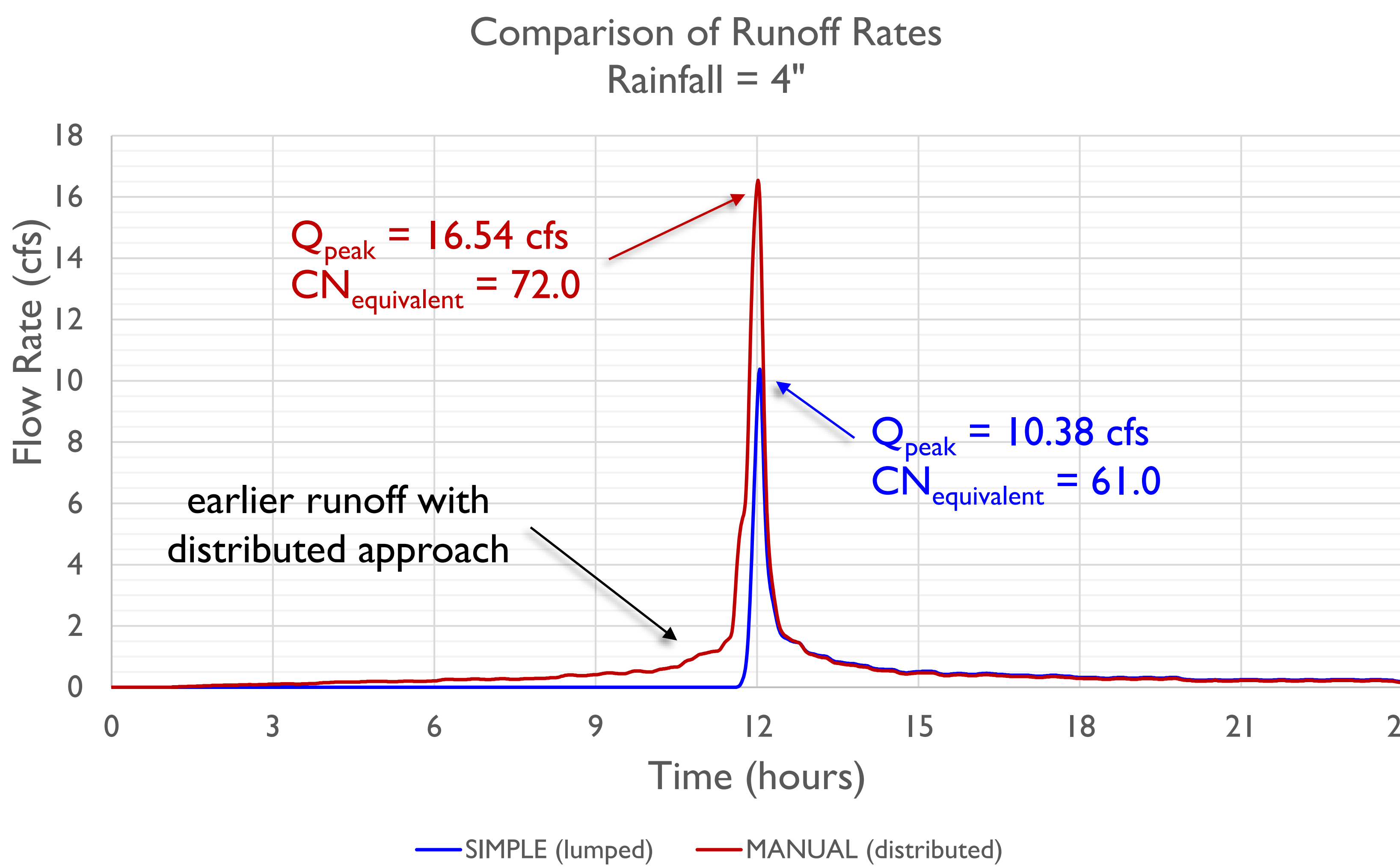
Curve Number (CN) Method

Equivalent CNs – what are they?

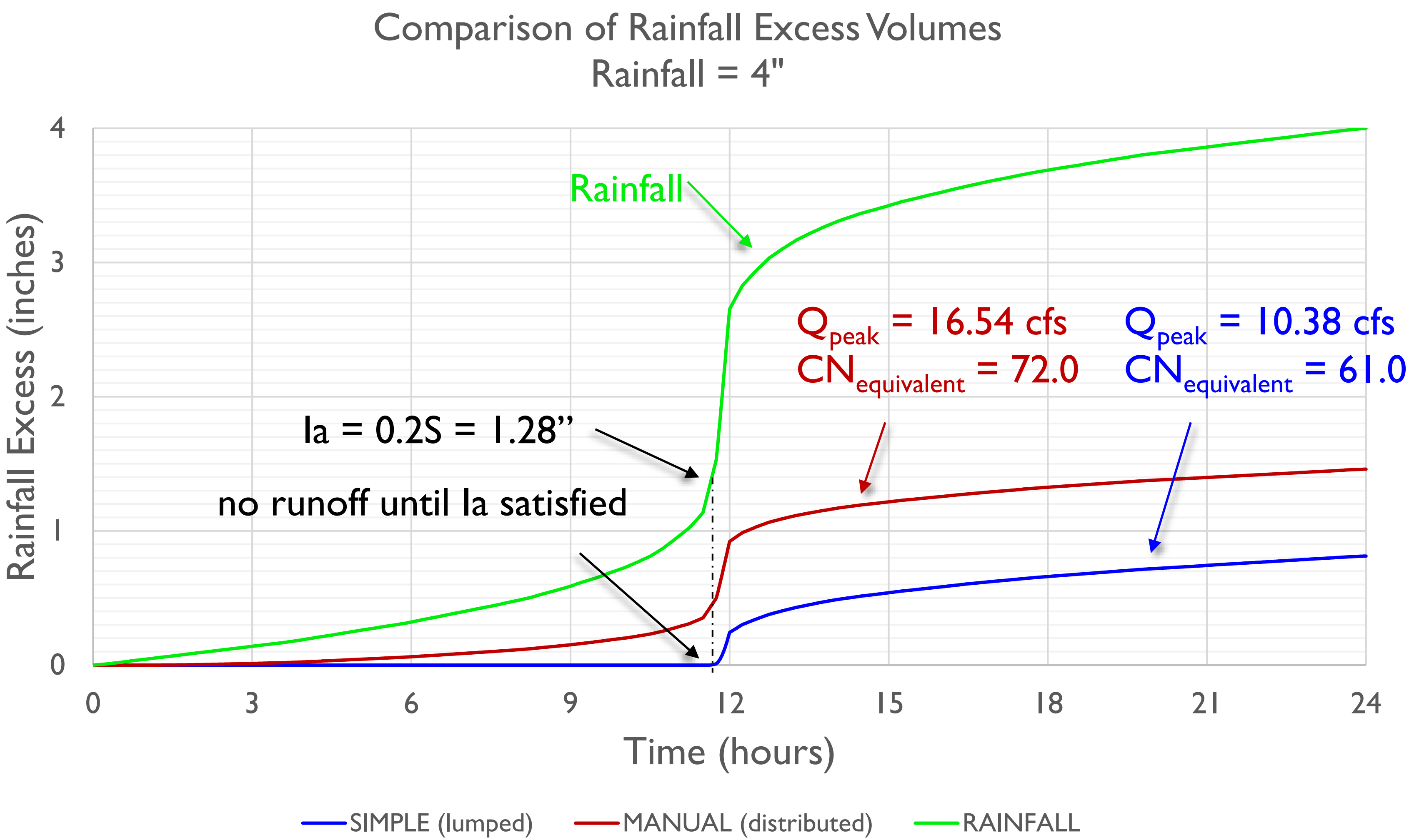
Total Rainfall [in]	Total Runoff [in]	Area [ac]	Equivalent Curve Number
4.000	1.463	10.0000	72.0
6.000	2.472	10.0000	66.3
8.000	3.675	10.0000	63.0
10.000	5.021	10.0000	60.8

Solve for Equivalent CN from Total Rainfall and Runoff

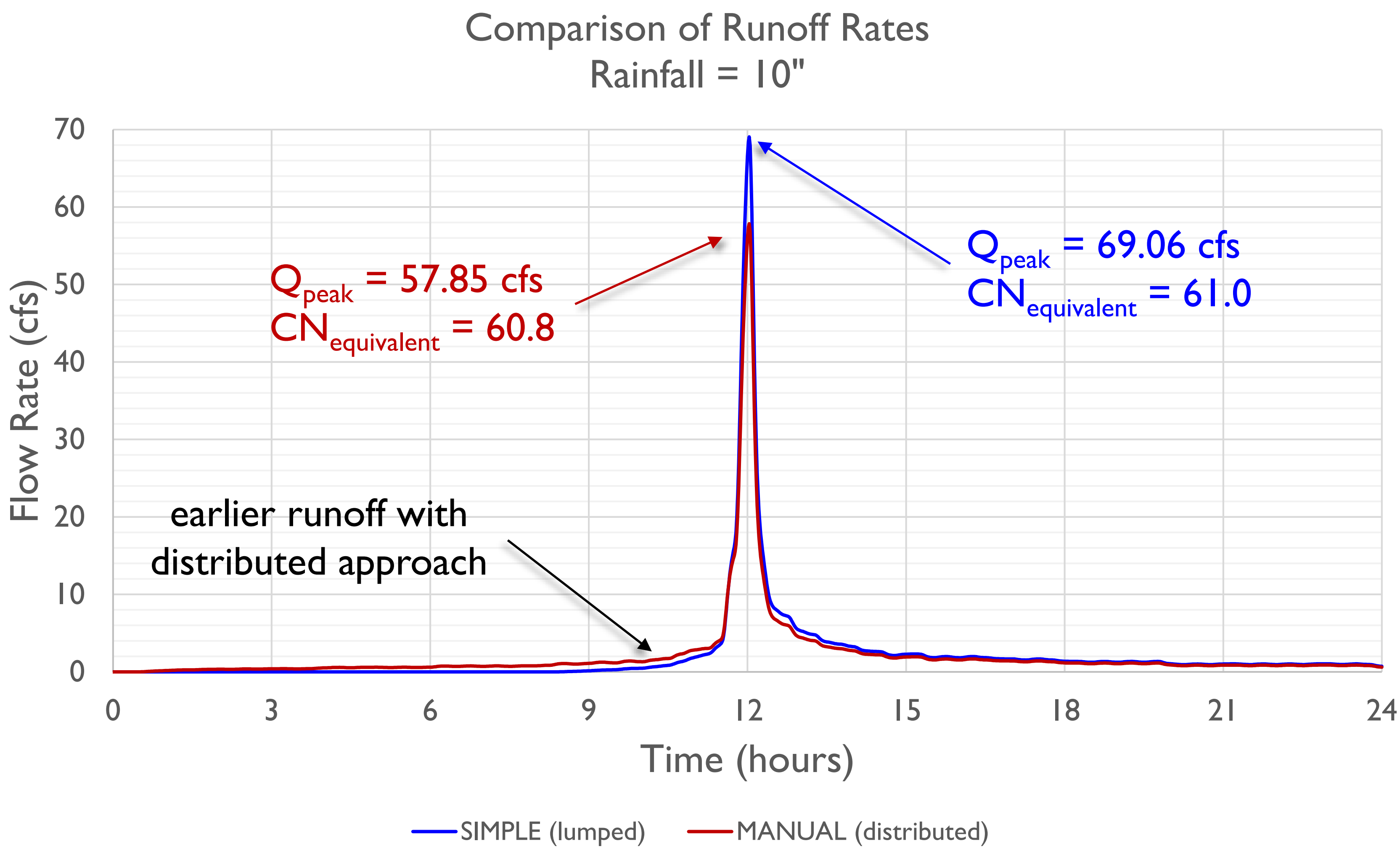
Curve Number (CN) Method



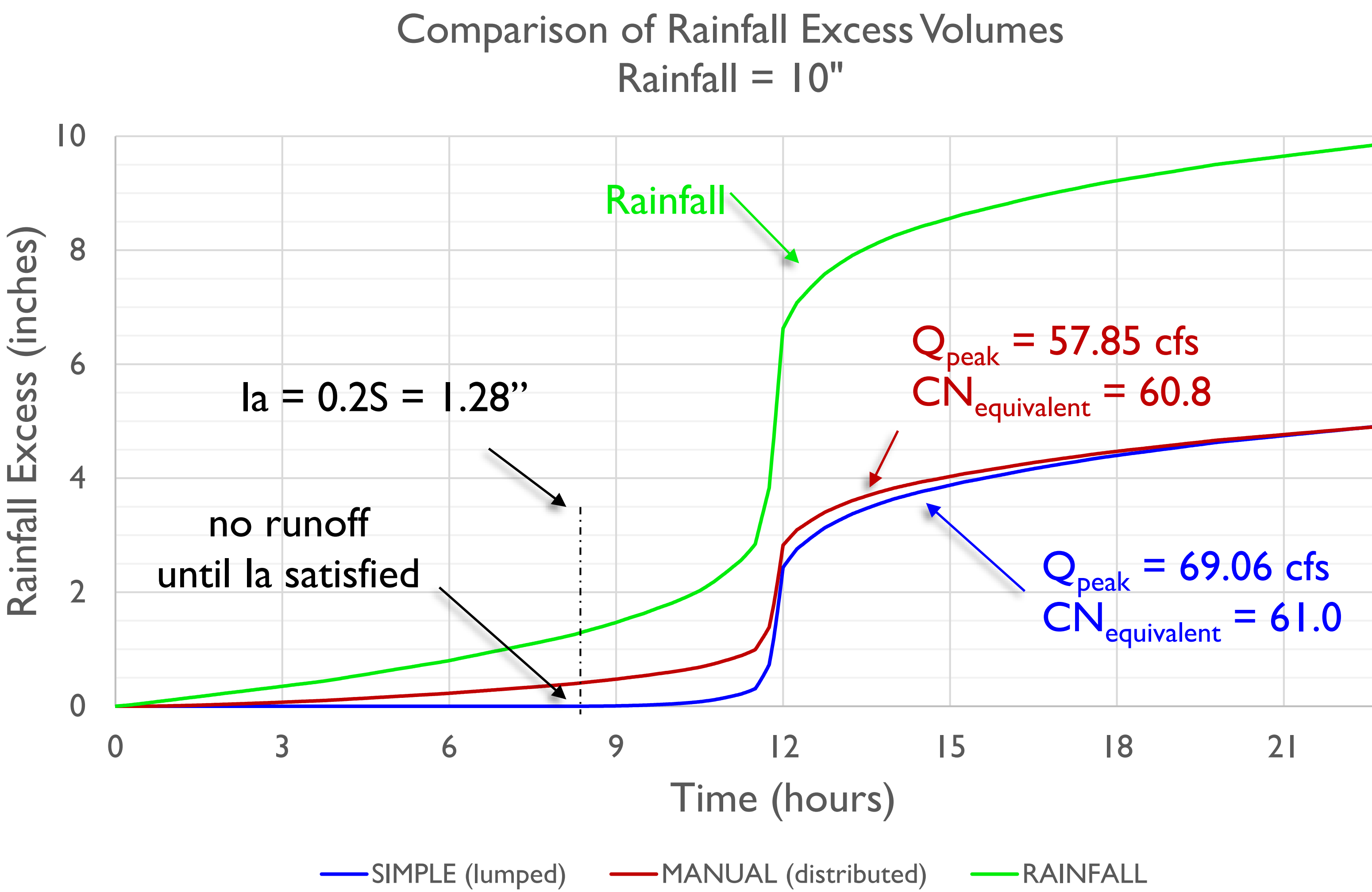
Curve Number (CN) Method



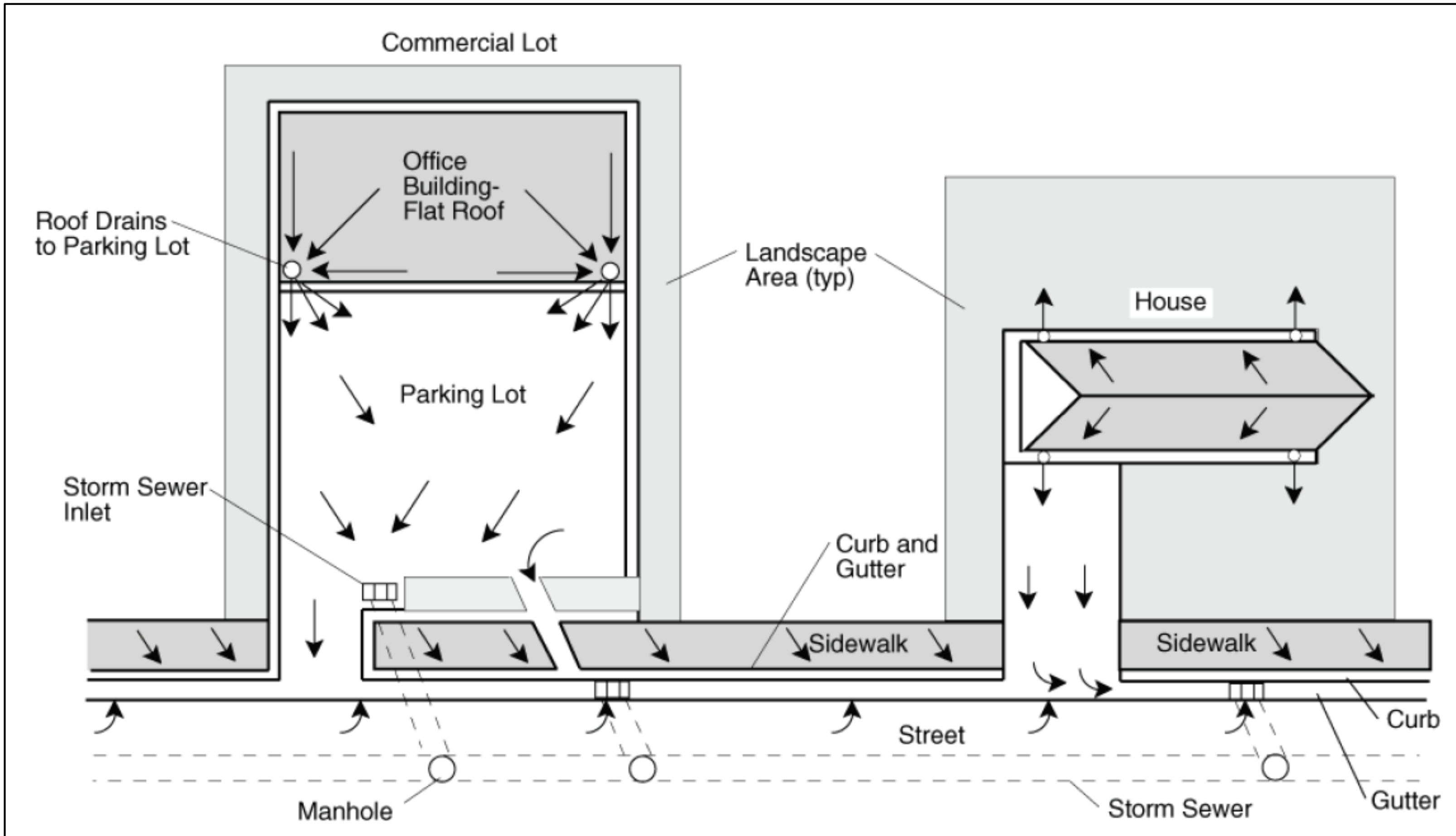
Curve Number (CN) Method



Curve Number (CN) Method

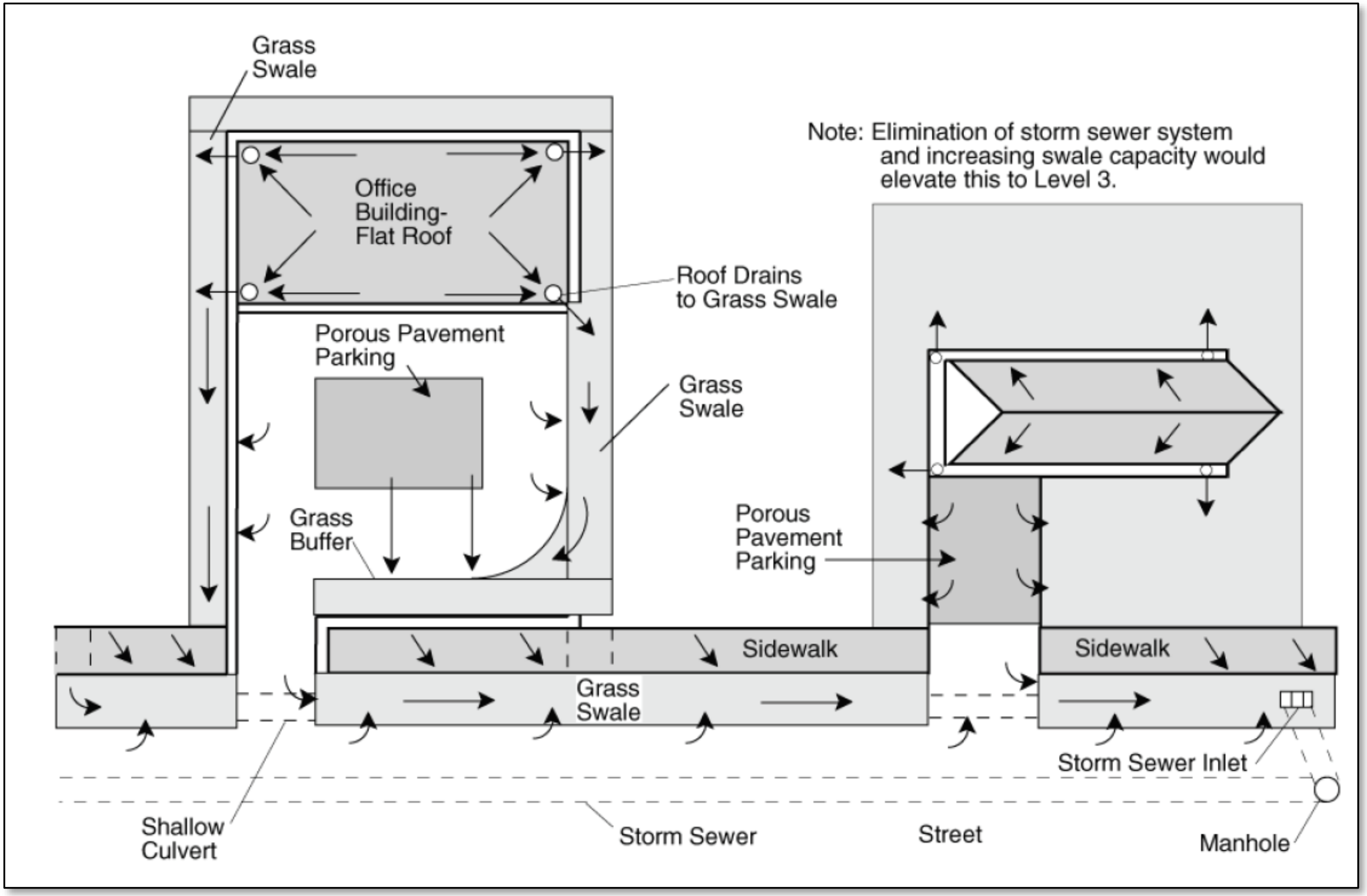


Impervious Areas



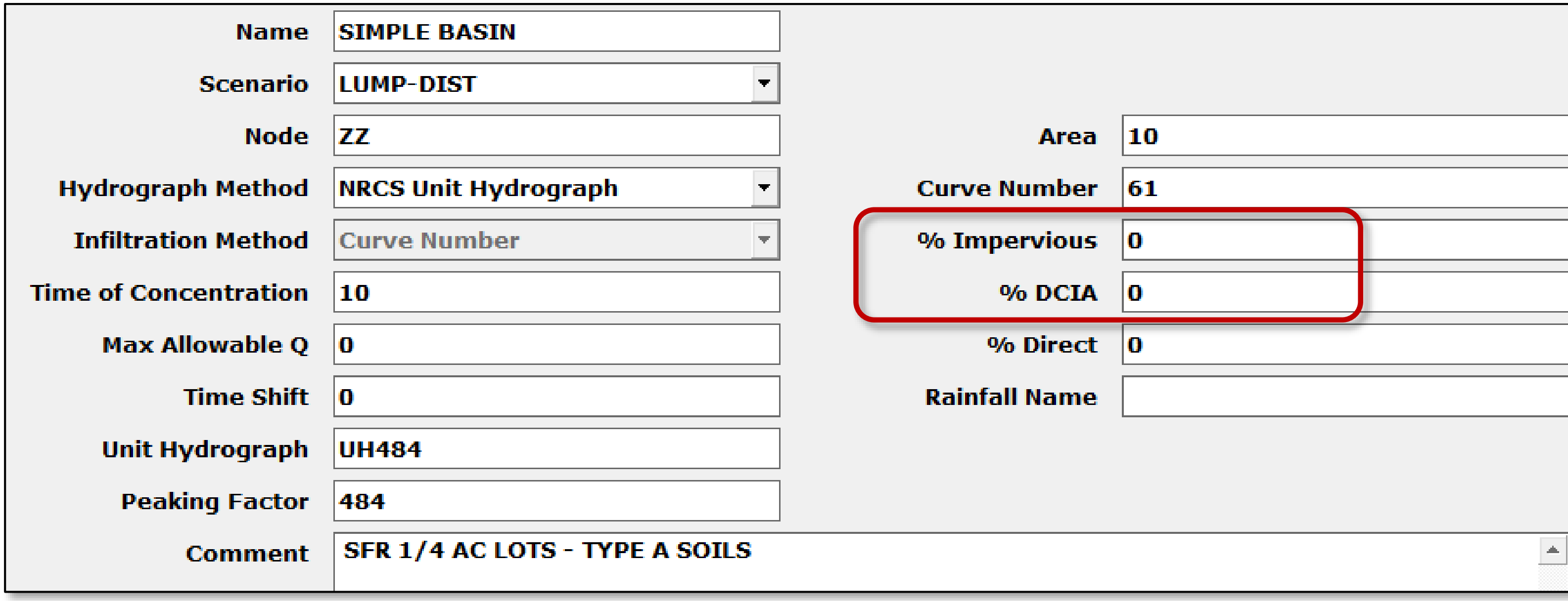
Source: Urbonas, 1993

Impervious Areas



Source: Urbonas, 1993

% Impervious and % DCIA



% Impervious and % DCIA

- Directly Connected Impervious Areas (DCIAs) are those impervious areas that are hydraulically connected to the conveyance system and then to the basin outlet point without flowing over pervious areas.

% Impervious and % DCIA

Example DCIA

% Impervious and % DCIA

Example DCIA

% Impervious and % DCIA

Example DCIA

% Impervious and % DCIA

- Directly Connected Impervious Areas (DCIAs) are those impervious areas that are hydraulically connected to the conveyance system and then to the basin outlet point without flowing over pervious areas.
- Conversely, non-DCIAs are those impervious areas that flow over pervious areas before entering the conveyance system, and subsequently either joining the DCIAs or flowing to the basin outlet as sheet flow.

% Impervious and % DCIA

Example Non-DCIA

% Impervious and % DCIA

Example Non-DCIA

% Impervious and % DCIA

- Directly Connected Impervious Areas (DCIAs) are those impervious areas that are hydraulically connected to the conveyance system and then to the basin outlet point without flowing over pervious areas.
- Conversely, Non-DCIAs are those impervious areas that flow over pervious areas before entering the conveyance system, and subsequently either joining the DCIAs or flowing to the basin outlet as sheet flow.
- Total Impervious Area (TIA) is equal to the sum of DCIA and non-DCIA.

% Impervious and % DCIA

Recall the following assumptions from TR-55 that are implicit in the CN table:

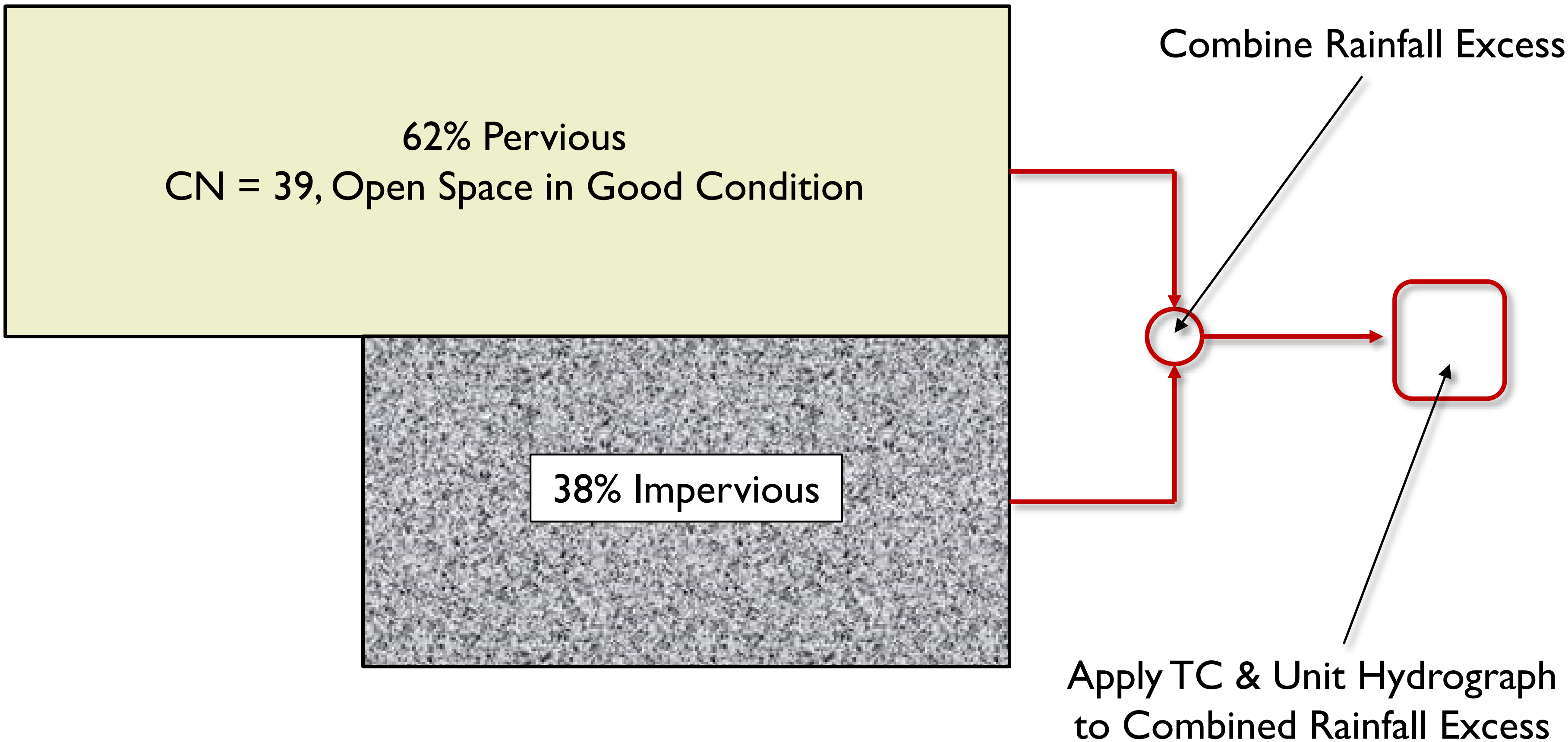
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows:

1. impervious areas are directly connected to the drainage system
2. impervious areas have a CN of 98
3. pervious areas are considered equivalent to open space in good hydrologic condition

	% IMP	A	B	C	D
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

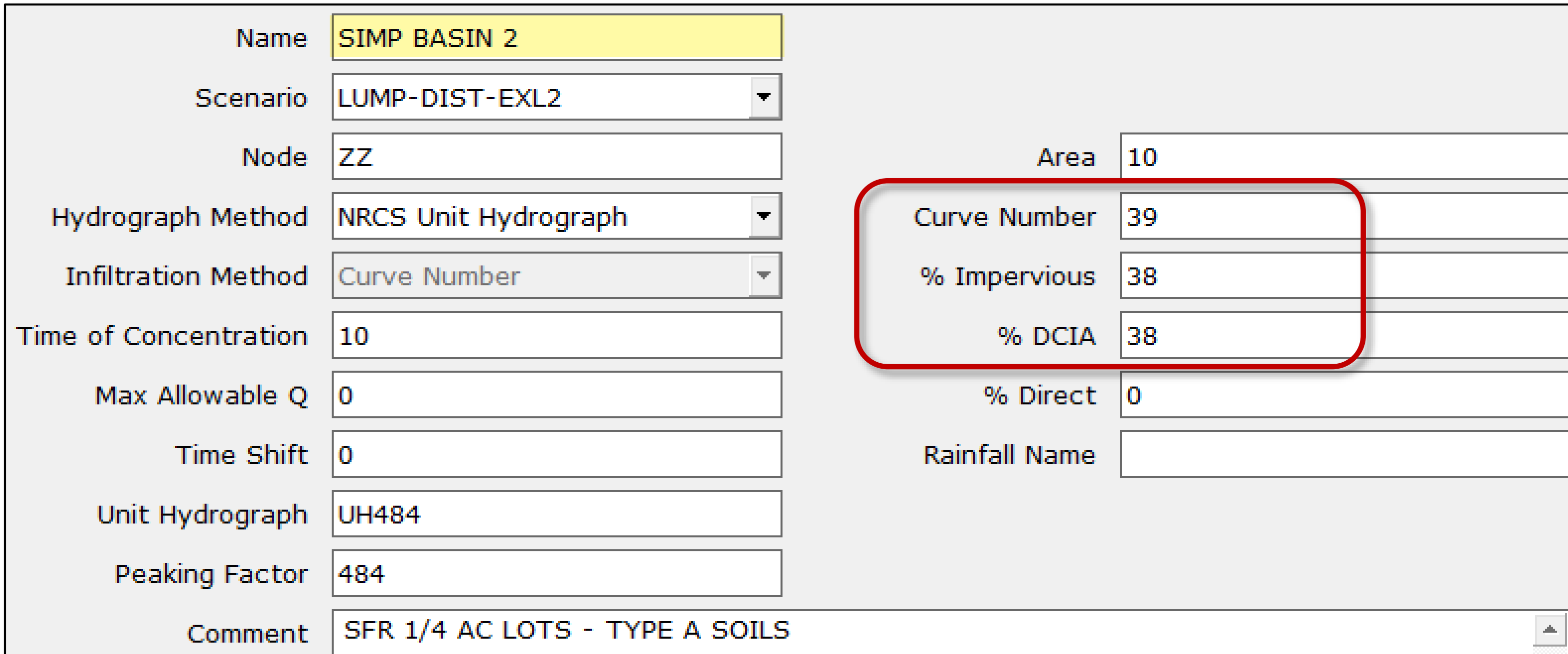
% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)



% Impervious and % DCIA

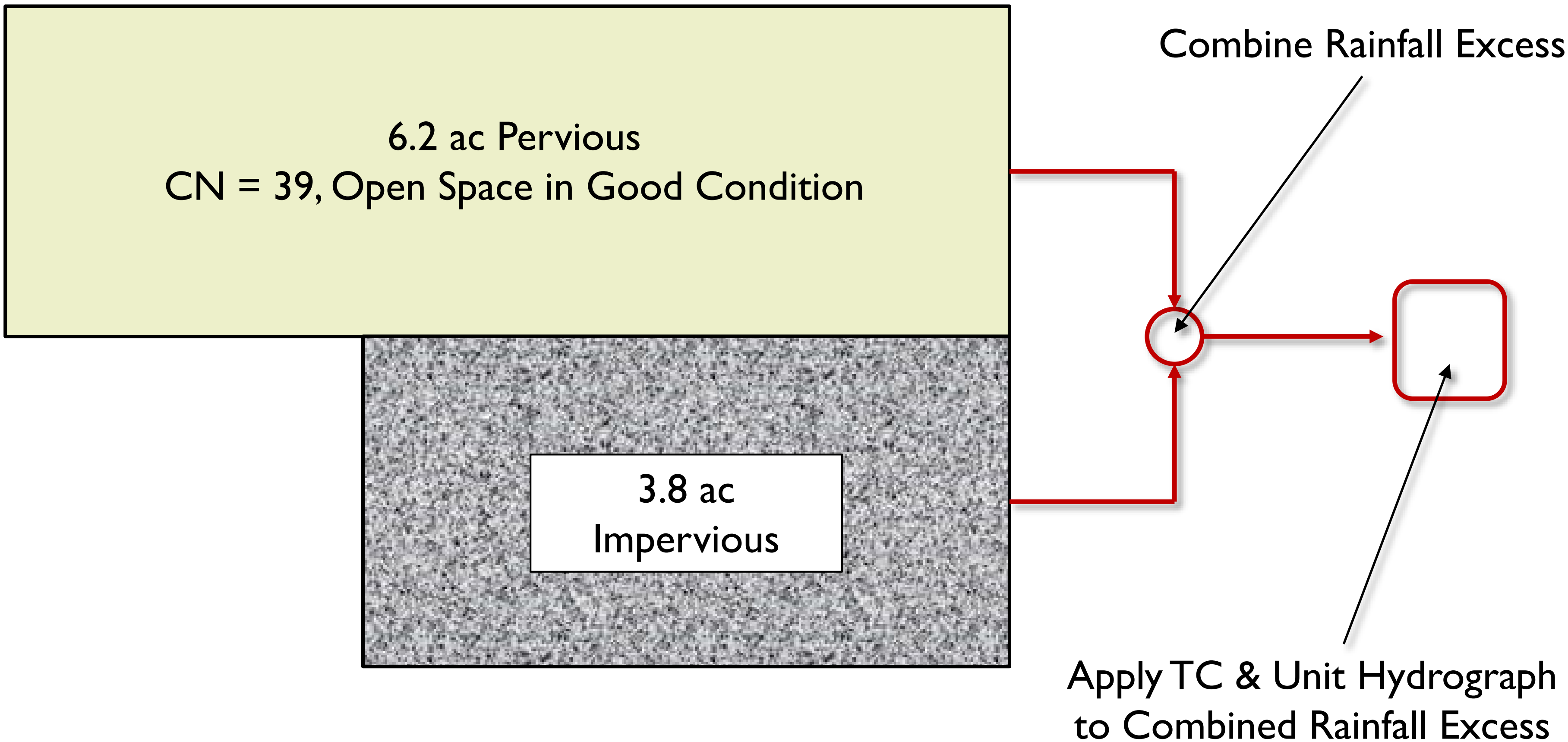
The TR-55 assumptions can be included in the "Simple Basin" data form as follows:



Curve Number	= 39 represents open space in good condition for type A soil.
% Impervious	= 38% is the TR-55 assumption for residential ¼-ac lots
% DCIA	= 38% is the TR-55 assumption that all impervious areas are directly connected to the drainage system

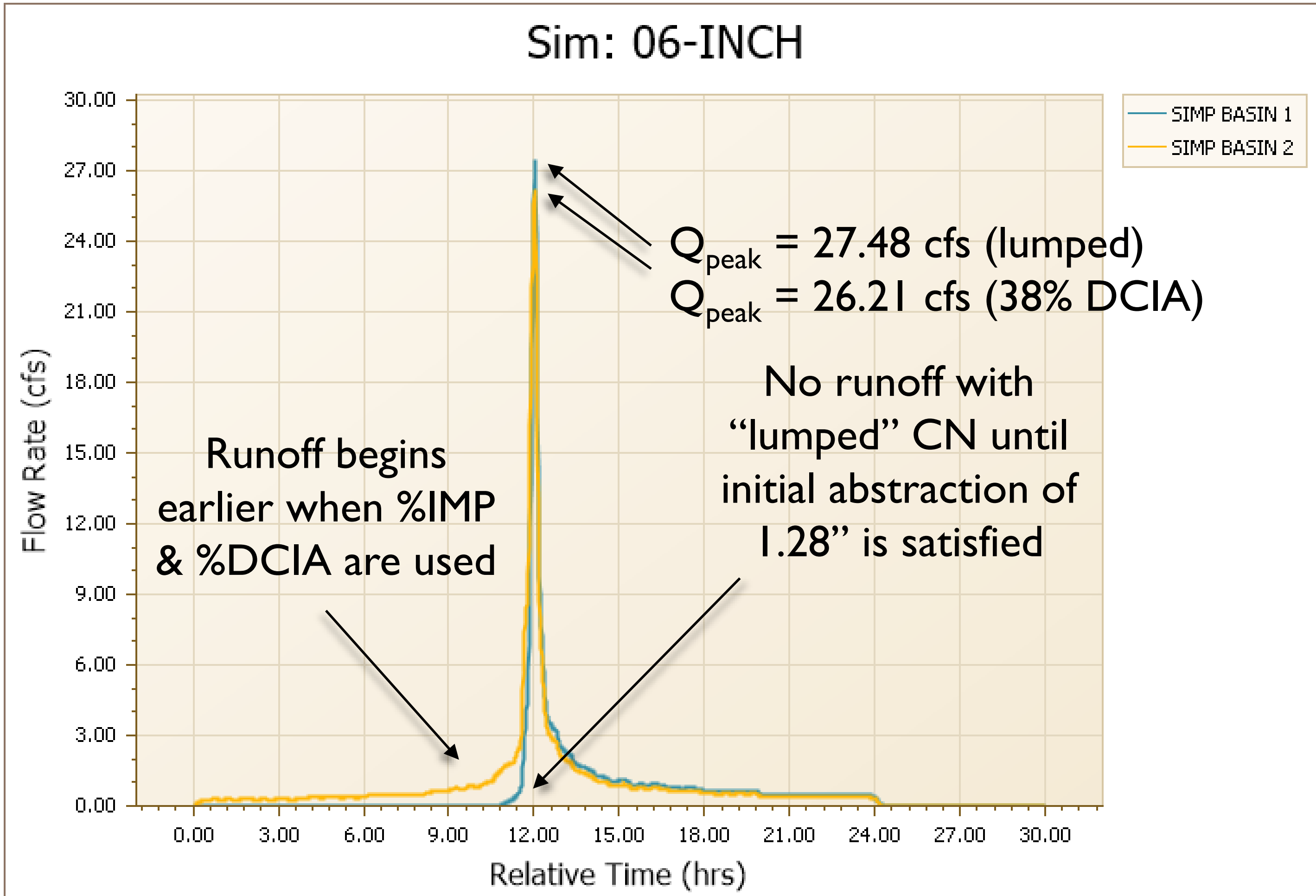
% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)



% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)



% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)

Simple Basin Runoff Summary [LUMP-DIST-EXL2]

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
SIMP BASIN 1	04-INCH	10.38	12.0500	4.000	0.814	10.0000	61.0	0.00	0.00
SIMP BASIN 2	04-INCH	16.67	12.0167	4.000	1.552	10.0000	73.3	38.00	38.00
SIMP BASIN 1	06-INCH	27.48	12.0333	6.000	2.010	10.0000	61.0	0.00	0.00
SIMP BASIN 2	06-INCH	26.21	12.0333	6.000	2.562	10.0000	67.3	38.00	38.00
SIMP BASIN 1	08-INCH	47.54	12.0333	8.000	3.453	10.0000	61.0	0.00	0.00
SIMP BASIN 2	08-INCH	40.91	12.0333	8.000	3.767	10.0000	63.8	38.00	38.00
SIMP BASIN 1	10-INCH	69.06	12.0333	10.000	5.045	10.0000	61.0	0.00	0.00
SIMP BASIN 2	10-INCH	57.90	12.0333	10.000	5.113	10.0000	61.5	38.00	38.00

Basin Name	Sim Name	Max Flow [cfs]
SIMP BASIN 1	04-INCH	10.38
SIMP BASIN 2	04-INCH	16.67
SIMP BASIN 1	06-INCH	27.48
SIMP BASIN 2	06-INCH	26.21
SIMP BASIN 1	08-INCH	47.54
SIMP BASIN 2	08-INCH	40.91
SIMP BASIN 1	10-INCH	69.06
SIMP BASIN 2	10-INCH	57.90

The highlighted max flows (DCIA included) are very close to the manual basin "distributed" approach previously presented.

% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)

Simple Basin Runoff Summary [LUMP-DIST-EXL2]

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
SIMP BASIN 1	04-INCH	10.38	12.0500	4.000	0.814	10.0000	61.0	0.00	0.00
SIMP BASIN 2	04-INCH	16.67	12.0167	4.000	1.552	10.0000	73.3	38.00	38.00
SIMP BASIN 1	06-INCH	27.48	12.0333	6.000	2.010	10.0000	61.0	0.00	0.00
SIMP BASIN 2	06-INCH	26.21	12.0333	6.000	2.562	10.0000	67.3	38.00	38.00
SIMP BASIN 1	08-INCH	47.54	12.0333	8.000	3.453	10.0000	61.0	0.00	0.00
SIMP BASIN 2	08-INCH	40.91	12.0333	8.000	3.767	10.0000	63.8	38.00	38.00
SIMP BASIN 1	10-INCH	69.06	12.0333	10.000	5.045	10.0000	61.0	0.00	0.00
SIMP BASIN 2	10-INCH	57.90	12.0333	10.000	5.113	10.0000	61.5	38.00	38.00

Basin Name	Total Rainfall [in]	Total Runoff [in]	Area [ac]	Equivalent Curve Number
SIMP BASIN 1	4.000	0.814	10.0000	61.0
SIMP BASIN 2	4.000	1.552	10.0000	73.3
SIMP BASIN 1	6.000	2.010	10.0000	61.0
SIMP BASIN 2	6.000	2.562	10.0000	67.3
SIMP BASIN 1	8.000	3.453	10.0000	61.0
SIMP BASIN 2	8.000	3.767	10.0000	63.8
SIMP BASIN 1	10.000	5.045	10.0000	61.0
SIMP BASIN 2	10.000	5.113	10.0000	61.5

Equivalent CN varies with rainfall when % IMP & % DCIA are used

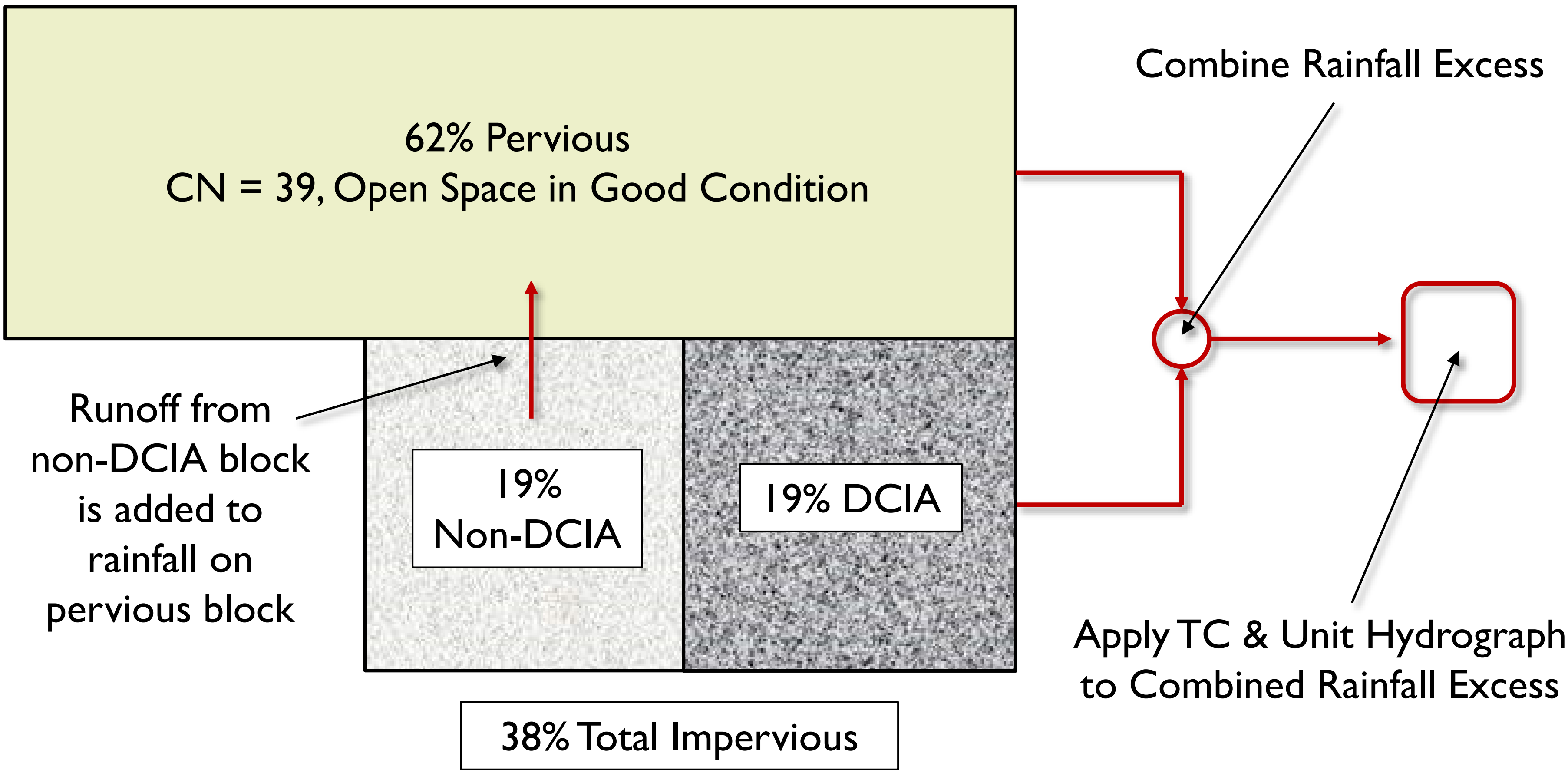
% Impervious and % DCIA

The following TR-55 assumption is very conservative, especially for residential with ¼-ac lots:

> [2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows:
>
> 1. impervious areas are directly connected to the drainage system

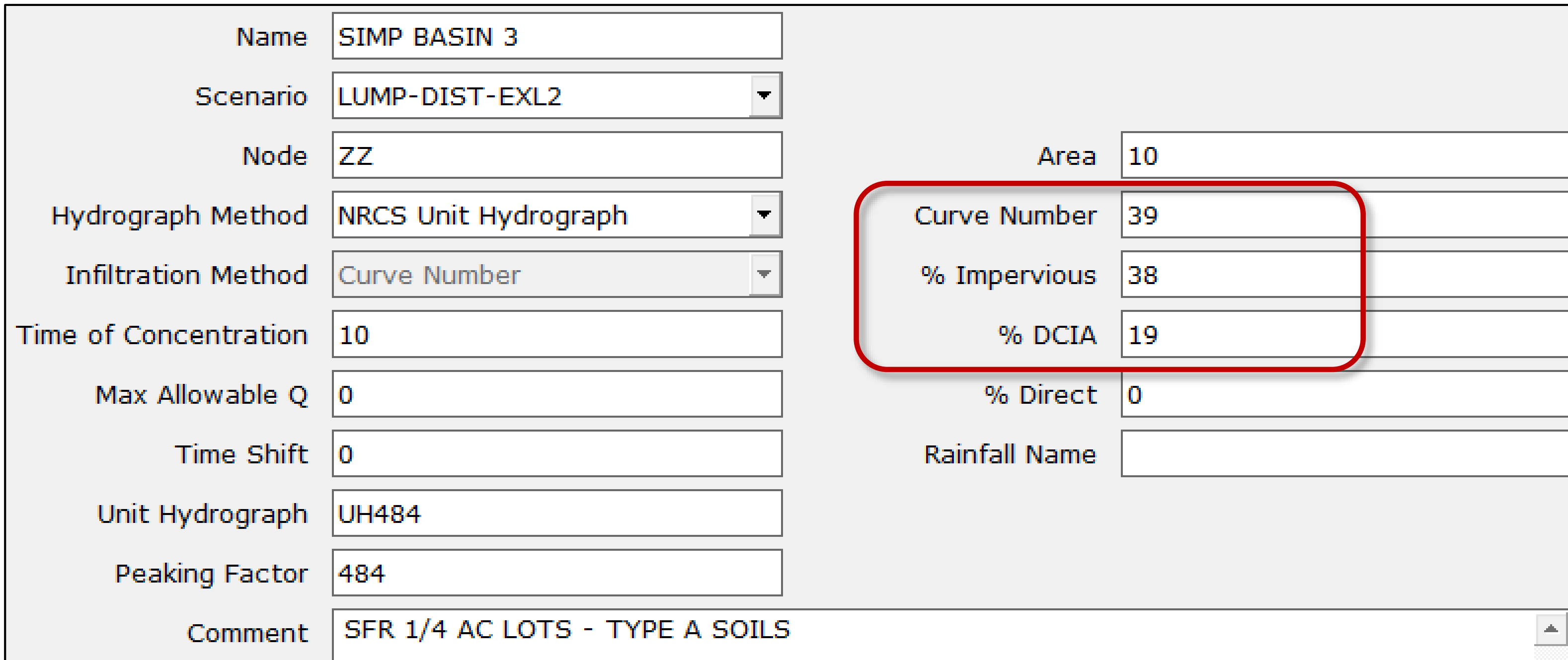
% Impervious and % DCIA

Assuming the impervious area is evenly split between DCIA and non-DCIA is more reasonable:



% Impervious and % DCIA

% Impervious & % DCIA can be included in the "Simple Basin" data form as follows:

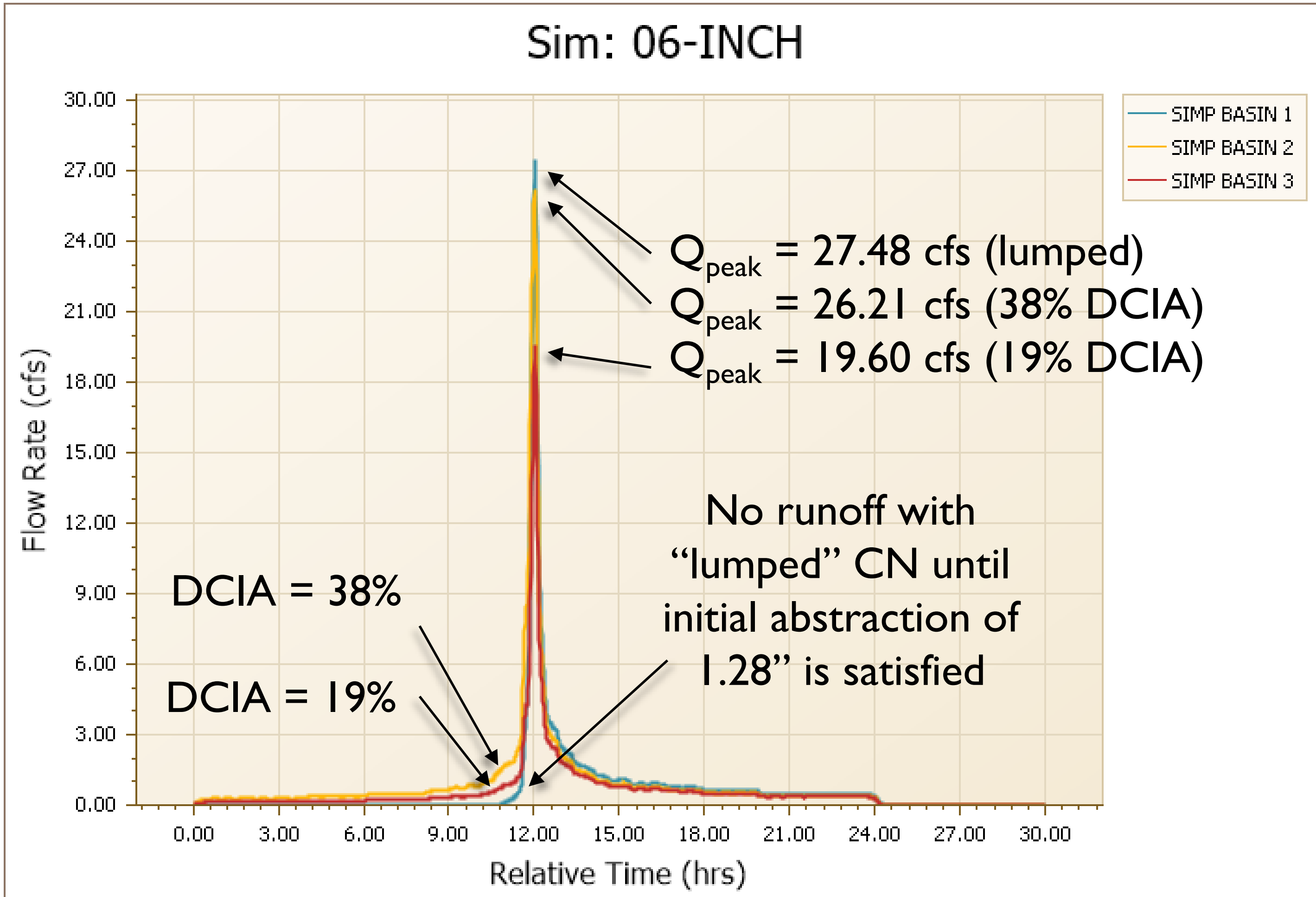


Name	SIMP BASIN 3
Scenario	LUMP-DIST-EXL2
Node	ZZ
Hydrograph Method	NRCS Unit Hydrograph
Infiltration Method	Curve Number
Time of Concentration	10
Max Allowable Q	0
Time Shift	0
Unit Hydrograph	UH484
Peaking Factor	484
Area	10
Curve Number	39
% Impervious	38
% DCIA	19
% Direct	0
Rainfall Name	
Comment	SFR 1/4 AC LOTS - TYPE A SOILS

Curve Number	= 39 represents open space in good condition for type A soil.
% Impervious	= 38% is the TR-55 assumption for residential ¼-ac lots
% DCIA	= 19% assumes 50% of impervious area is directly connected

% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)



% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)

Simple Basin Runoff Summary [LUMP-DIST-EXL2]

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
SIMP BASIN 1	04-INCH	10.38	12.0500	4.000	0.814	10.0000	61.0	0.00	0.00
SIMP BASIN 2	04-INCH	16.67	12.0167	4.000	1.552	10.0000	73.3	38.00	38.00
SIMP BASIN 3	04-INCH	8.45	12.0333	4.000	0.916	10.0000	62.9	38.00	19.00
SIMP BASIN 1	06-INCH	27.48	12.0333	6.000	2.010	10.0000	61.0	0.00	0.00
SIMP BASIN 2	06-INCH	26.21	12.0333	6.000	2.562	10.0000	67.3	38.00	38.00
SIMP BASIN 3	06-INCH	19.60	12.0333	6.000	1.820	10.0000	58.7	38.00	19.00
SIMP BASIN 1	08-INCH	47.54	12.0333	8.000	3.453	10.0000	61.0	0.00	0.00
SIMP BASIN 2	08-INCH	40.91	12.0333						38.00
SIMP BASIN 3	08-INCH	35.25	12.0333						19.00
SIMP BASIN 1	10-INCH	69.06	12.0333						0.00
SIMP BASIN 2	10-INCH	57.90	12.0333						38.00
SIMP BASIN 3	10-INCH	53.11	12.0333						19.00

Basin Name	Sim Name	Max Flow [cfs]
SIMP BASIN 1	04-INCH	10.38
SIMP BASIN 2	04-INCH	16.67
SIMP BASIN 3	04-INCH	8.45
SIMP BASIN 1	06-INCH	27.48
SIMP BASIN 2	06-INCH	26.21
SIMP BASIN 3	06-INCH	19.60
SIMP BASIN 1	08-INCH	47.54
SIMP BASIN 2	08-INCH	40.91
SIMP BASIN 3	08-INCH	35.25
SIMP BASIN 1	10-INCH	69.06
SIMP BASIN 2	10-INCH	57.90
SIMP BASIN 3	10-INCH	53.11

Max flows are consistently lower when 50% of the impervious area is non-DCIA

(residential with ¼-ac lots, type A soils)

% Impervious and % DCIA

(residential with ¼-ac lots, type A soils)

Simple Basin Runoff Summary [LUMP-DIST-EXL2]

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
SIMP BASIN 1	04-INCH	10.38	12.0500	4.000	0.814	10.0000	61.0	0.00	0.00
SIMP BASIN 2	04-INCH	16.67	12.0167	4.000	1.552	10.0000	73.3	38.00	38.00
SIMP BASIN 3	04-INCH	8.45	12.0333	4.000	0.916	10.0000	62.9	38.00	19.00
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SIMP BASIN 2	06-INCH	26.21	12.0333	6.000	2.562	10.0000	67.3	38.00	38.00
SIMP BASIN 3	06-INCH	19.60	12.0333	6.000	1.820	10.0000	58.7	38.00	19.00
SIMP BASIN 1	08-INCH	47.54	12.0333	8.000	3.453	10.0000	61.0	0.00	0.00
SIMP					3.767	10.0000	63.8	38.00	38.00
SIMP					2.975	10.0000	56.7	38.00	19.00
SIMP					5.045	10.0000	61.0	0.00	0.00
SIMP					5.113	10.0000	61.5	38.00	38.00
SIMP					4.304	10.0000	55.5	38.00	19.00

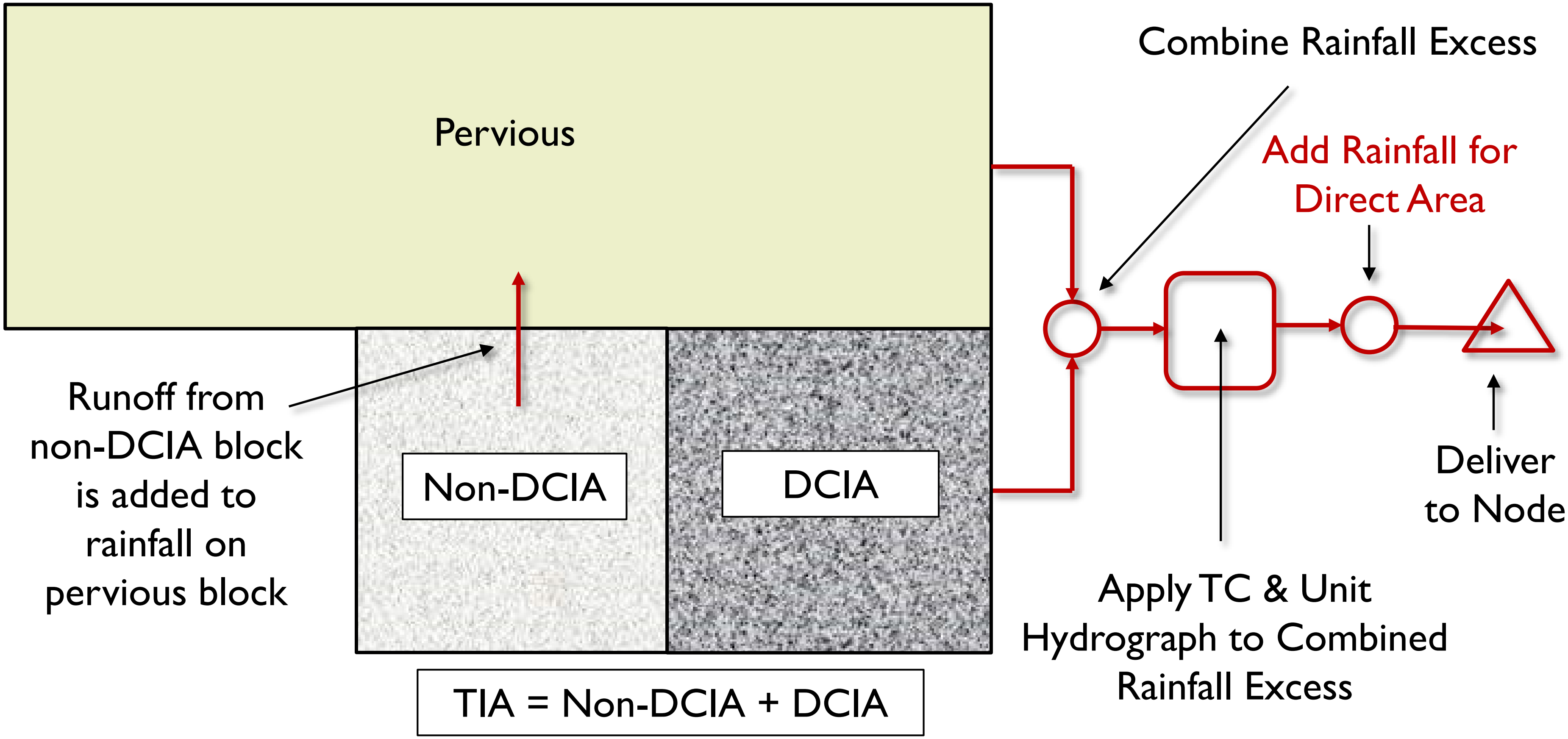
Equivalent Curve Number	% Imperv	% DCIA
61.0	0.00	0.00
73.3	38.00	38.00
→ 62.9	38.00	19.00
61.0	0.00	0.00
67.3	38.00	38.00
→ 58.7	38.00	19.00
61.0	0.00	0.00
63.8	38.00	38.00
→ 56.7	38.00	19.00
61.0	0.00	0.00
61.5	38.00	38.00
→ 55.5	38.00	19.00

The equivalent CN is consistently lower when 50% of the impervious area is non-DCIA

(residential with ¼-ac lots, type A soils)

% Direct

The "% Direct" parameter is used to apply rainfall directly to a basin's outlet, bypassing any type of hydrograph techniques like the NRCS unit hydrograph method. It is optional and can be used for water bodies.



% Direct

Example*

The basin (red dotted line) shown to the right drains into a wet detention pond (blue shaded area).

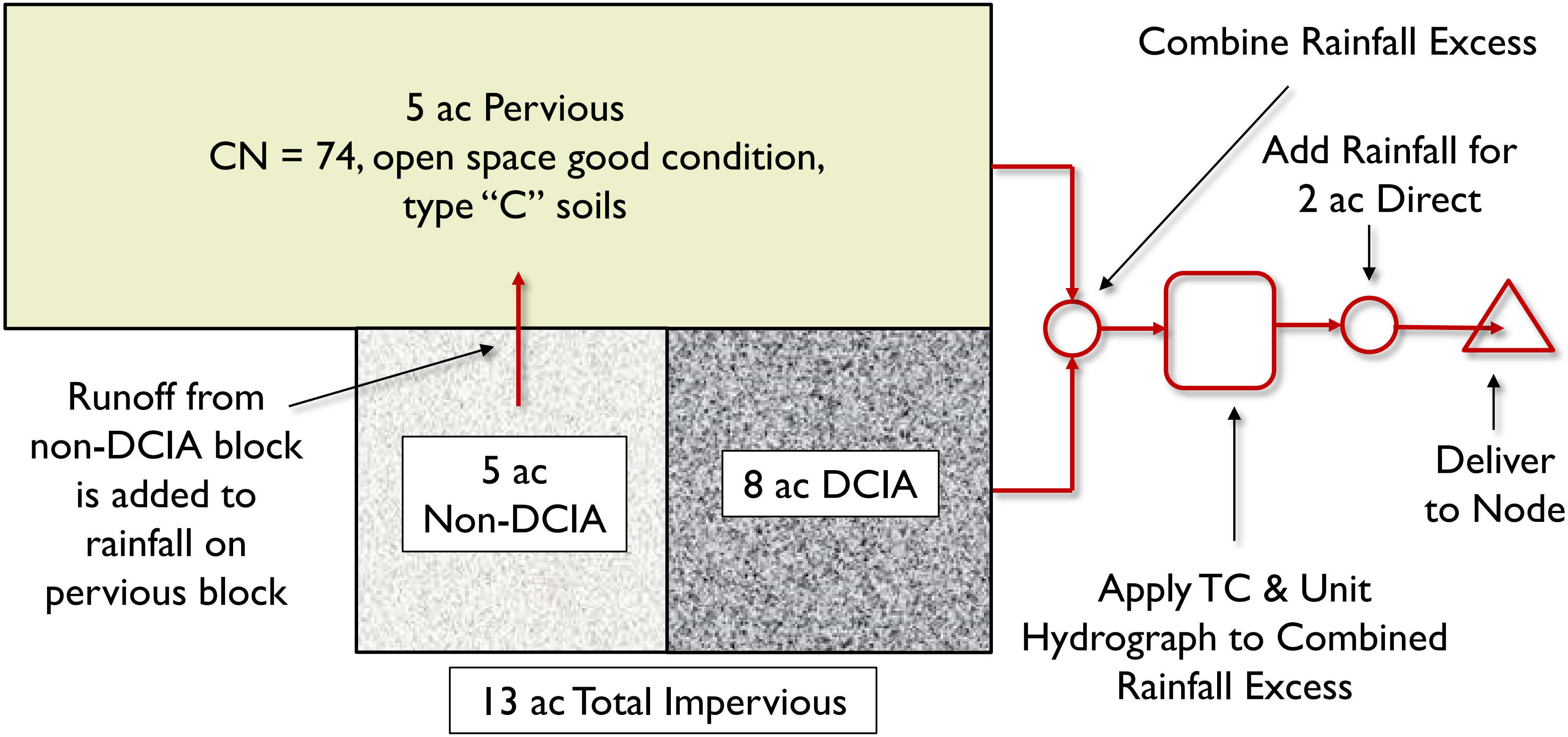
- Hydrologic Soil Group "C"
- Basin Area: 20 ac
- Impervious Area: 13 ac
- DCIA: 8 ac
- Pond Area: 2 ac

TC calculated to water's edge

* The above are not actual values and are for illustrative purposes only.

% Direct

The "% Direct" parameter is used to apply rainfall directly to a basin's outlet, bypassing any type of hydrograph techniques like the NRCS unit hydrograph method. It is optional and can be used for water bodies.



% Direct

The "Simple Basin" parameters are set as follows:

CN = 74 (open space good condition, type "C" soils)

% Impervious	= (13/20) x 100	= 65%
% DCIA	= (8/20) x 100	= 40%
% Direct	= (2/20) x 100	= 10%

Name	SIMP BASIN 4		
Scenario	LUMP-DIST-EXL2		
Node	ZZ	Area	20
Hydrograph Method	NRCS Unit Hydrograph	Curve Number	74
Infiltration Method	Curve Number	% Impervious	65
Time of Concentration	10	% DCIA	40
Max Allowable Q	0	% Direct	10
Time Shift	0	Rainfall Name	
Unit Hydrograph	UH484		
Peaking Factor	484		

Curve Number
% Impervious, % DCIA, % Direct
- a few rules -

The following rules apply to simple basins, impervious lookup tables and curve number lookup tables:

1. The CN represents everything that is not % Impervious and not % Direct

Curve Number
% Impervious, % DCIA, % Direct
- a few rules -

The following rules apply to simple basins, impervious lookup tables and curve number lookup tables:

1. The CN represents everything that is not % Impervious and not % Direct
2. % DCIA can never exceed % Impervious

Curve Number
% Impervious, % DCIA, % Direct
- a few rules -

The following rules apply to simple basins, impervious lookup tables and curve number lookup tables:

1. The CN represents everything that is not % Impervious and not % Direct
2. % DCIA can never exceed % Impervious
3. If % Impervious is 100, then % DCIA must be 100

Curve Number
% Impervious, % DCIA, % Direct
- a few rules -

The following rules apply to simple basins, impervious lookup tables and curve number lookup tables:

1. The CN represents everything that is not % Impervious and not % Direct
2. % DCIA can never exceed % Impervious
3. If % Impervious is 100, then % DCIA must be 100
4. % Impervious plus % Direct can never exceed 100

Lumped vs. Distributed?

1. Be consistent between PRE and POST conditions.

Lumped vs. Distributed?

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2. The distributed method is a more accurate approach but do not expect a single curve number for each basin. Also, the equivalent curve number will likely vary by storm event.

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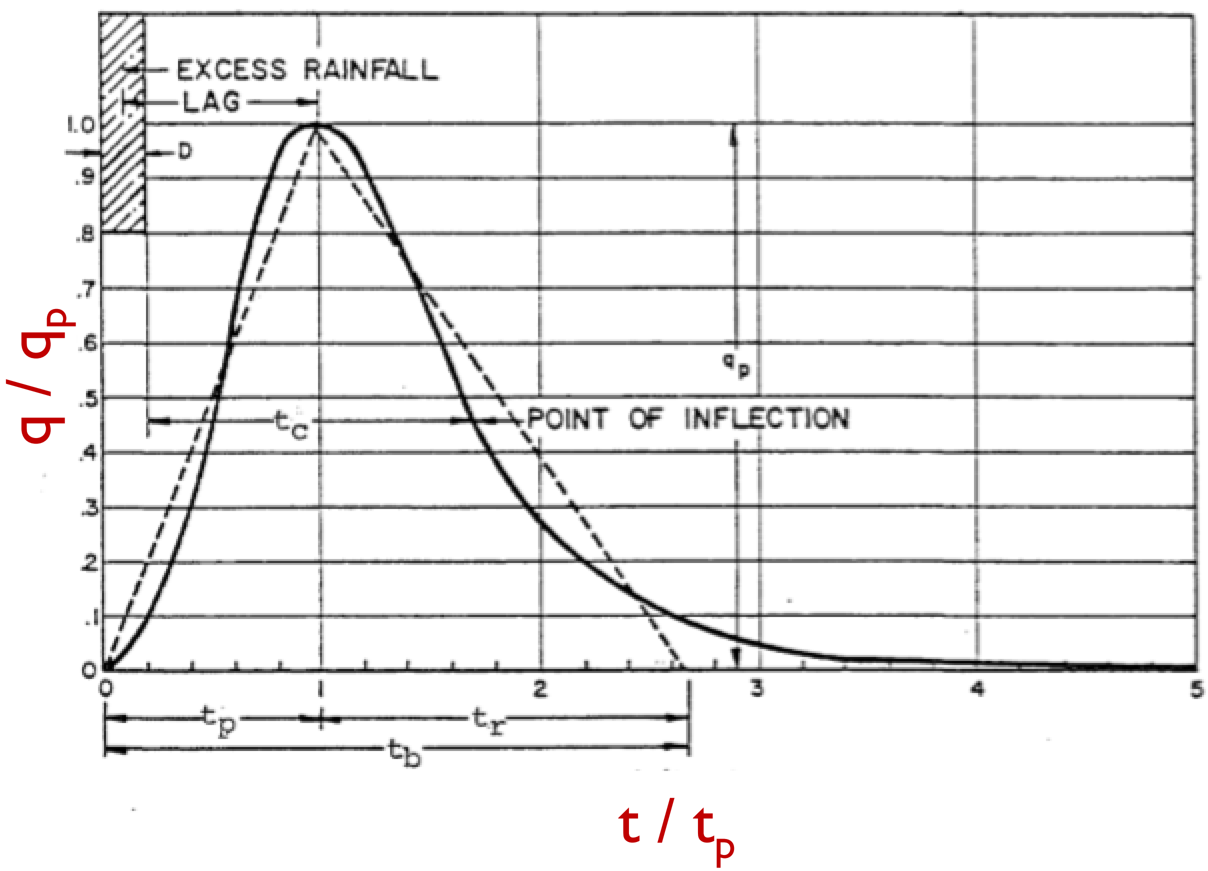
2. The distributed method is a more accurate approach but do not expect a single curve number for each basin. Also, the equivalent curve number will likely vary by storm event.
3. If the "lumped" approach (simple basins) is used, a separate worksheet should be provided with area weighted curve number calculations.

Lumped vs. Distributed?

1. Be consistent between PRE and POST conditions.
2. The distributed method is a more accurate approach but do not expect a single curve number for each basin. Also, the equivalent curve number will likely vary by storm event.
3. If the "lumped" approach (simple basins) is used, a separate worksheet should be provided with area weighted curve number calculations.
4. If the "distributed" approach (manual basins) is used, the manual basin input report will include the breakdown of area, land cover and soil combinations. However, it is important that the Impervious and Curve Number lookup tables also be provided (covered in example #1).

NRCS Unit Hydrograph Method

A unit hydrograph is the hydrograph resulting from one inch of rainfall excess generated uniformly over a catchment area at a contant rate during a specified time interval.



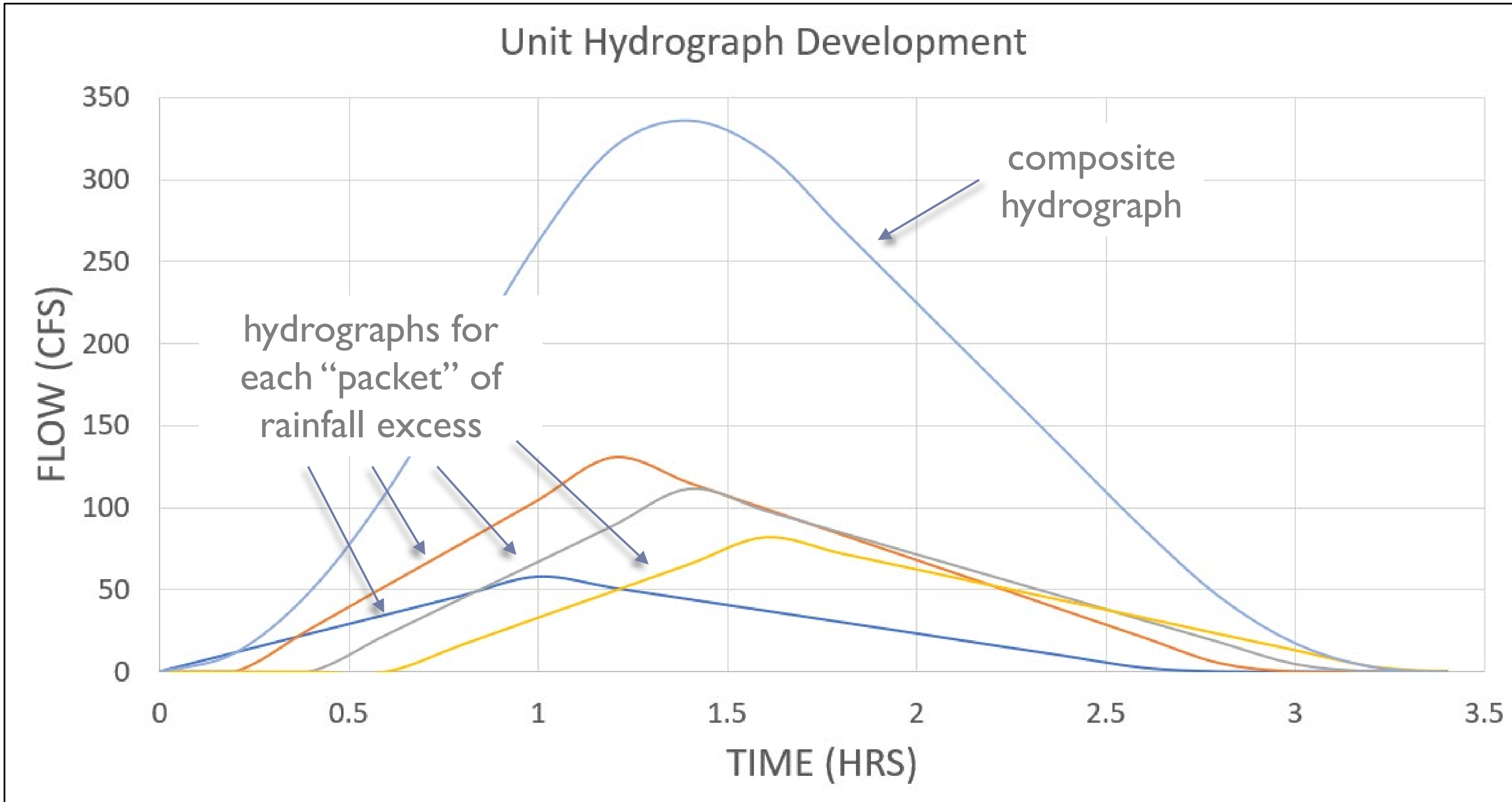
NRCS Unit Hydrograph Method

$$q_p = \frac{(K')(A)(Q)}{t_p}$$

$$t_p = \frac{2}{3} t_c$$

q_p	peak discharge of unit hydrograph (f^3s^{-1})
t_p	time to peak discharge (hours)
K'	peak rate factor
A	drainage area (square miles)
Q	direct runoff depth (inches)
t_c	time of concentration (hours)

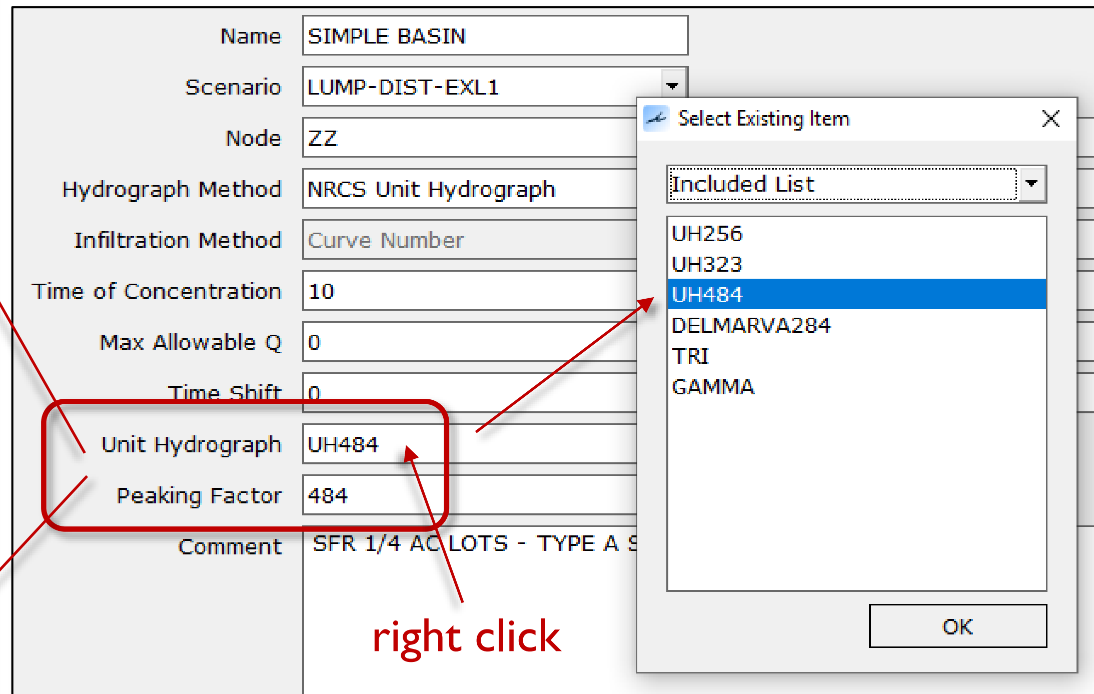
NRCS Unit Hydrograph Method



NRCS Unit Hydrograph Method

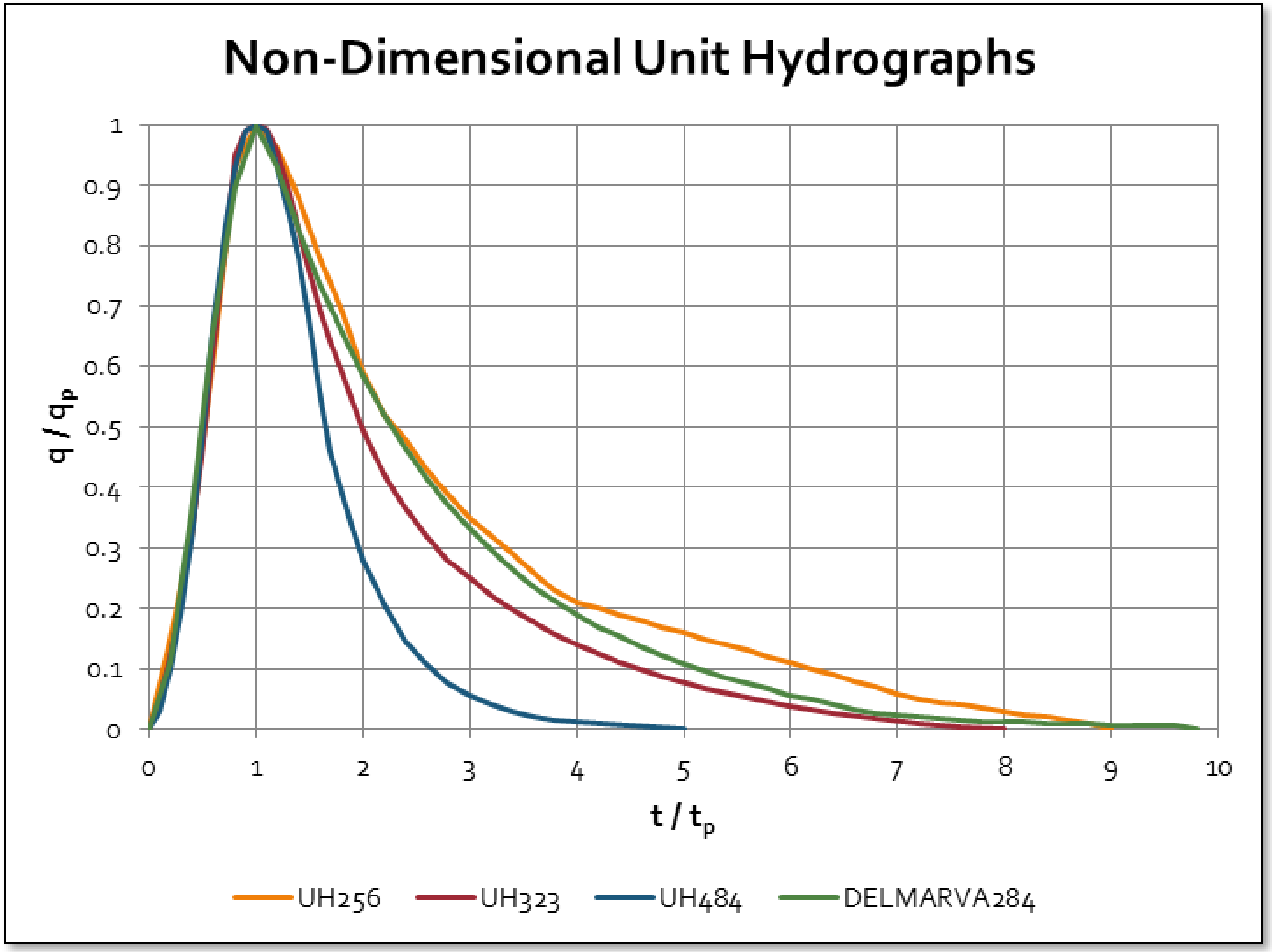
Time Ratios (t/t_p)	Discharge Ratios (q/q_p)
0	.000
.1	.030
.2	.100
.3	.190
.4	.310
.5	.470
.6	.660
.7	.820
.8	.930
.9	.990
1.0	1.000
1.1	.990
1.2	.930
1.3	.860
1.4	.780
1.5	.680
1.6	.560
1.7	.460
1.8	.390
1.9	.330
2.0	.280
2.2	.207
2.4	.147
2.6	.107
2.8	.077
3.0	.055
3.2	.040
3.4	.029
3.6	.021
3.8	.015
4.0	.011
4.5	.005
5.0	.000

Unit Hydrograph & Peaking Factor Specified by Individual Basin



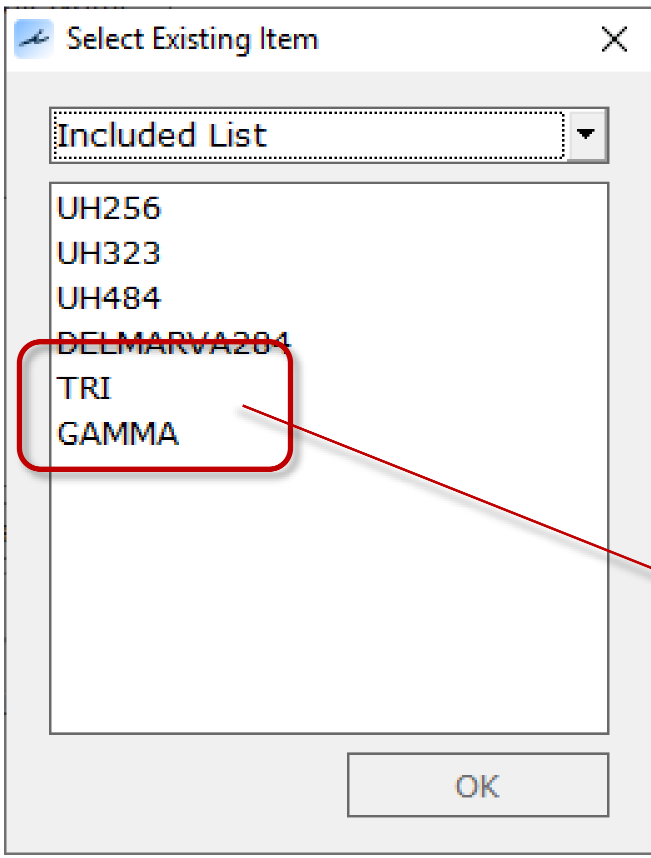
NRCS Unit Hydrograph Method

Dimensionless Curvilinear Unit Hydrographs Included with ICPR4



NRCS Unit Hydrograph Method

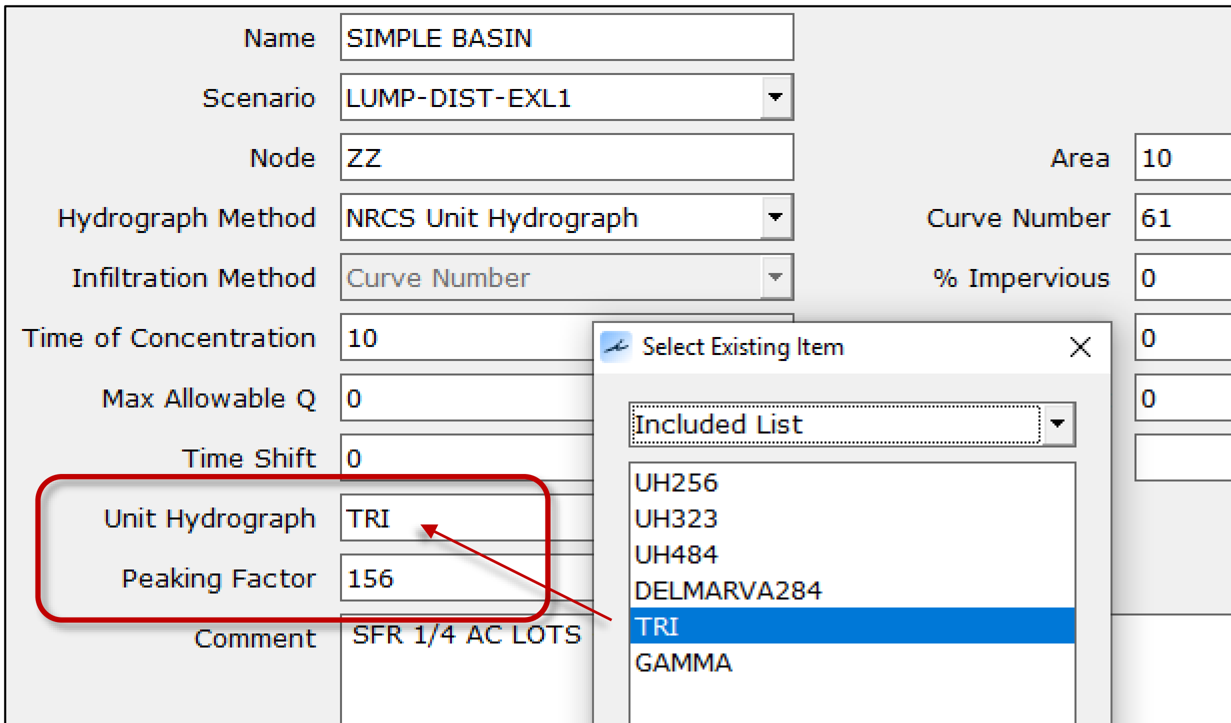
Gamma and Triangular Unit Hydrograph Functions with User Specified Peaking Factor



Name	Peak Rate Factor
UH256	256
UH323	323
UH484	484
DELMARVA-284	284
TRI	50 - 1100
GAMMA	110 - 1100

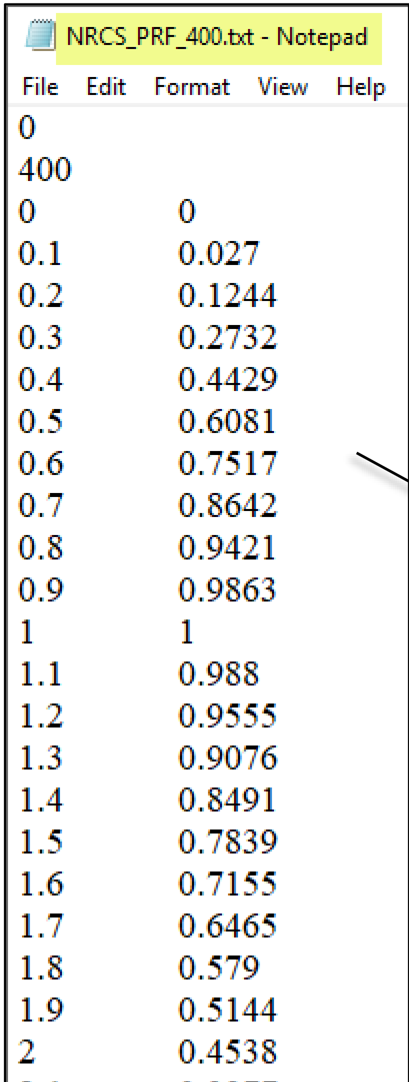
NRCS Unit Hydrograph Method

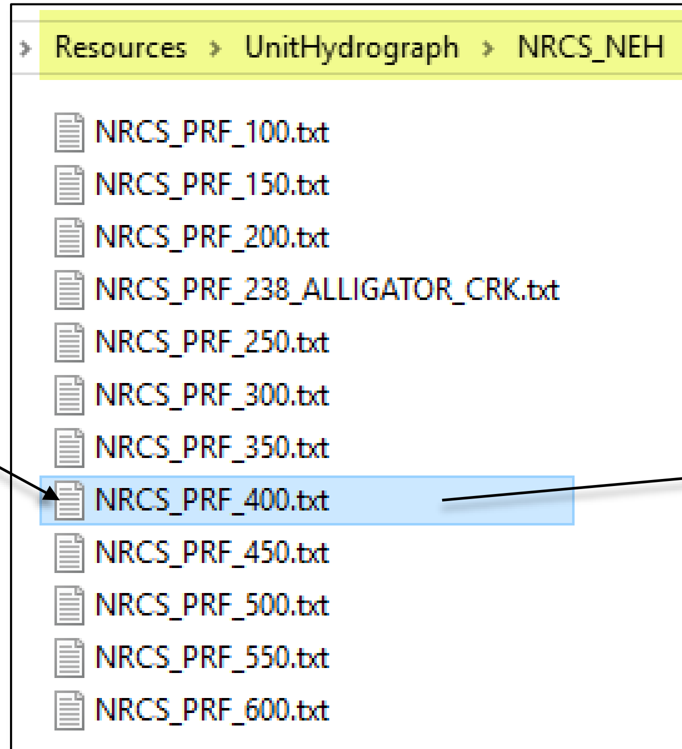
Gamma and Triangular Unit Hydrograph Functions with User Specified Peaking Factor

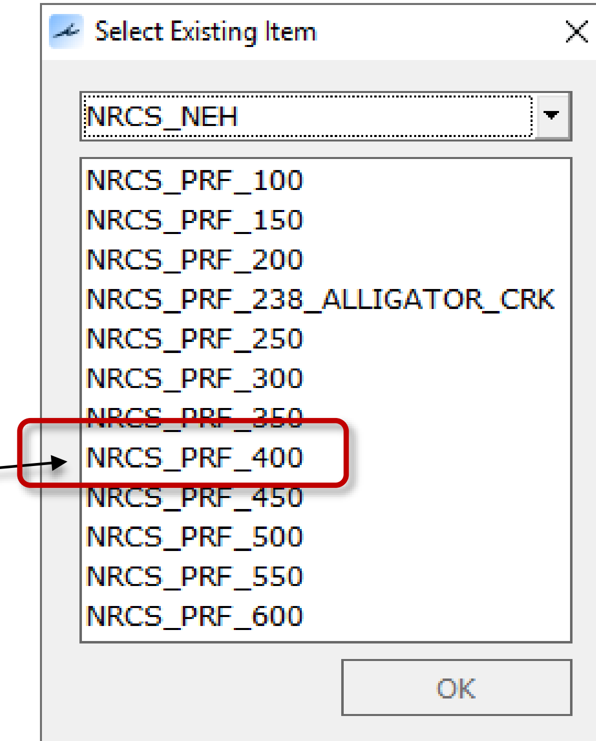


Select either "TRI" or "GAMMA" and then type in the "Peaking Factor"

NRCS Unit Hydrograph Method







custom unit hydrographs can be created in text files and placed in a project's "UnitHydrograph" resources folder

these can be selected from dropdown lists in the basin data forms

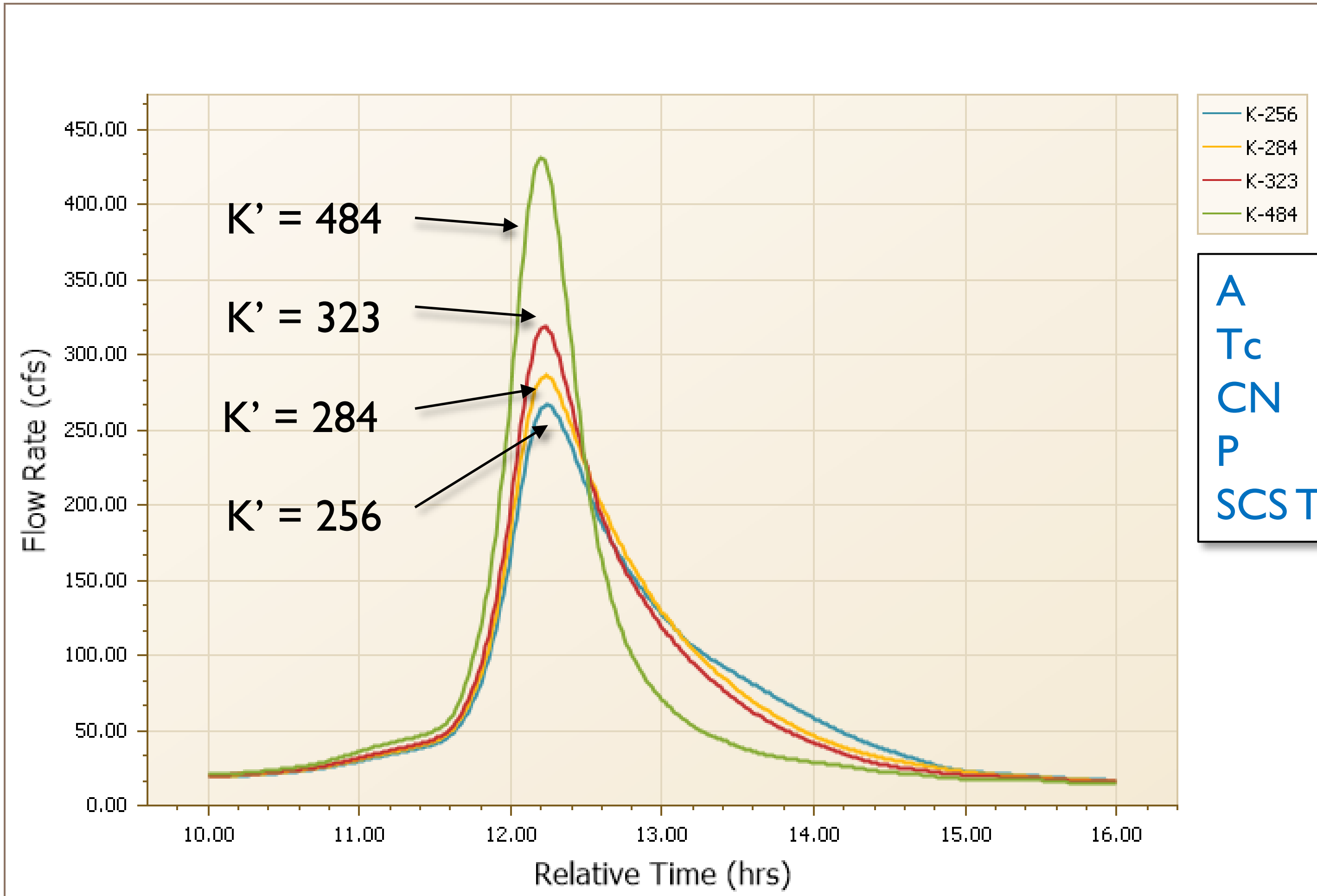
NRCS Unit Hydrograph Method

Peak Rate Factor

- Used to reflect the effect of watershed storage on runoff hydrograph shape
- Higher values are used for watersheds with little or no storage effects
- Lower values are used for watershed with significant ponding effects
- Typically specified by regulatory agency responsible for permits

NRCS Unit Hydrograph Method

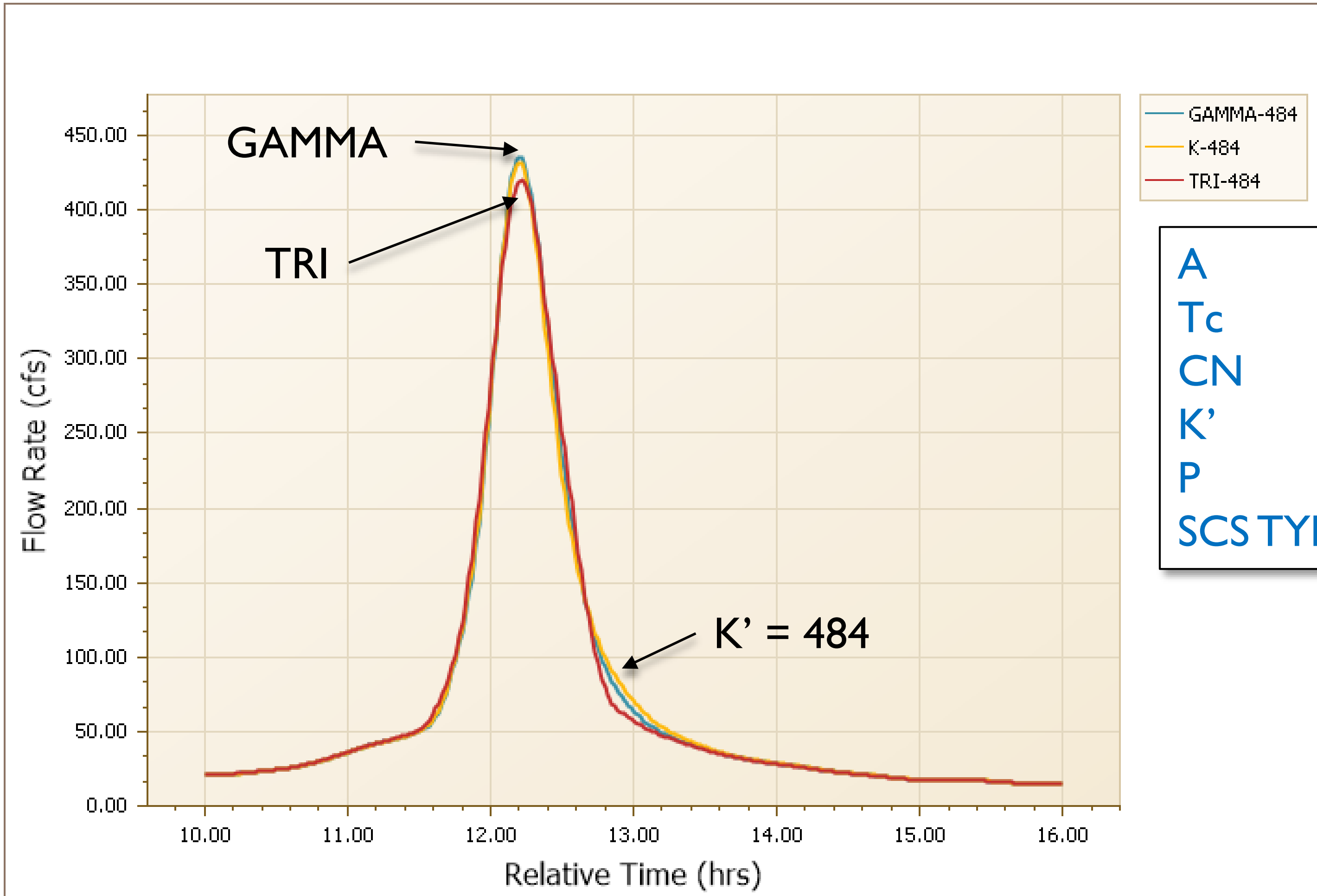
Peak Rate Factor Sensitivity



A = 100 ac
Tc = 30 min
CN = 100
P = 6" (24hr)
SCS TYPE II

NRCS Unit Hydrograph Method

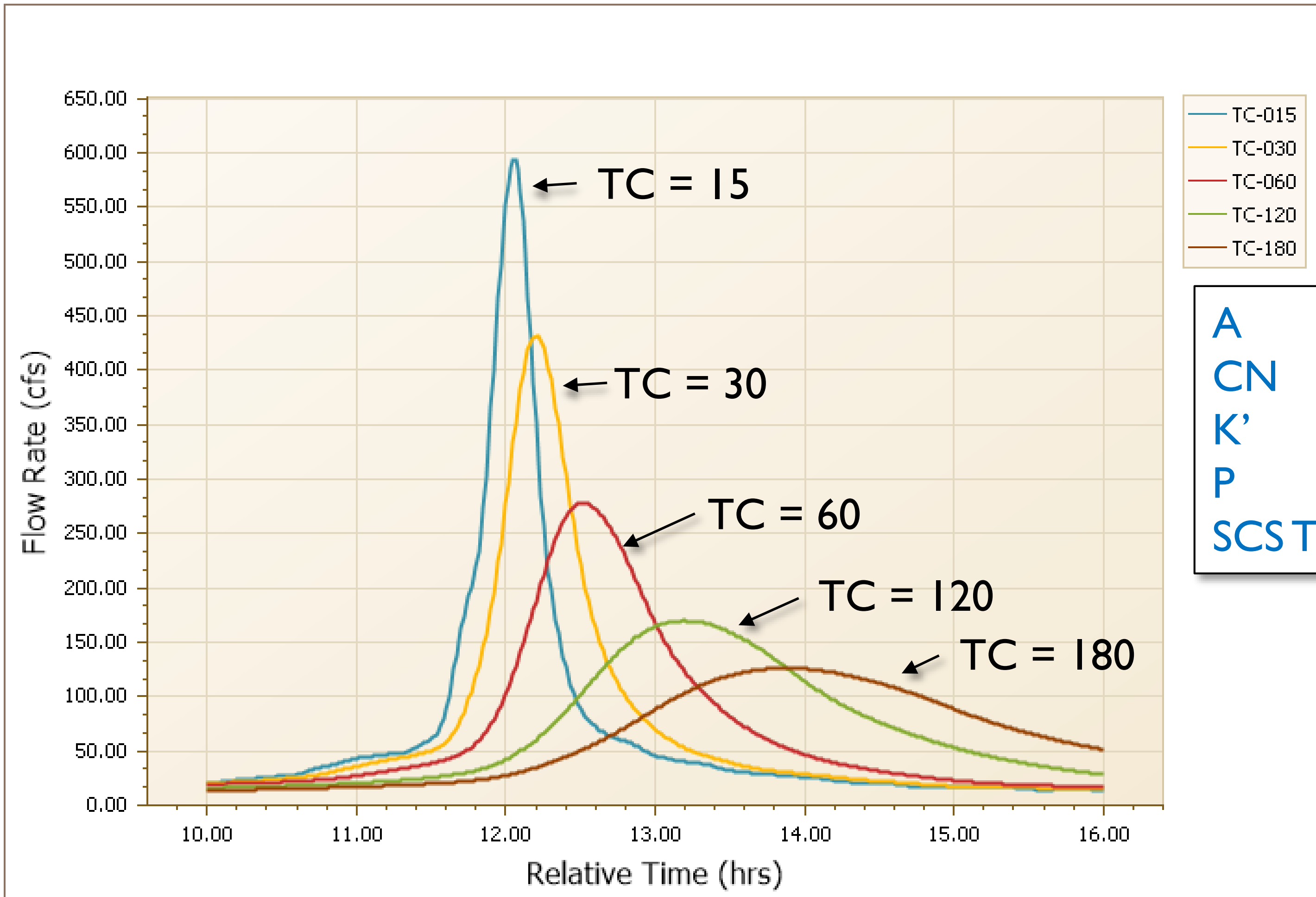
Peak Rate Factor Sensitivity



A	= 100 ac
Tc	= 30 min
CN	= 100
K'	= 484
P	= 6" (24hr)
SCS TYPE II	

NRCS Unit Hydrograph Method

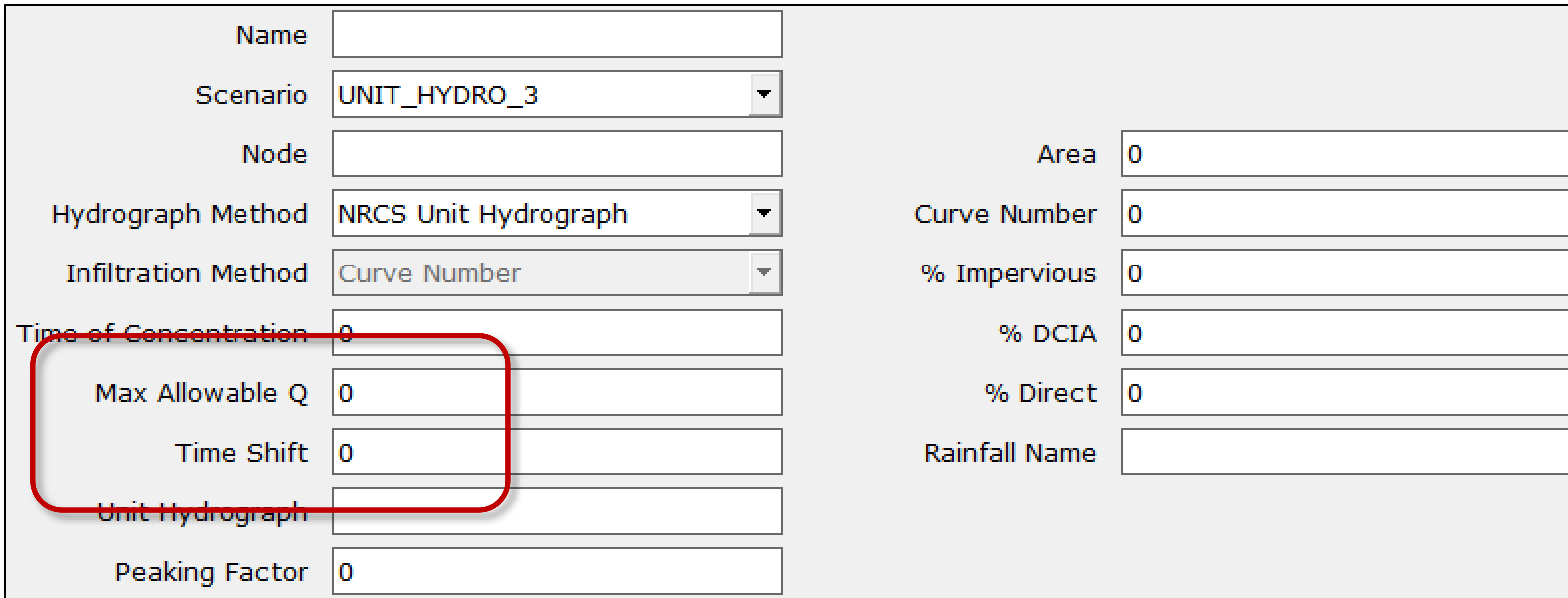
Time of Concentration Sensitivity



A = 100 ac
CN = 100
K' = 484
P = 6" (24hr)
SCS TYPE II

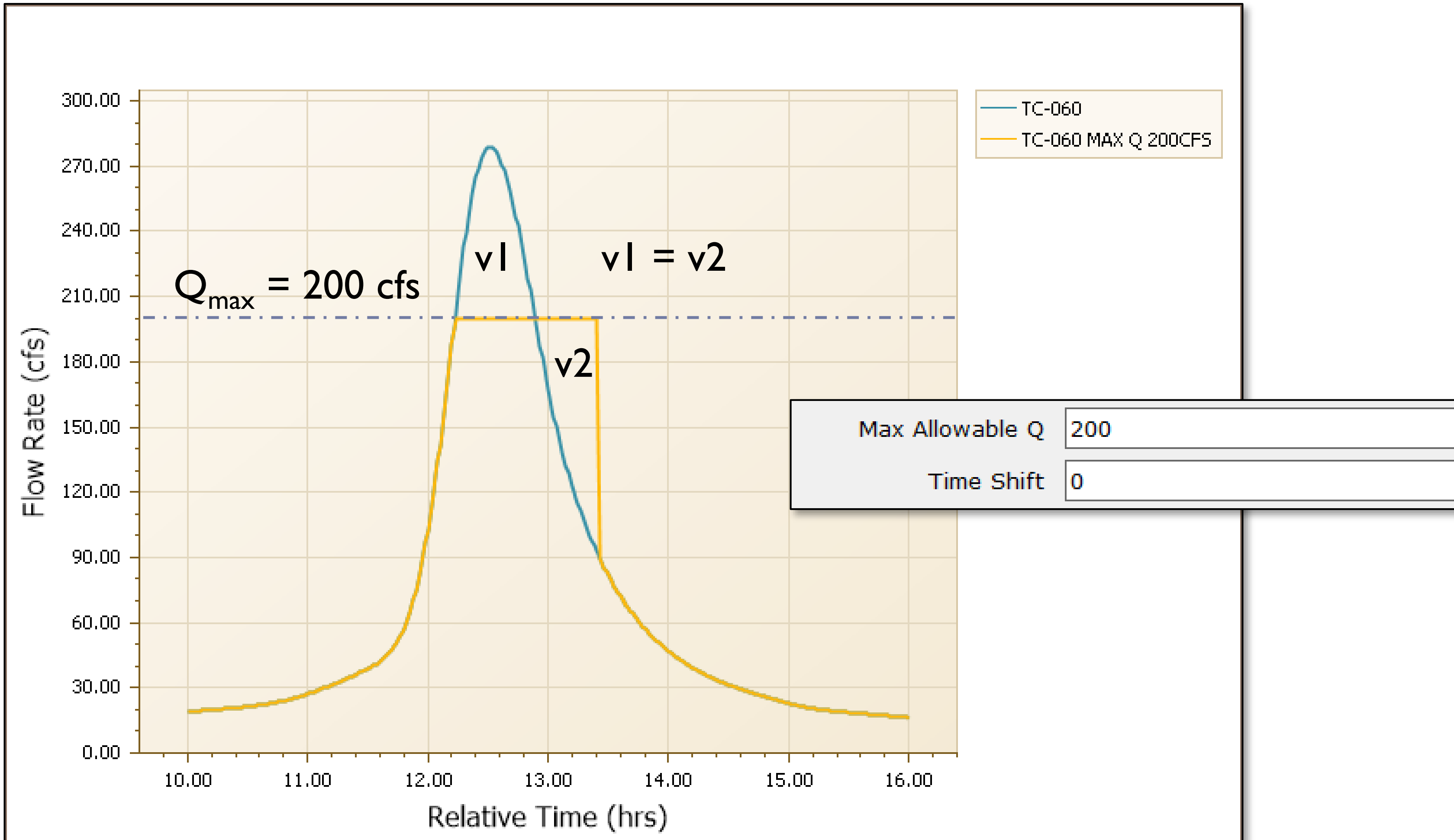
NRCS Unit Hydrograph Method

Max Allowable Q and Time Shift



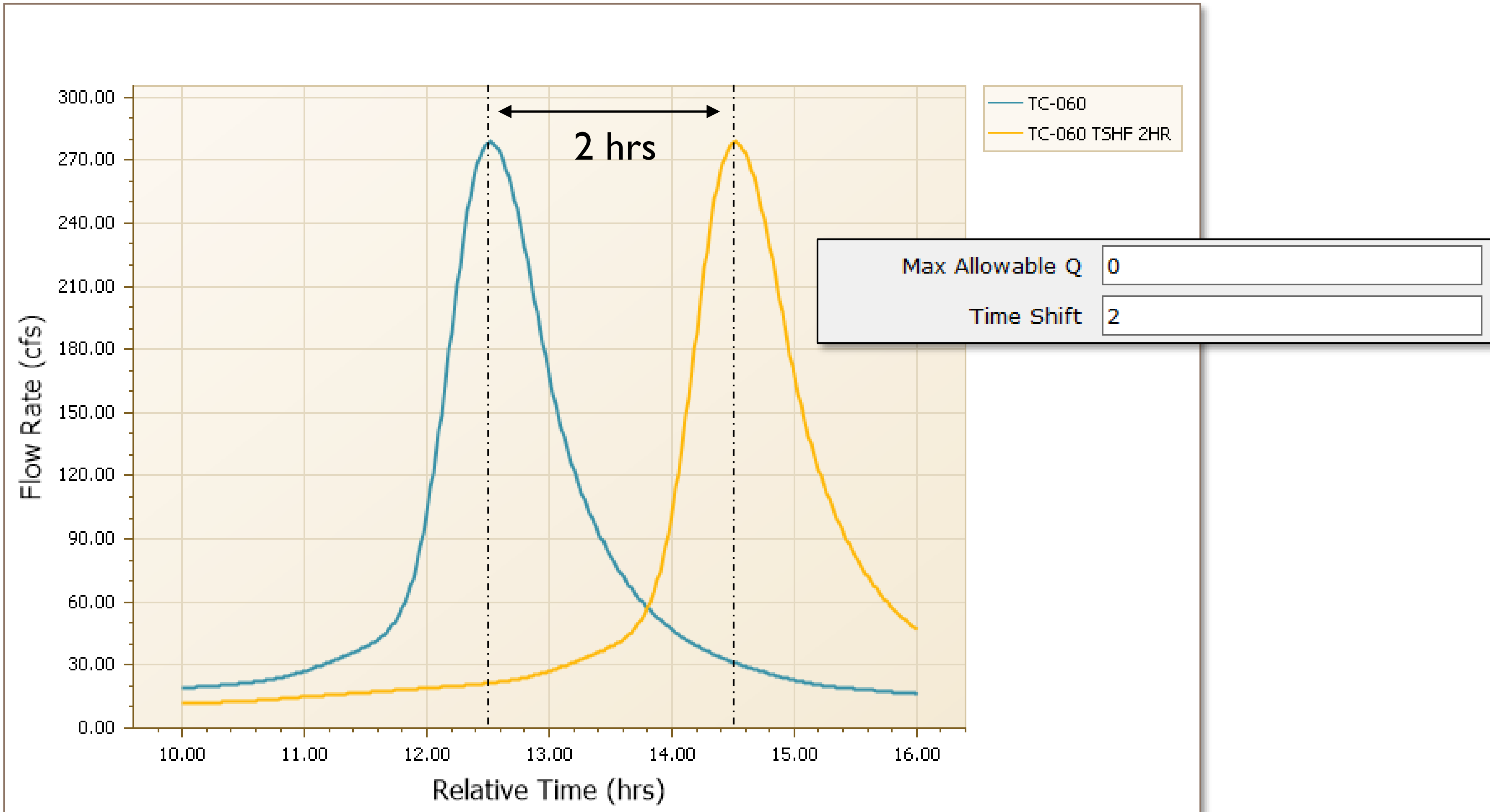
NRCS Unit Hydrograph Method

Max Allowable Q



NRCS Unit Hydrograph Method

Time Shift

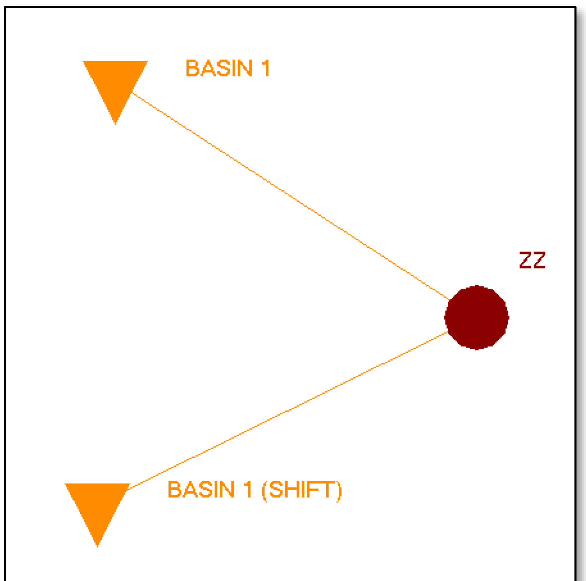


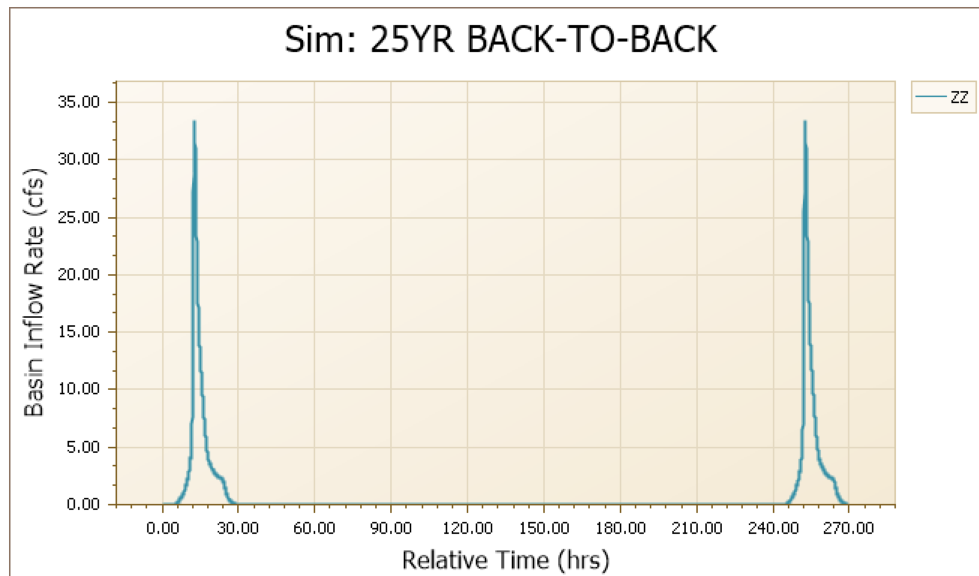
NRCS Unit Hydrograph Method

Using the Time Shift Parameter for Back-to-Back Storms

Simple Basin Data

Name	Node	Time of Concentration	Time Shift	Unit Hydrograph	Peaking Factor	Area	Curve Number
BASIN 1	ZZ	60	0	UH256	256	20	80
BASIN 1 (SHIFT)	ZZ	60	240	UH256	256	20	80





Santa Barbara Urban Hydrograph Method

The Santa Barbara Urban Hydrograph method (SBUH) was originally developed in the 1970s by James M. Stubchaer and became popular at that time due to ease of use on a programmable calculator. In the SBUH method, the final discharge hydrograph is obtained by routing the instantaneous hydrograph (i.e. rainfall excess) for each time step through an imaginary linear reservoir with a routing constant proportional to the time of concentration of the drainage basin.

Santa Barbara Urban Hydrograph Method

$$Q_i = Q_{i-1} + K\left(R_i + R_{i-1} - 2Q_{i-1}\right)$$

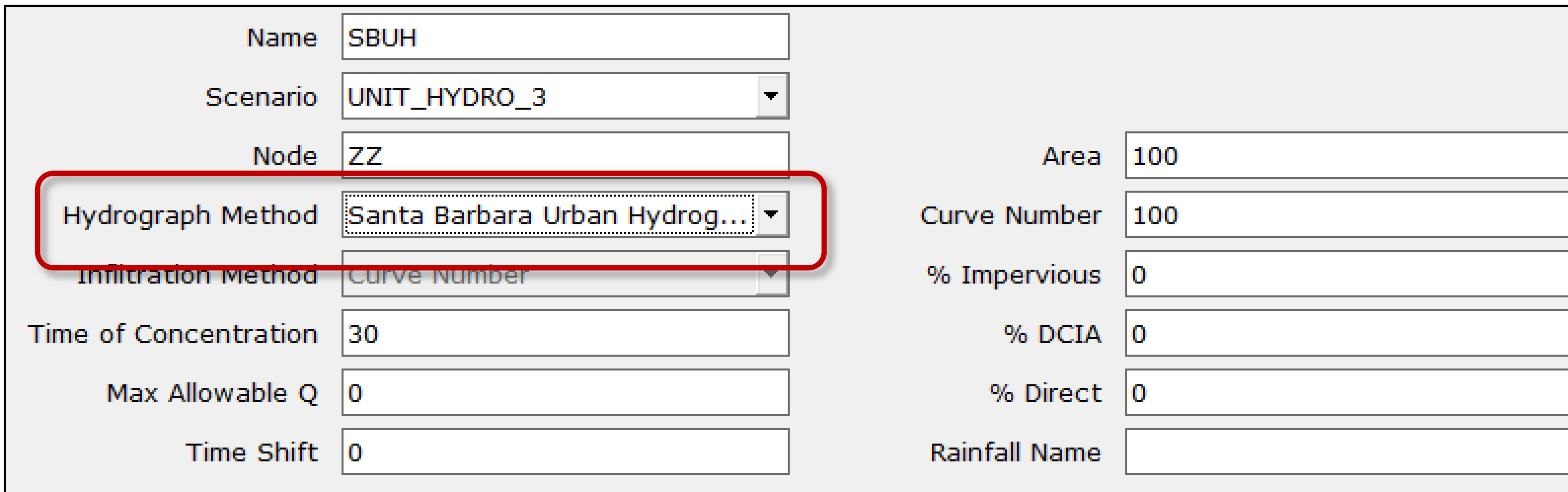
where,

Q_i	runoff at time t (f^3s^{-1} or m^3s^{-1})
Q_{i-1}	runoff at time $t-\Delta t$ (f^3s^{-1} or m^3s^{-1})
R_i	rainfall excess at time t (f^3s^{-1} or m^3s^{-1})
R_{i-1}	rainfall excess at time $t-\Delta t$ (f^3s^{-1} or m^3s^{-1})

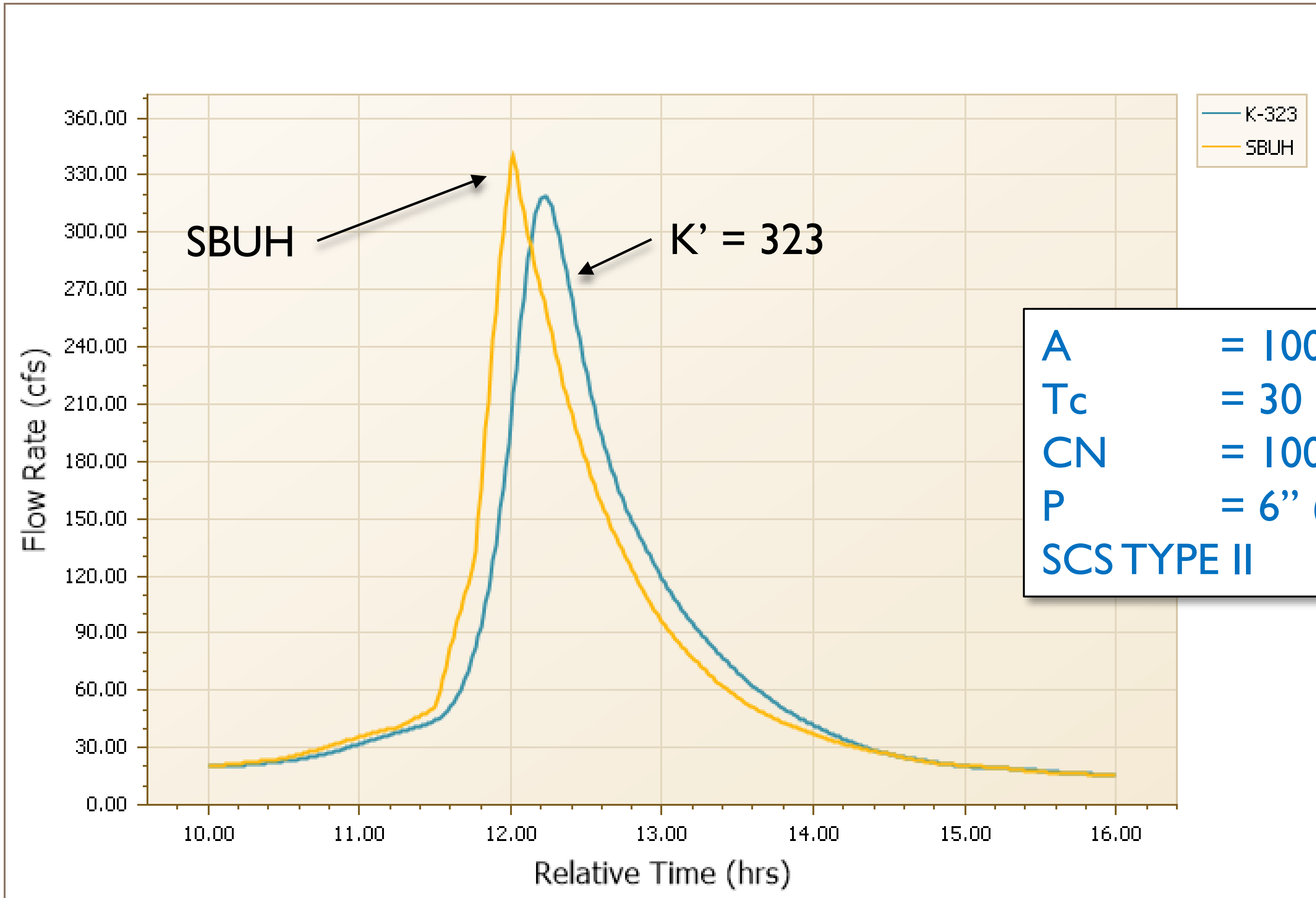
$$K = \frac{\Delta t}{\left(2t_c + \Delta t\right)}$$

t_c	time of concentration (minutes)
Δt	computational time increment (minutes)

Santa Barbara Urban Hydrograph Method



Santa Barbara Urban Hydrograph Method



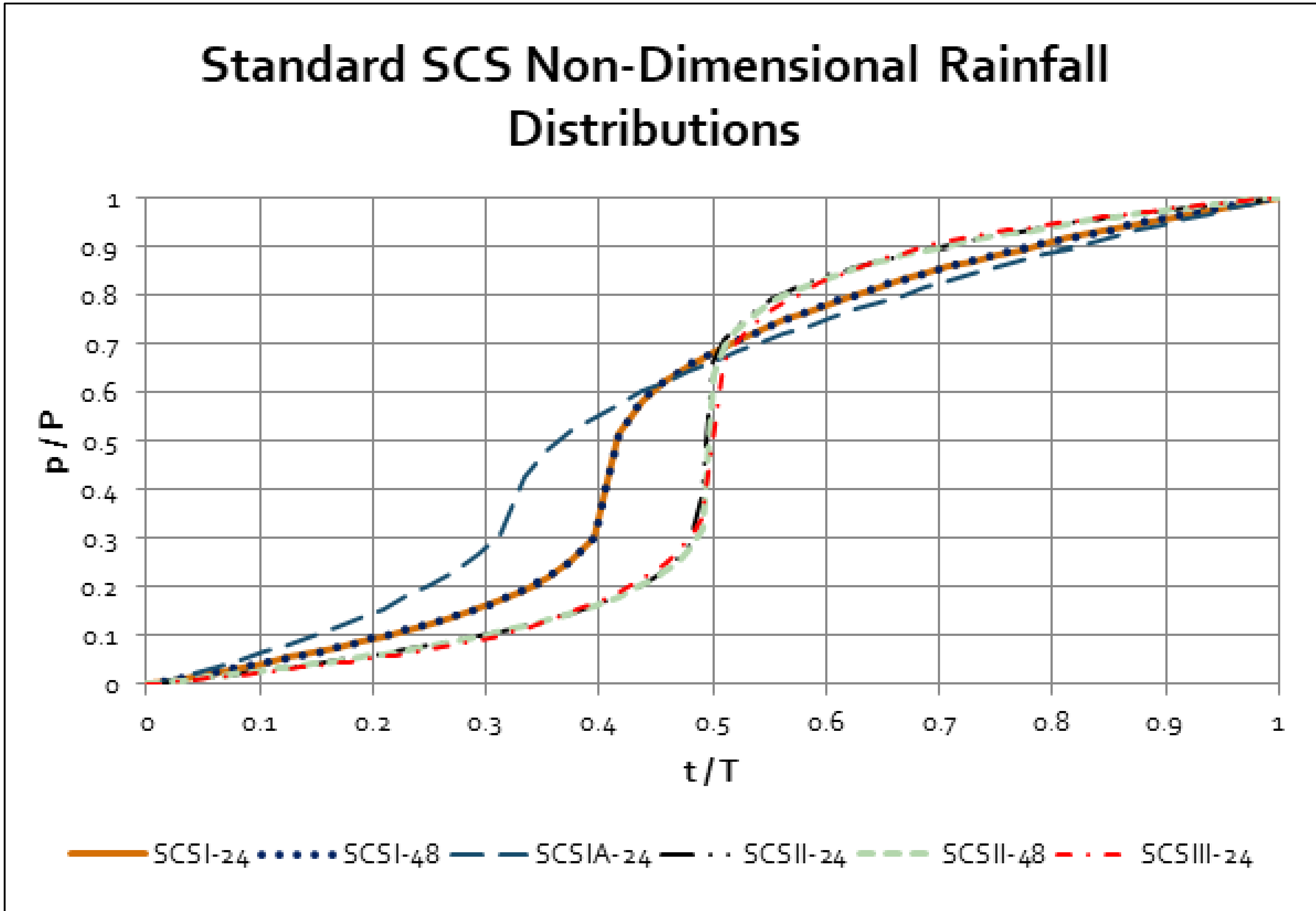
A = 100 ac
Tc = 30 min
CN = 100
P = 6" (24hr)
SCS TYPE II

Non-Dimensional Rainfall Distributions

ICPR4 includes 18 "built-in" non-dimensional rainfall distributions that can be used by specifying any of the following rainfall names along with the storm duration and rainfall amount.

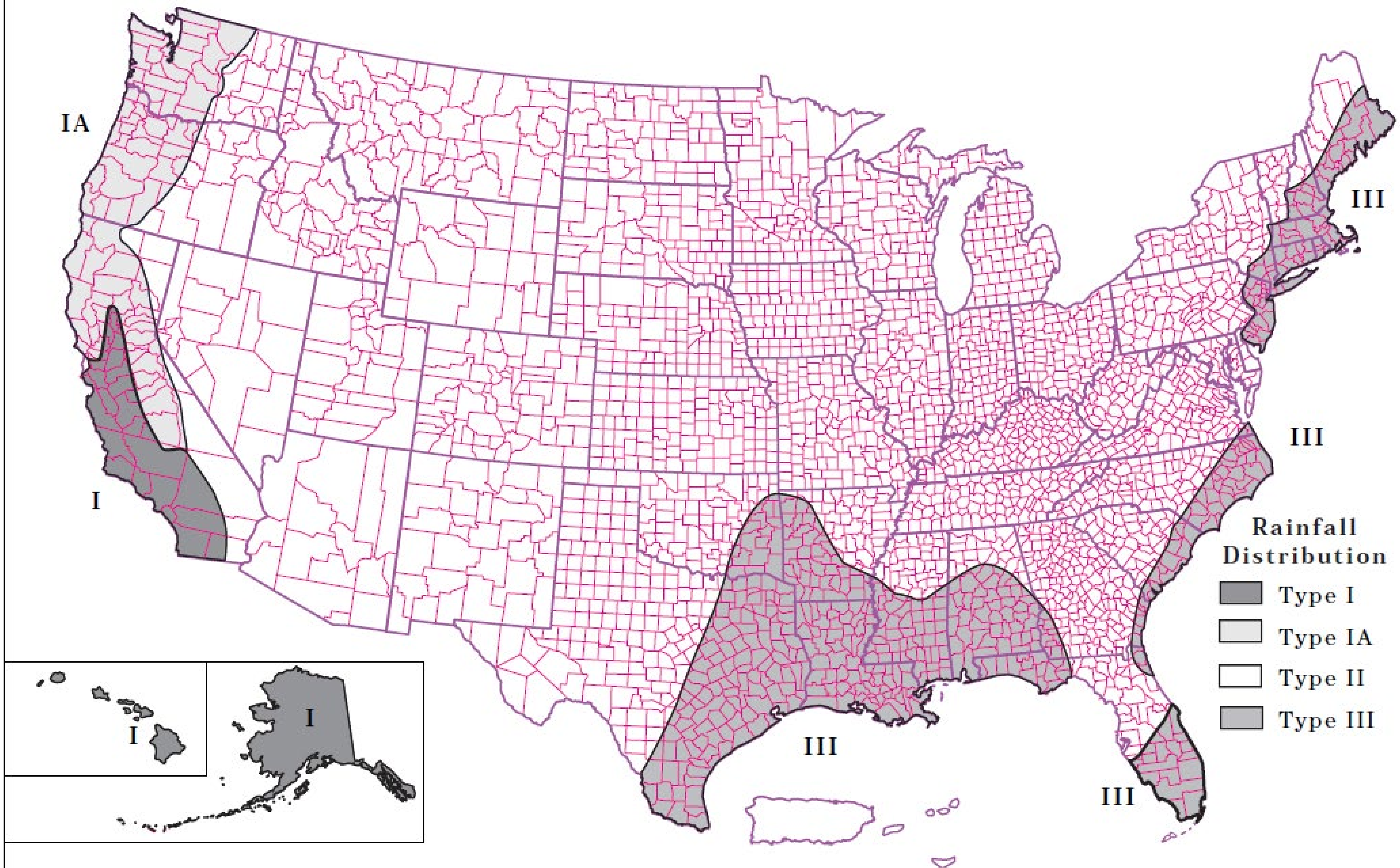
NAME	NAME	NAME
~SCSI-24	~FLMOD	~FDOT-4
~SCSI-48	~ORANGE	~FDOT-8
~SCSIA-24	~SFWMD-72	~FDOT-24
~SCSII-24	~SJRWMD-96	~FDOT-72
~SCSII-48	~FDOT-1	~FDOT-168
~SCSIII-24	~FDOT-2	~FDOT-240

Non-Dimensional Rainfall Distributions

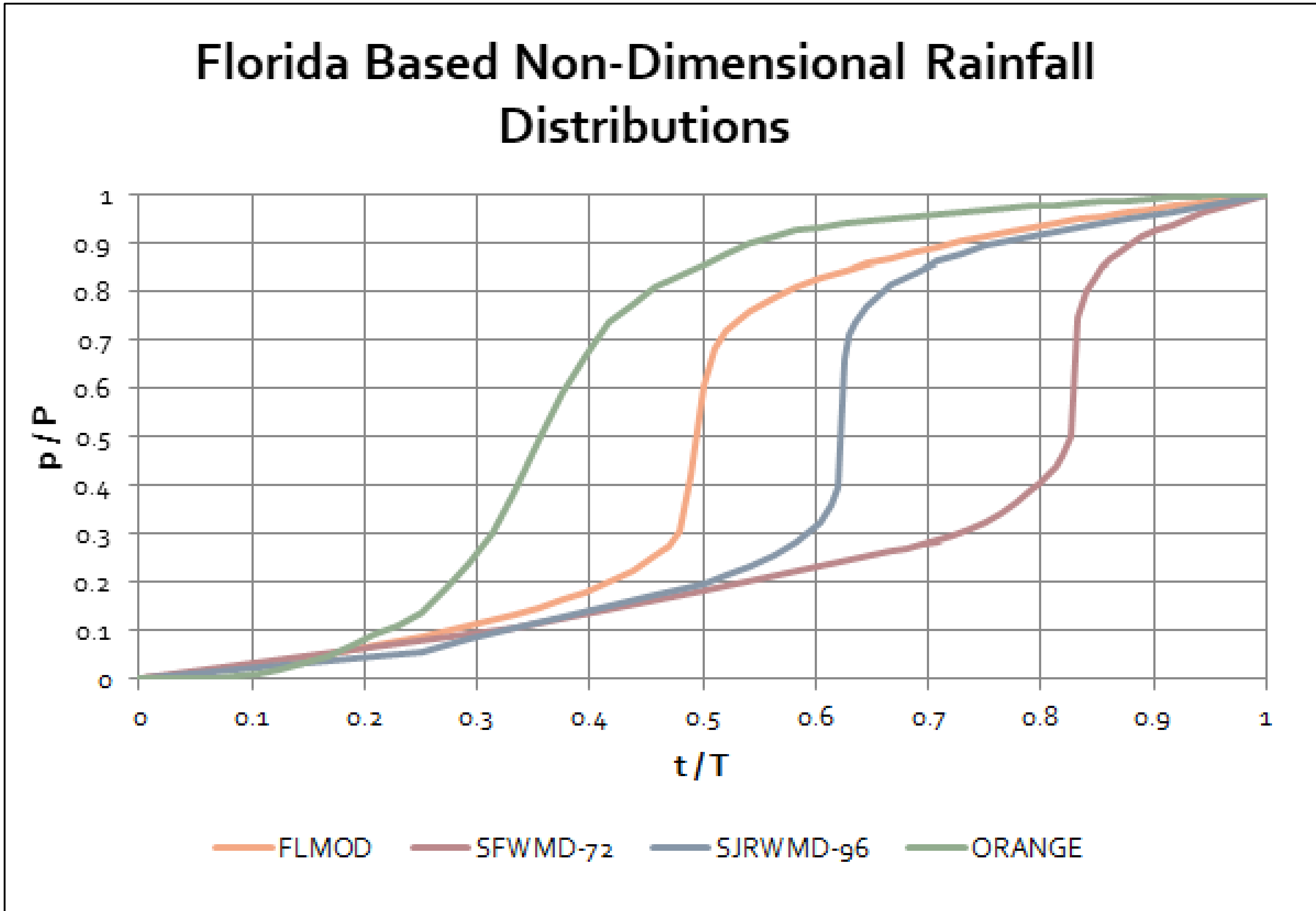


Non-Dimensional Rainfall Distributions

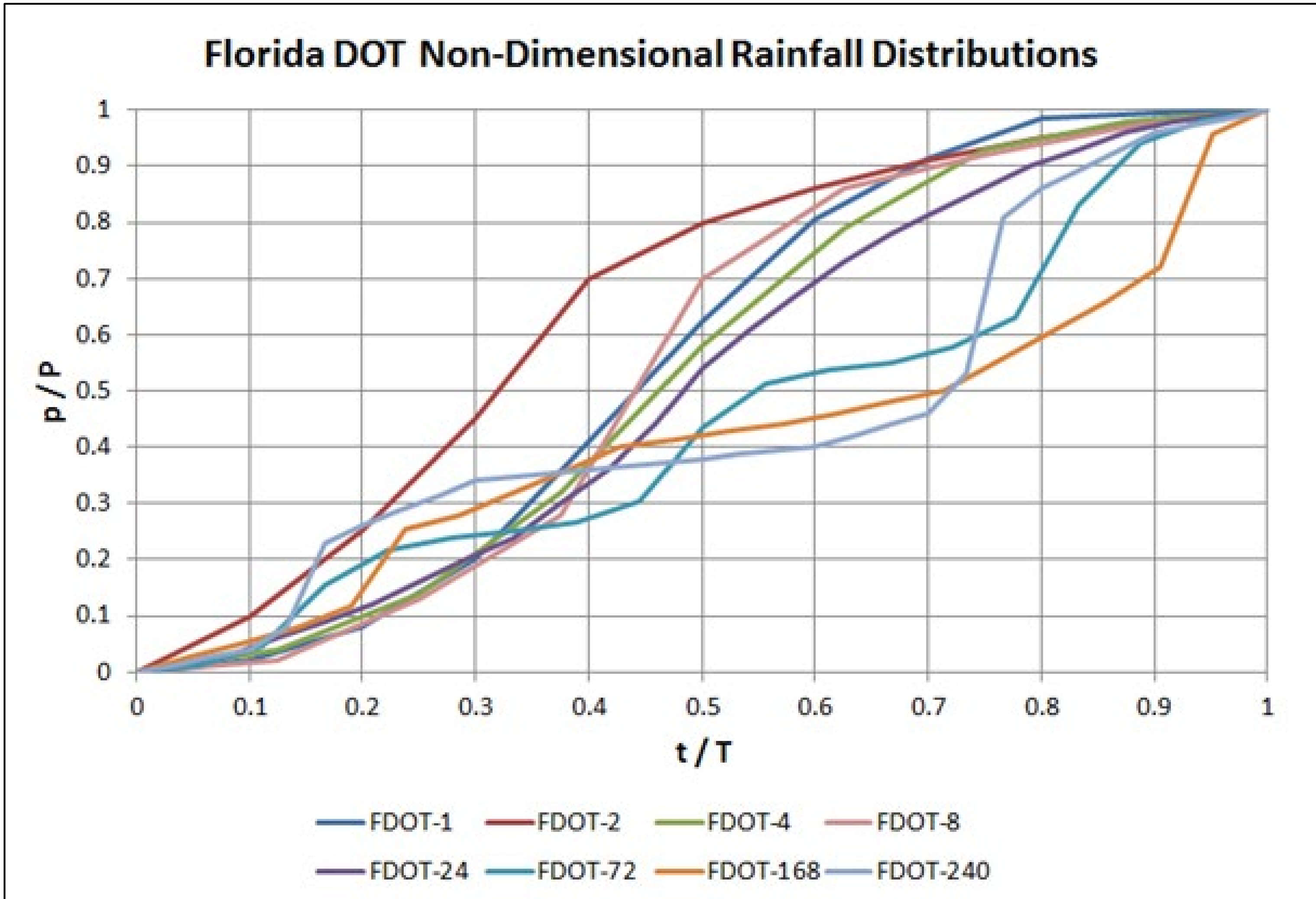
source: NRCS TR-55



Non-Dimensional Rainfall Distributions

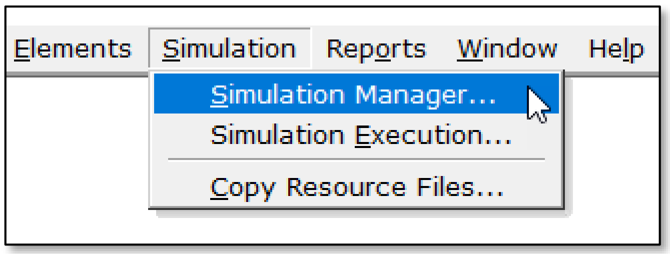


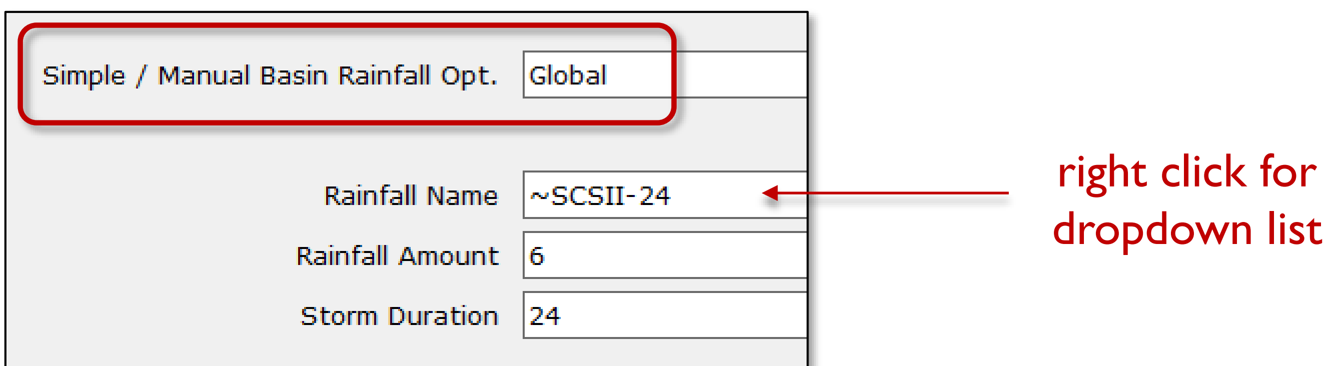
Non-Dimensional Rainfall Distributions



Non-Dimensional Rainfall Distributions

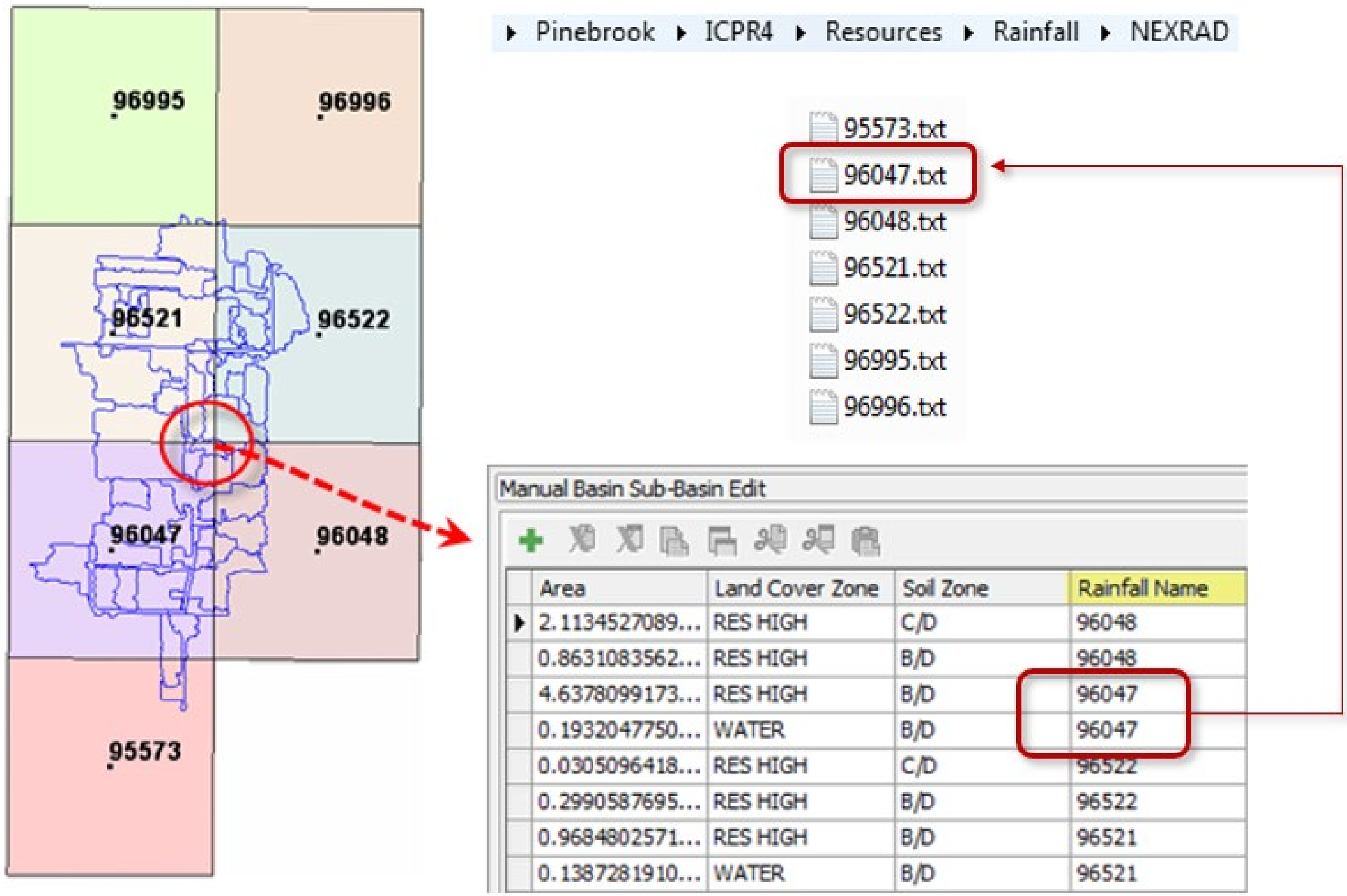
The rainfall distributions can be specified globally (i.e. for all basins) by setting the global rainfall data fields on the "Tolerances & Options" tab of the simulation manager.





Custom Rainfall Files

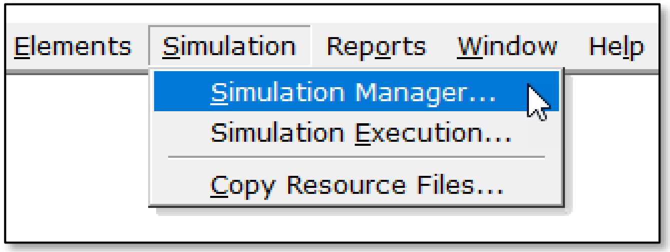
Text file (*.txt) can be created and placed in a sub-folder in the rainfall resources folder.

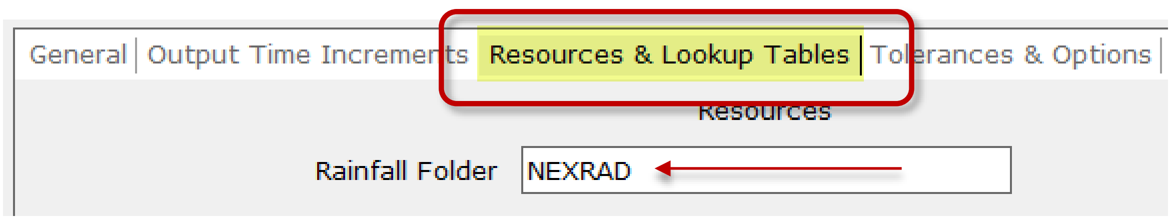


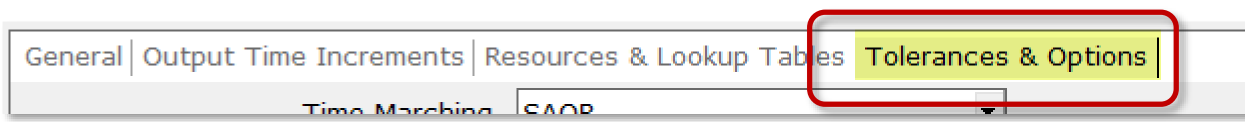
Area	Land Cover Zone	Soil Zone	Rainfall Name
2.1134527089...	RES HIGH	C/D	96048
0.8631083562...	RES HIGH	B/D	96048
4.6378099173...	RES HIGH	B/D	96047
0.1932047750...	WATER	B/D	96047
0.0305096418...	RES HIGH	C/D	96522
0.2990587695...	RES HIGH	B/D	96522
0.9684802571...	RES HIGH	B/D	96521
0.1387281910...	WATER	B/D	96521

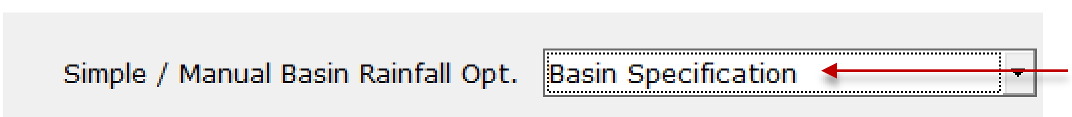
Custom Rainfall Files

The "rainfall folder" is specified on the "Resources & Lookup Tables" tab of the simulation manager.









Custom Rainfall Files

File Type	Description
0	Historical Data (English Units - inches)
1	Historical Data (Metric Units – millimeters)
2	Dimensionless Mass Curve (English Units – inches)
3	Dimensionless Mass Curve (Metric Units – millimeters)

File Type; Storm Duration; Total Rainfall; Dimensionless Time; Dimensionless Rainfall

```
2
24.0
10.6
0         0
0.0417    0.00046
0.0833    0.00178
0.125     0.00451
0.1667    0.0089
0.2083    0.02026
0.25      0.03573
0.2917    0.06157
0.3333    0.09602
0.375     0.14664
0.4167    0.21059
0.4583    0.29448
0.5       0.4392
0.5417    0.64992
0.5833    0.74509
0.625     0.82
0.6667    0.87693
0.7083    0.91918
0.75      0.95158
0.7917    0.97342
0.8333    0.98623
0.875     0.99406
0.9167    0.99717
0.9583    0.99905
1         1
END
```

File Type; Rainfall Packet Time Increment; Year; Month; Day; Hour; Rainfall Amount

```
0
60
2012    4    3     23.000   0.001
2012    4    6     6.000    0.002
2012    4    7     2.000    0.033
2012    4    7     3.000    0.911
2012    4    7     4.000    1.125
2012    4    7     5.000    0.566
2012    4    7     6.000    0.093
2012    4    18    16.000   0.035
2012    4    18    17.000   0.013
2012    4    18    18.000   0.006
2012    4    18    23.000   0.001
2012    4    19    9.000    0.015
2012    4    19    11.000   0.043
2012    4    19    16.000   0.192
2012    4    20    23.000   0.004
2012    4    21    0.000    0.002
2012    4    21    12.000   0.001
2012    4    21    13.000   0.001
2012    4    21    15.000   0.010
2012    4    21    17.000   0.012
2012    4    21    18.000   0.003
2012    4    21    19.000   0.005
2012    4    21    22.000   0.007
2012    4    21    23.000   0.010
2012    4    22    0.000    0.007
2012    4    22    1.000    0.050
2012    4    22    2.000    0.082
2012    4    22    3.000    0.194
2012    4    22    4.000    0.010
2012    4    22    8.000    0.010
2012    4    22    9.000    0.001
2012    4    22    11.000   0.003
END
```

Example #1

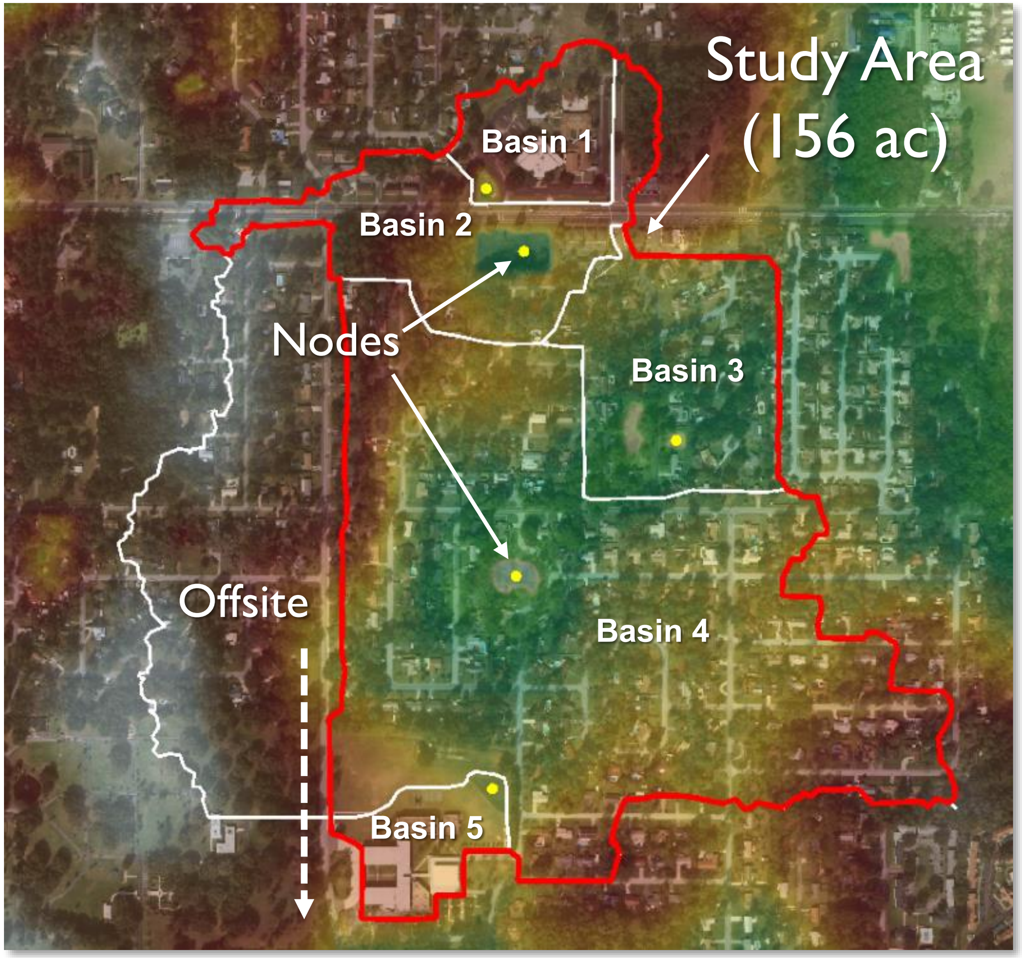
Land-Locked System

Project Setting

Basin Map Layer

This area is located in the City of Ocala and includes several land-locked basins with no outlets other than highwater overflows.

DCIA is very important for land-locked.

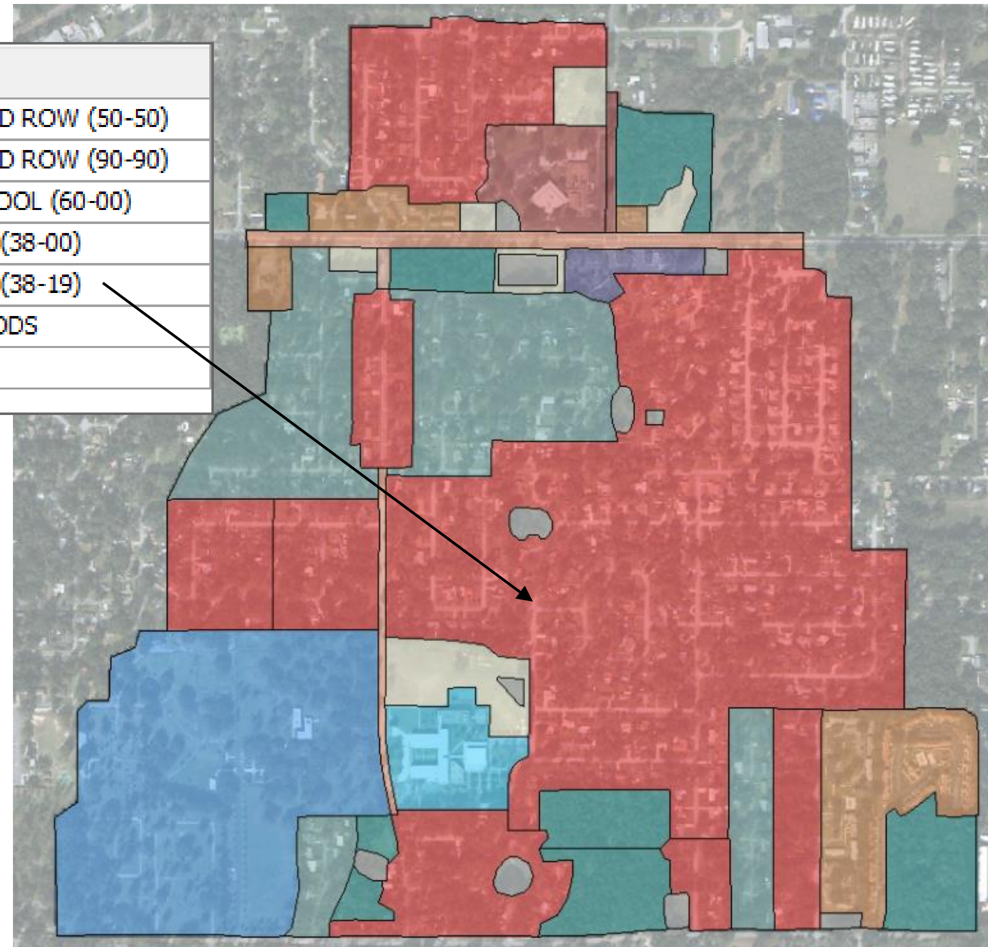


Project Setting

Land Cover Map Layer

Raster Legend

CEMETARY (10-00)	ROAD ROW (50-50)
CHURCH (50-10)	ROAD ROW (90-90)
COMMERCIAL (60-30)	SCHOOL (60-00)
COMMERCIAL (75-50)	SFR (38-00)
GRASS	SFR (38-19)
POND	WOODS
ROAD ROW (50-00)	



"SFR (38-19)"

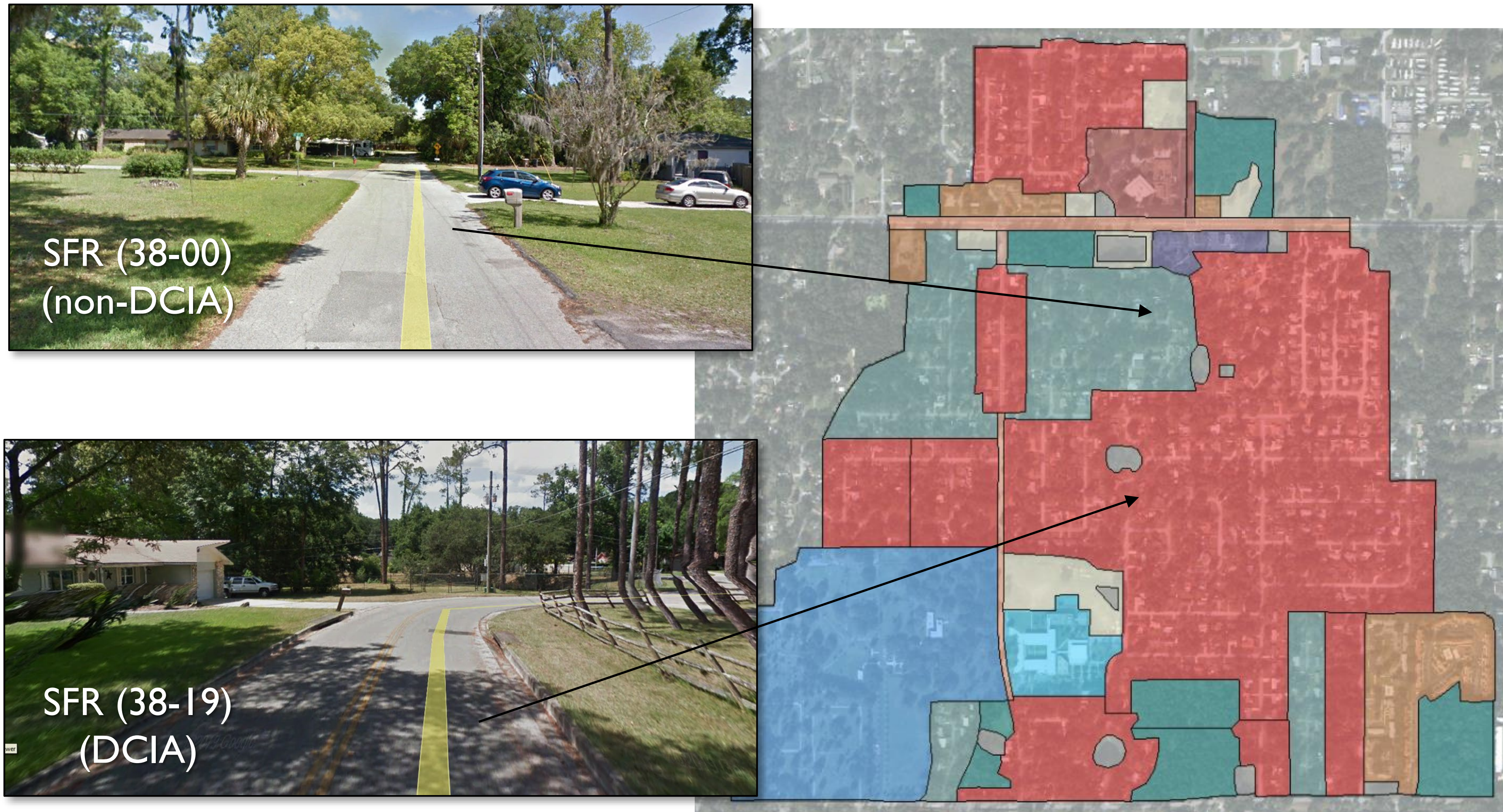
Single Family Residential

38% Total Impervious Area

19% DCIA

Project Setting

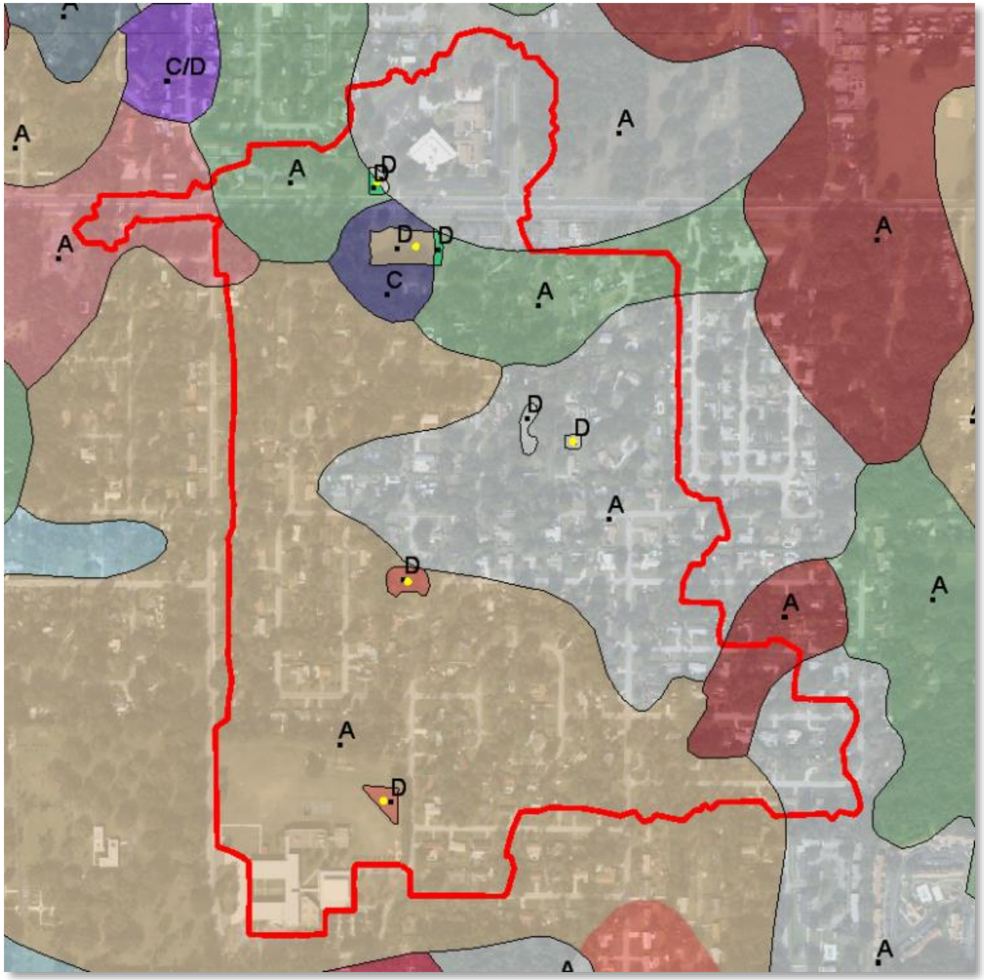
Land Cover Map Layer



Project Setting

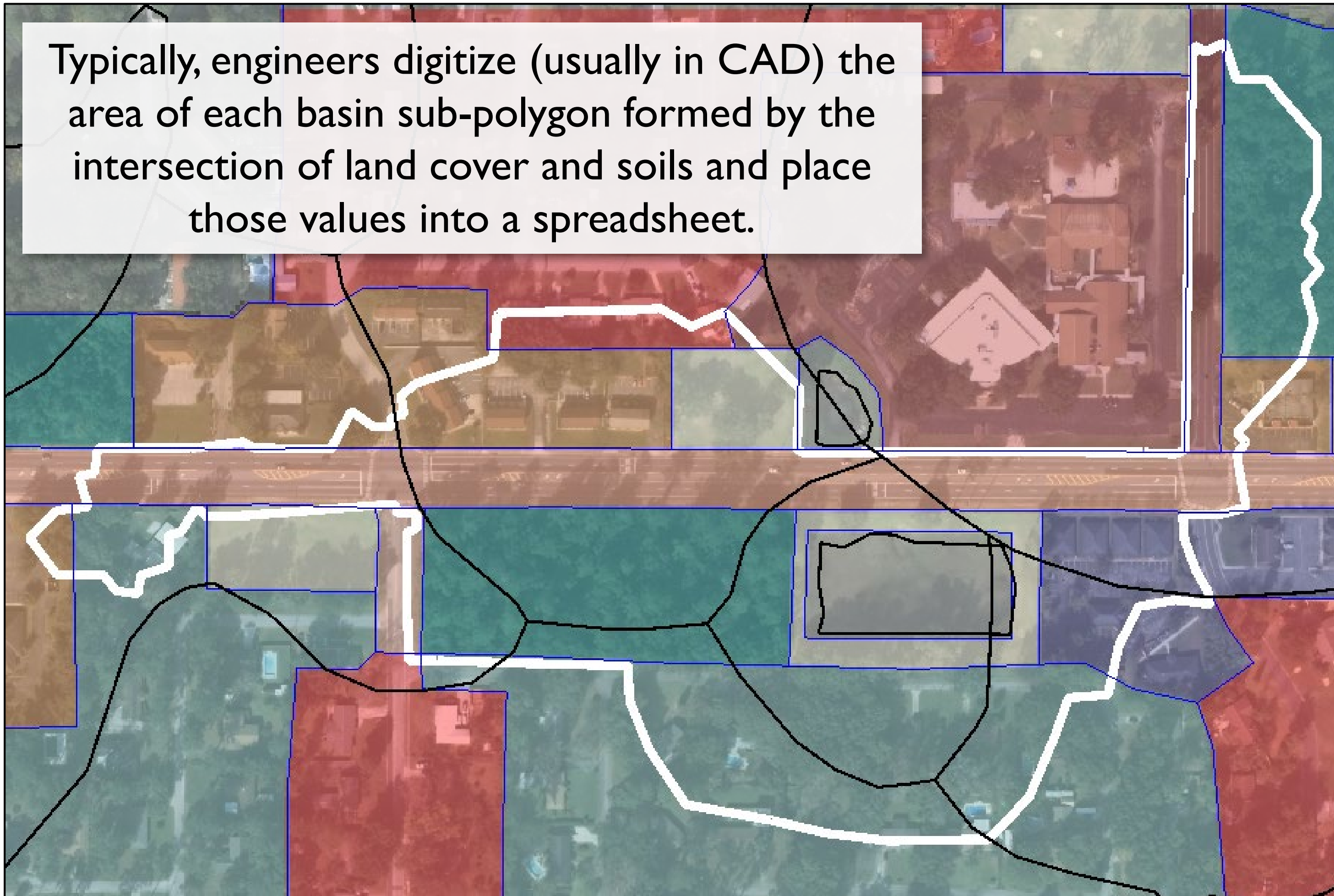
Soils Map Layer

If the CN method is to be used, then the hydrologic groups should be identified for each soil type.



Basin 2

Intersection with Land Cover & Soils



Lumped Approach Using Simple Basins

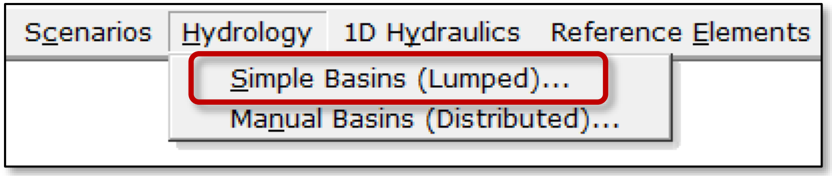
Curve Numbers – Area Weighted Average

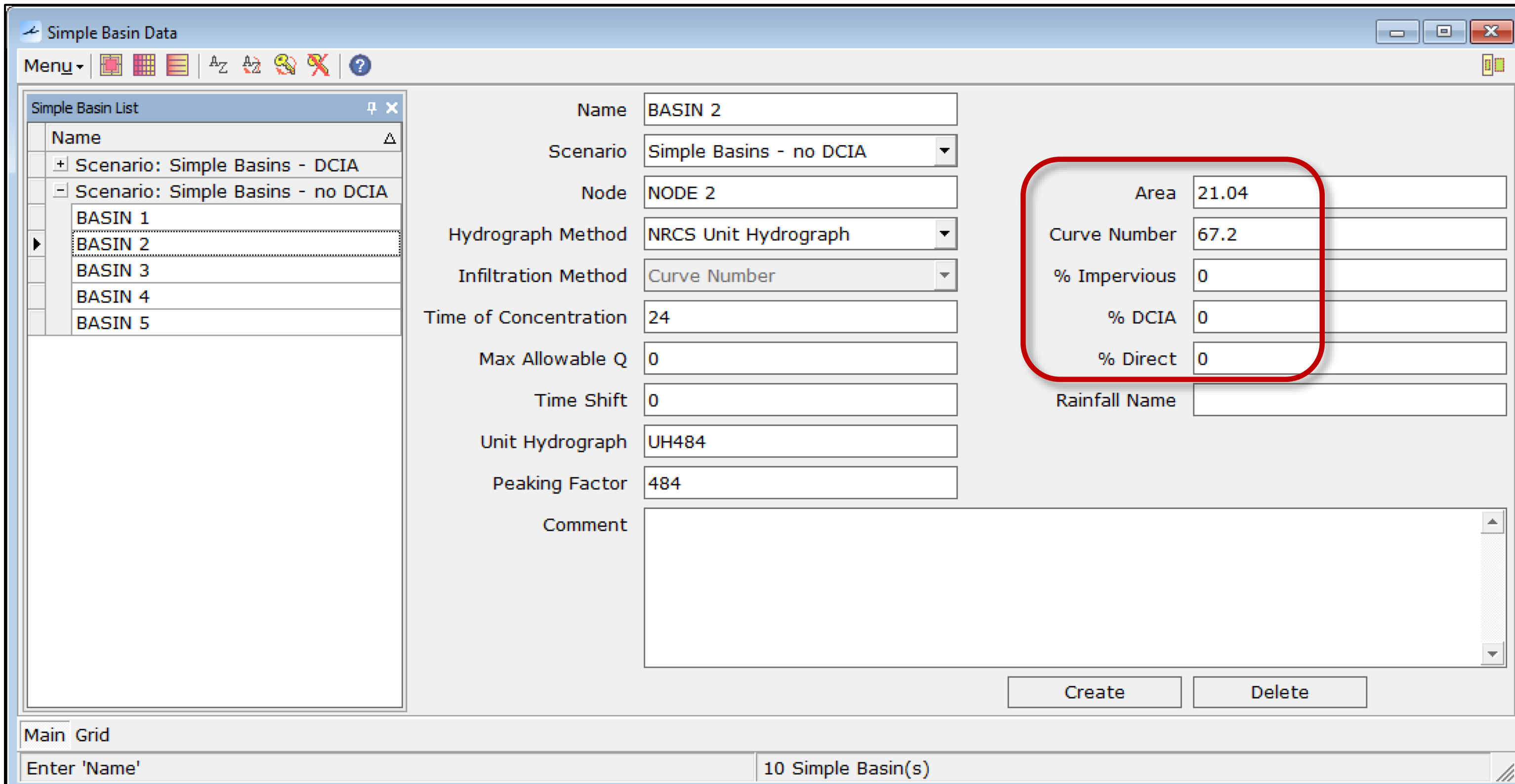
BASIN	AREA (ac)	LAND COVER	HSG	CN	%IMP	%DCIA	AREA (ac)	A x CN	A x %IMP	A x %DCIA
BASIN 2	3.19	SFR (38-00)	A	61	0	0		194.5	0.0	0.0
	1.28	SFR (38-00)	C	83	0	0		106.2	0.0	0.0
	1.17	COMMERCIAL (75-50)	A	81	0	0		94.9	0.0	0.0
	0.65	GRASS	C	74	0	0		48.2	0.0	0.0
	1.14	GRASS	A	39	0	0		44.3	0.0	0.0
	0.55	WOODS	C	70	0	0		38.3	0.0	0.0
	4.25	WOODS	A	30	0	0		127.6	0.0	0.0
	0.51	SFR (38-19)	A	61	0	0		31.2	0.0	0.0
	0.13	ROAD ROW (50-50)	A	69	0	0		9.0	0.0	0.0
	0.25	POND	C	98	0	0		[illegible]	0.0	0.0
	0.04	POND	A	98	0	0		3.5	0.0	0.0
	1.04	POND	D	98	0	0		102.2	0.0	0.0
	0.00	GRASS	D	80	0	0		0.3	0.0	0.0
	1.97	COMMERCIAL (60-30)	A	75	0	0		147.6	0.0	0.0
	3.71	ROAD ROW (90-90)	A	95	0	0		352.2	0.0	0.0
	0.32	ROAD ROW (90-90)	C	97	0	0		30.6	0.0	0.0
	0.82	ROAD ROW (50-00)	A	69	0	0		56.6	0.0	0.0
	0.03	CHURCH (50-10)	A	69	0	0		1.9	0.0	0.0
SUM	21.04							1413.3	0.0	0.0
AVG							**21.04**	**67.2**	**0.0**	**0.0**

impervious areas included in CNs

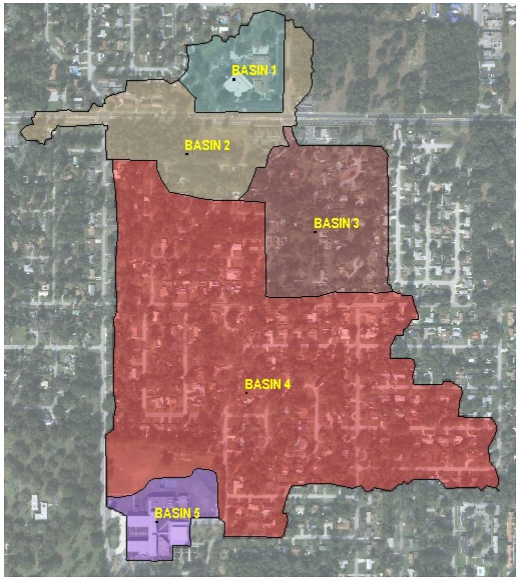
Typical Spreadsheet Supporting Calculation (external to ICPR)

Lumped Approach Using Simple Basins
Curve Numbers – Area Weighted Average

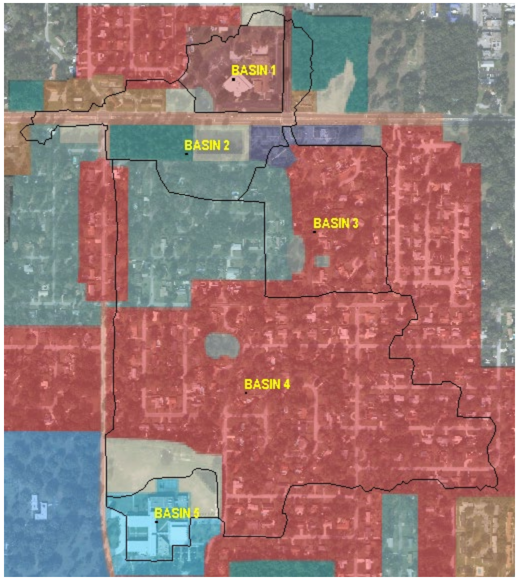




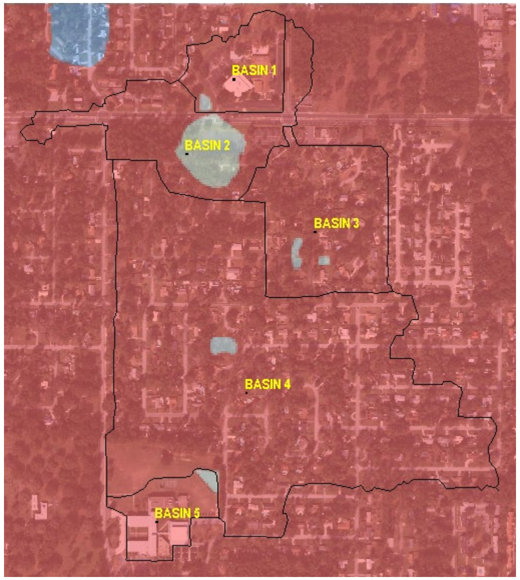
Distributed Approach Using Manual Basins
"Process Polygons" Tool



Basin Map Layer



Land Cover Map Layer

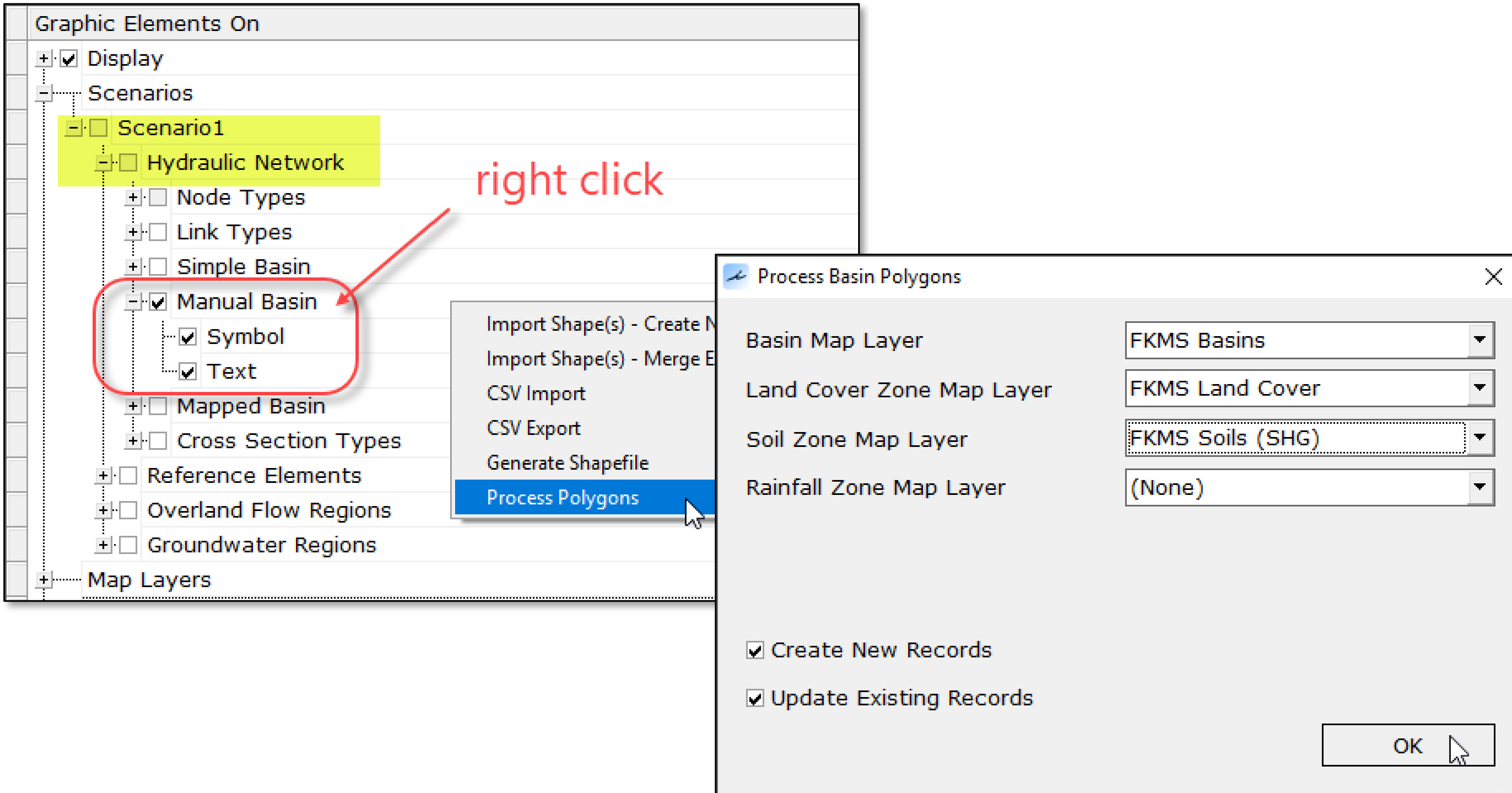


Soils Map Layer

Automatic Intersection of Map Layers

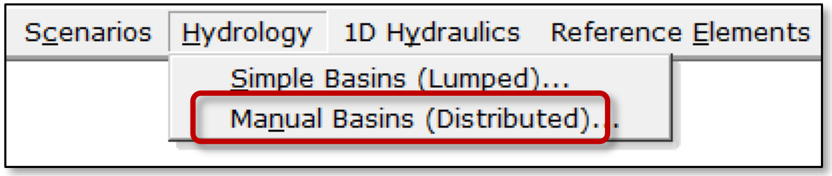
Distributed Approach Using Manual Basins

"Process Polygons" Tool

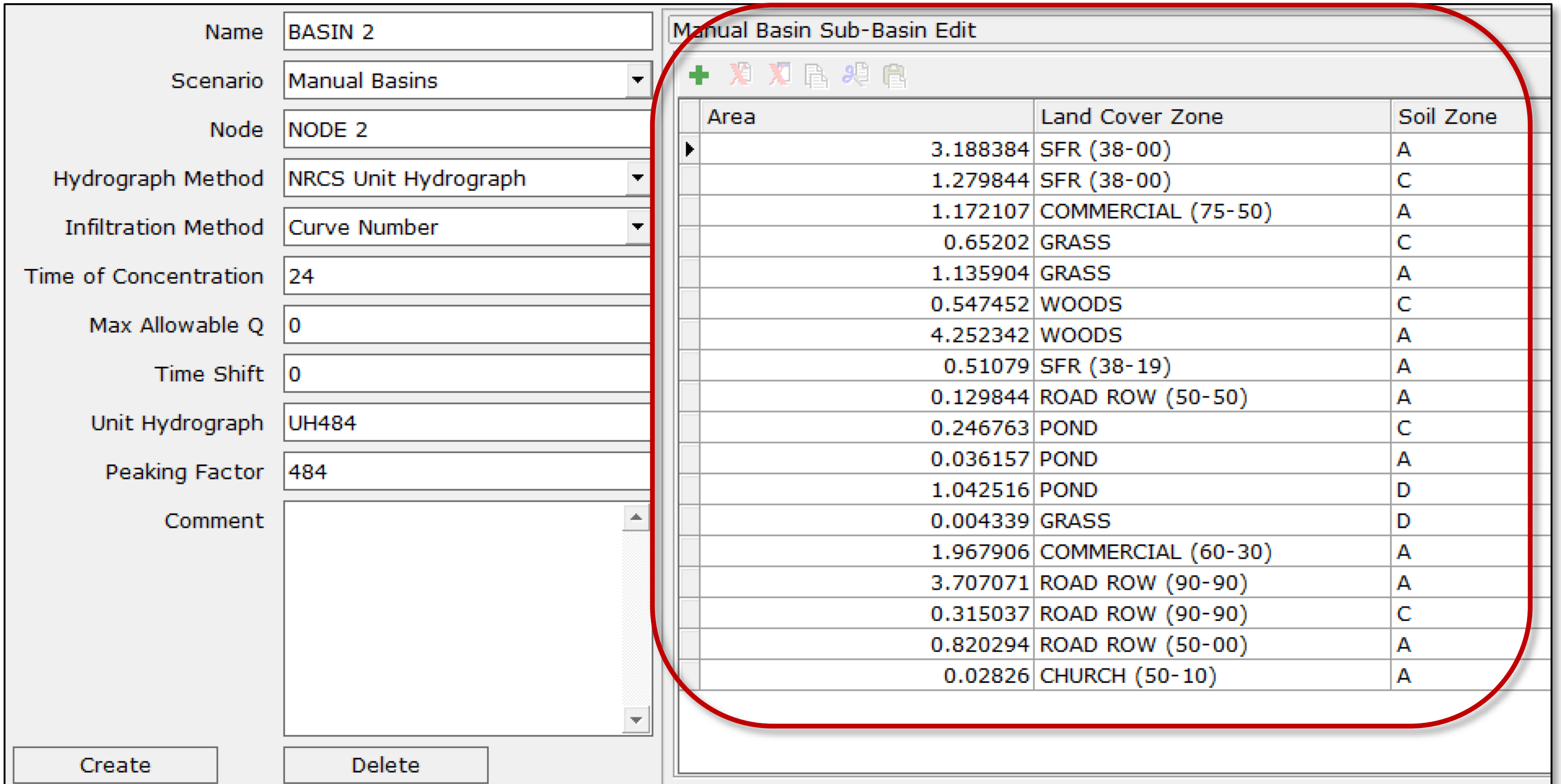


Distributed Approach Using Manual Basins

"Process Polygons" Tool



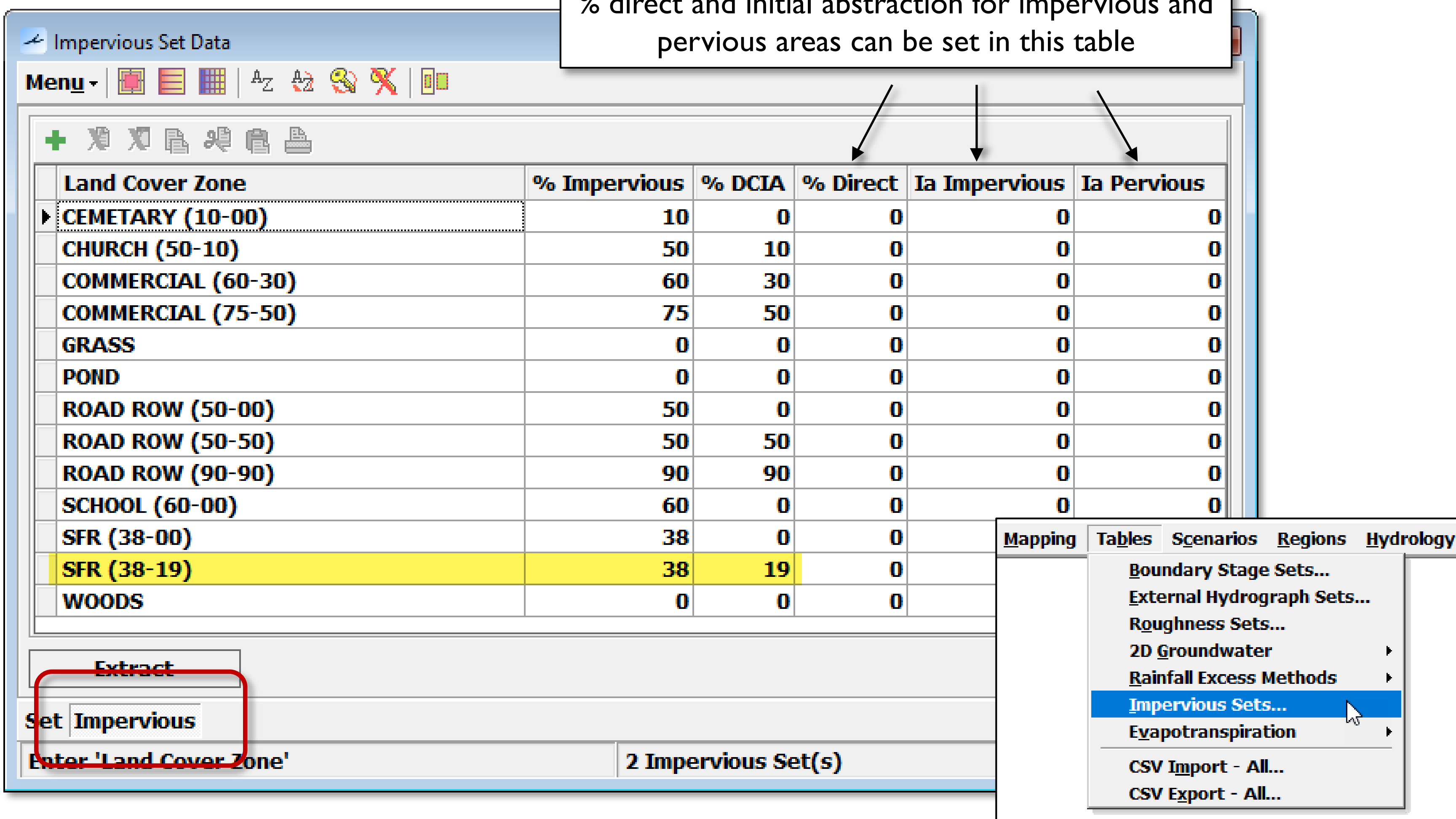
The sub-basin data are automatically populated for each basin. Impervious and curve number lookup tables are used to calculate runoff for each sub-basin before combining and applying TC and unit hydrograph.



Distributed Approach Using Manual Basins

Impervious Lookup Table

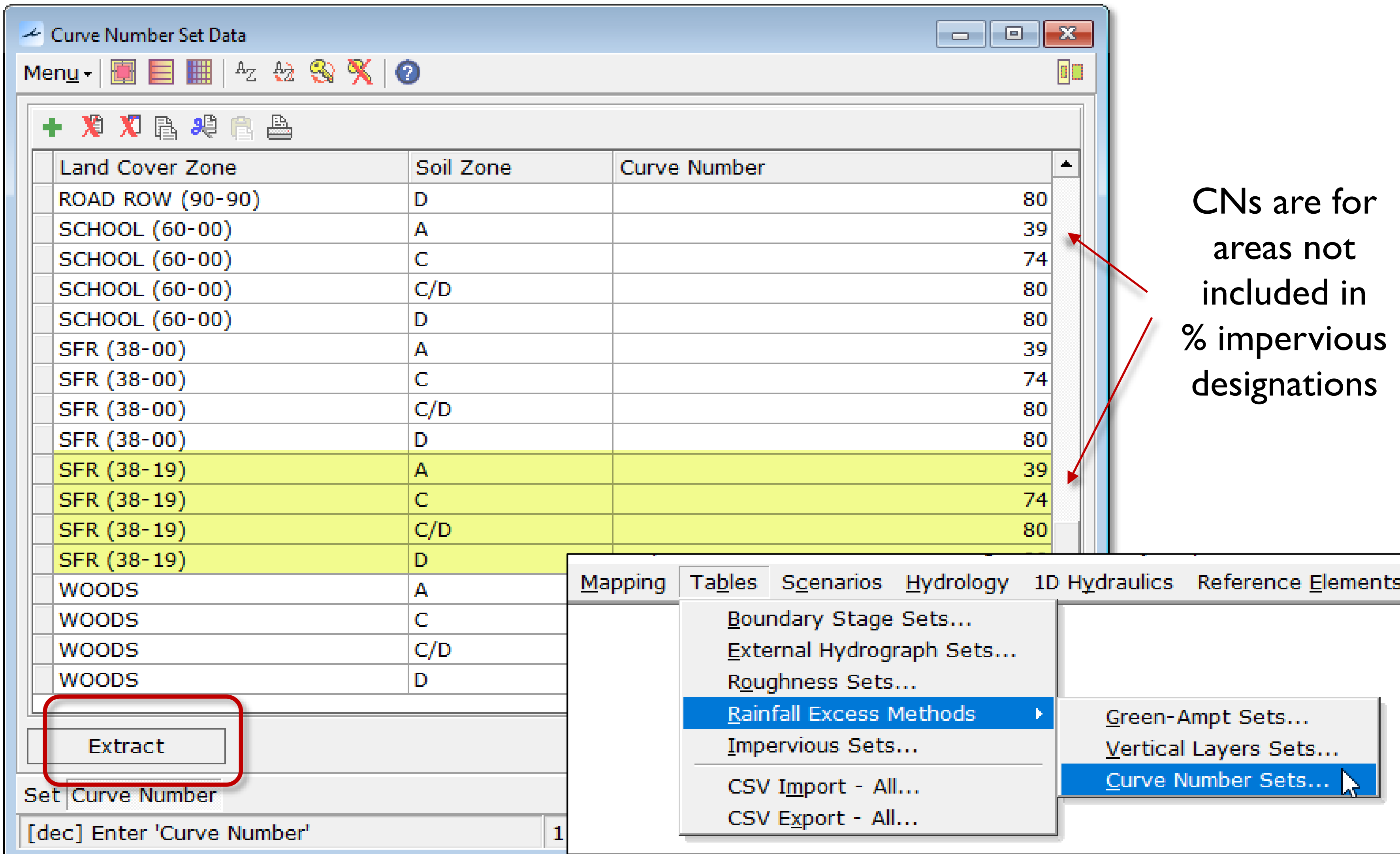
% direct and initial abstraction for impervious and pervious areas can be set in this table



Land Cover Zone	% Impervious	% DCIA	% Direct	Ia Impervious	Ia Pervious
CEMETARY (10-00)	10	0	0	0	0
CHURCH (50-10)	50	10	0	0	0
COMMERCIAL (60-30)	60	30	0	0	0
COMMERCIAL (75-50)	75	50	0	0	0
GRASS	0	0	0	0	0
POND	0	0	0	0	0
ROAD ROW (50-00)	50	0	0	0	0
ROAD ROW (50-50)	50	50	0	0	0
ROAD ROW (90-90)	90	90	0	0	0
SCHOOL (60-00)	60	0	0	0	0
SFR (38-00)	38	0	0		
SFR (38-19)	38	19	0		
WOODS	0	0	0		

Distributed Approach Using Manual Basins

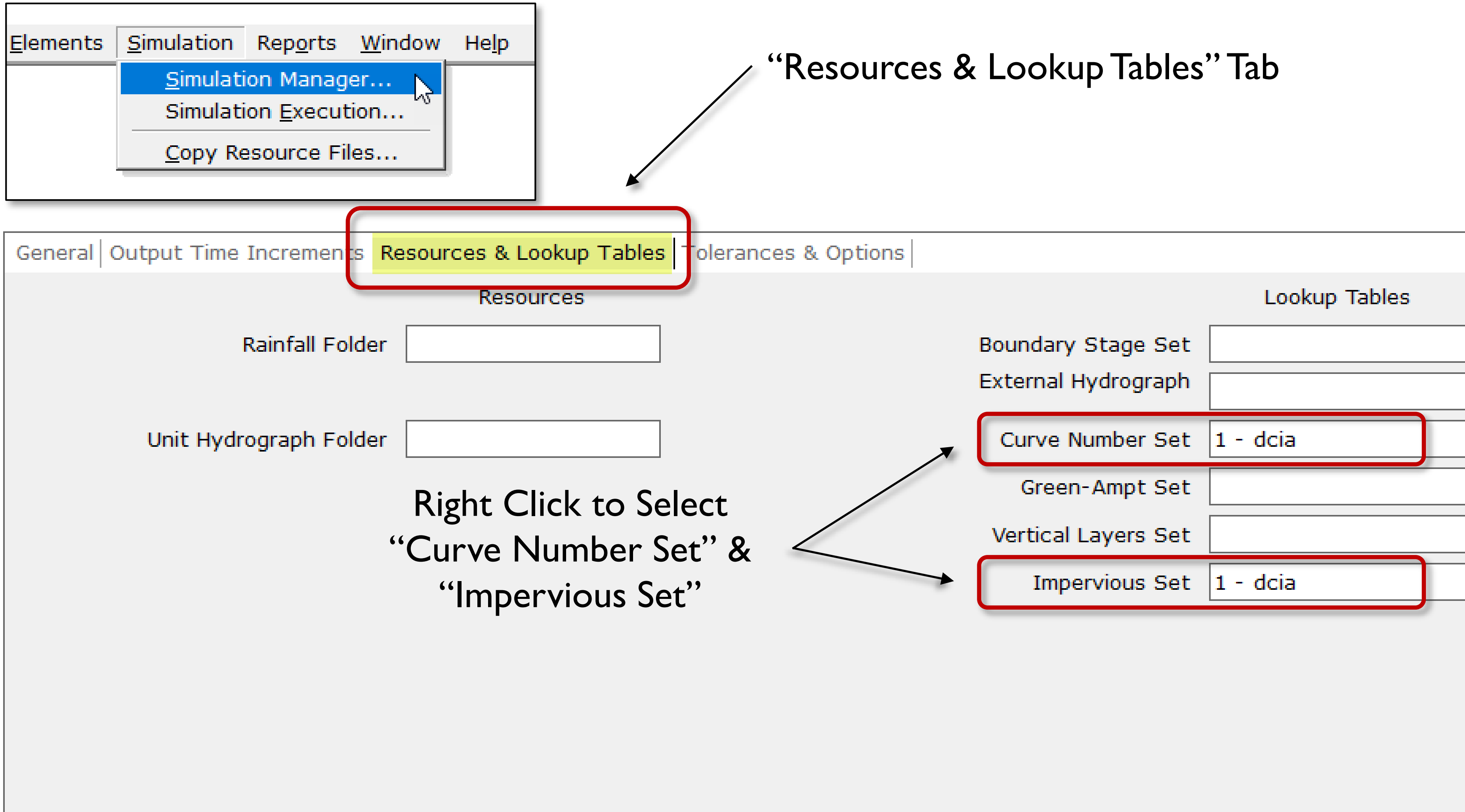
Curve Number Lookup Table



CNs are for areas not included in % impervious designations

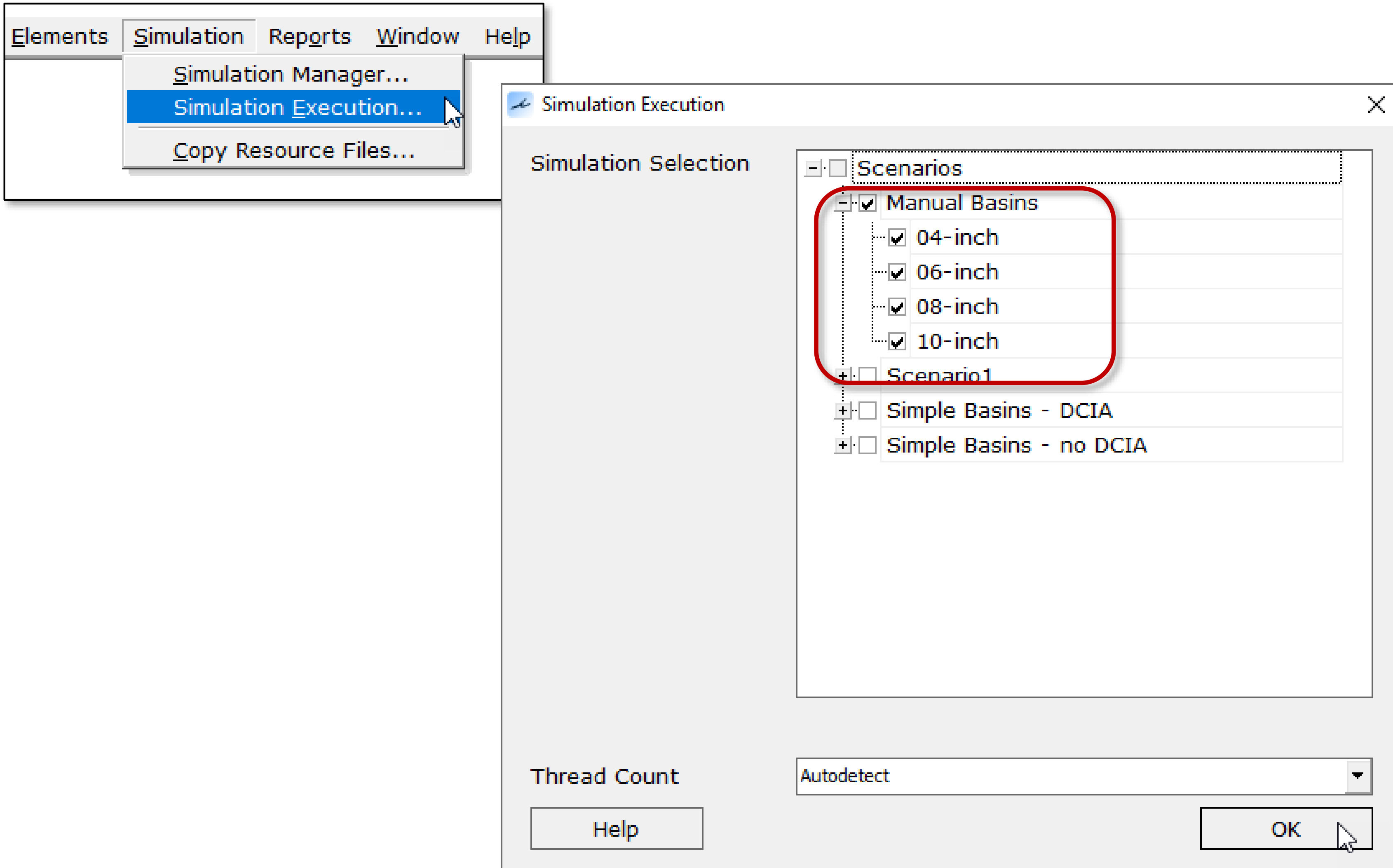
Connecting Lookup Tables to Simulations

Simulation Manager



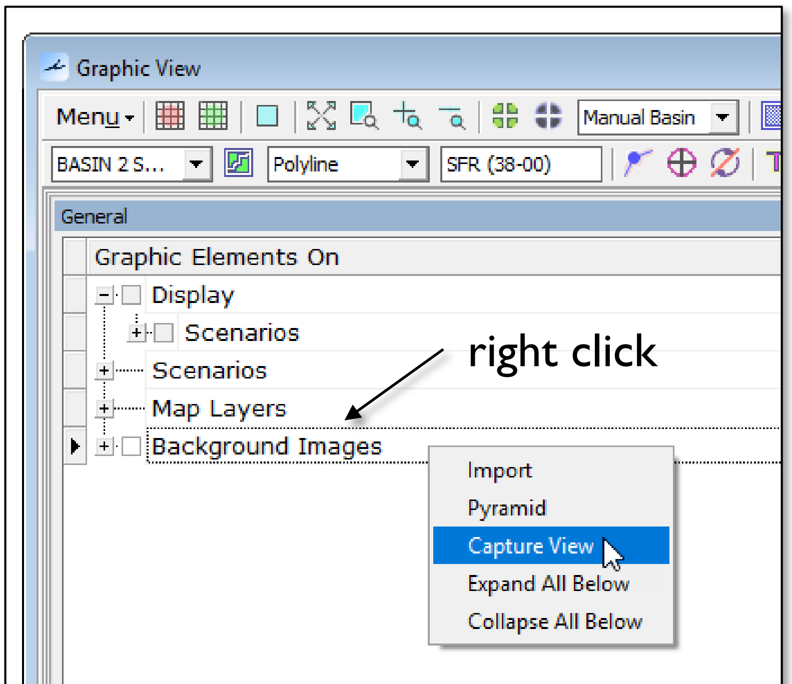
Executing Simulations

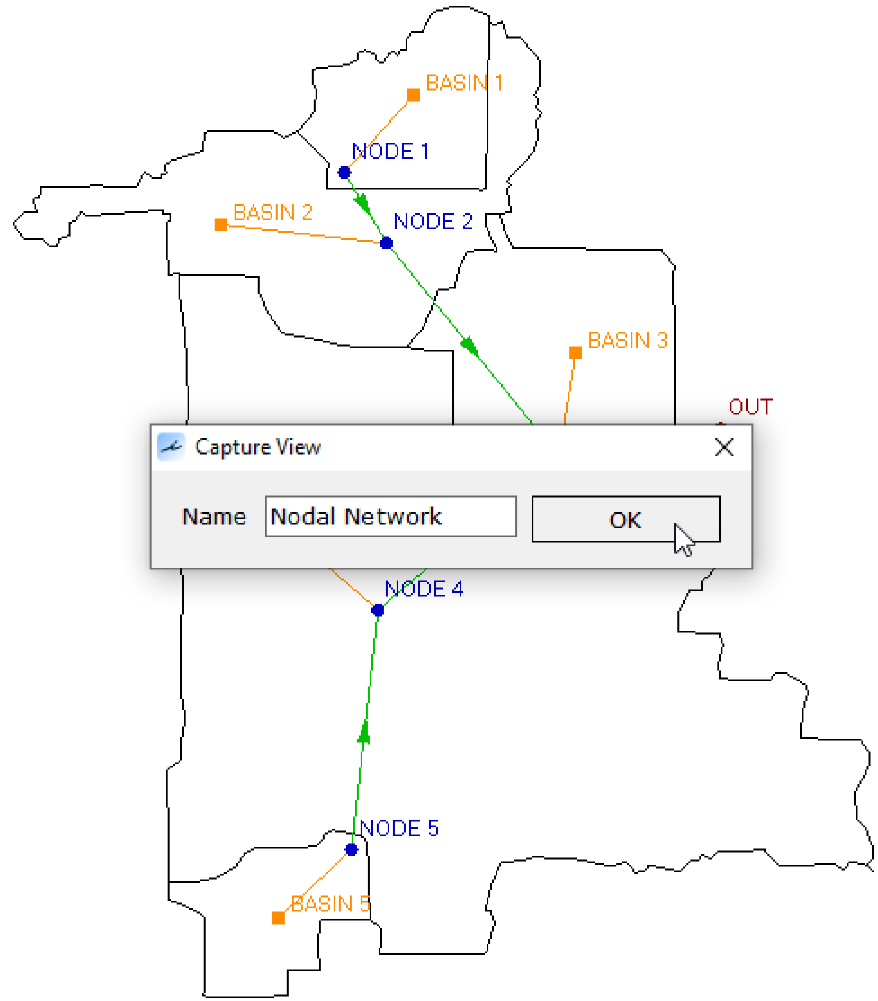
Simulation Execution



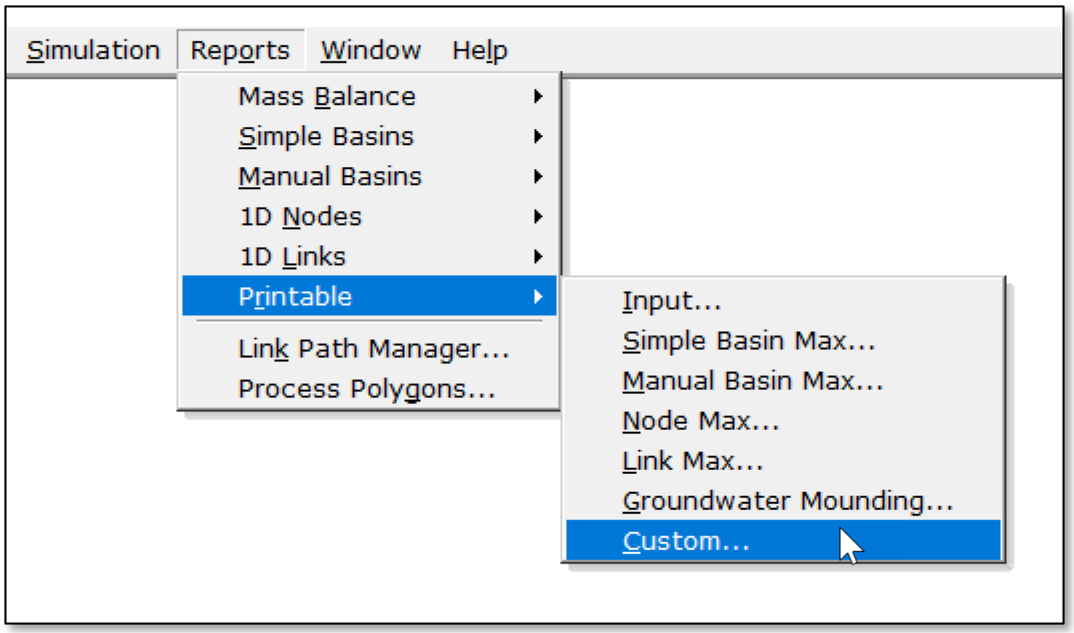
Incorporating Nodal Network into Reports

Capture View as Background Image

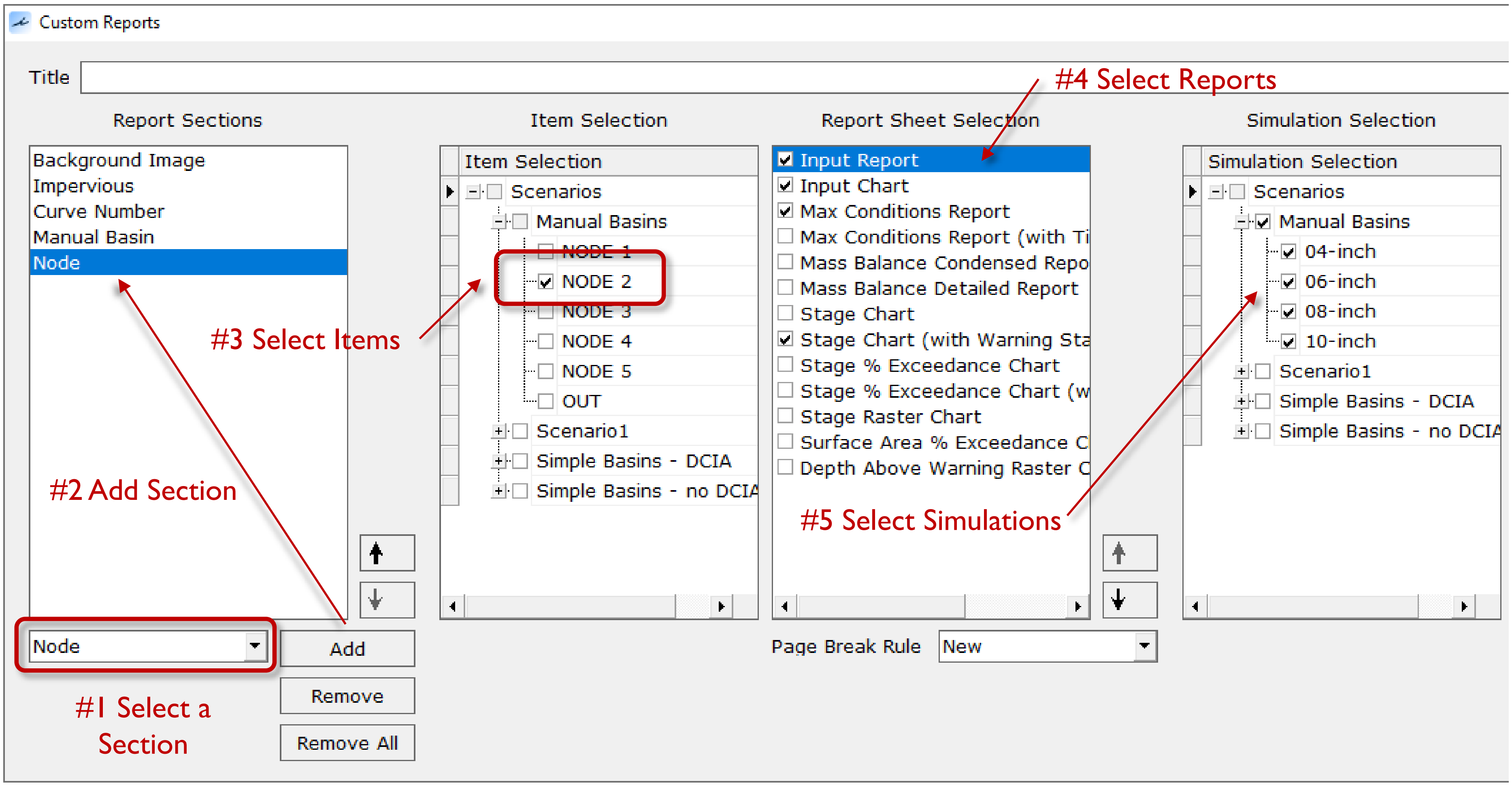




Custom Reports

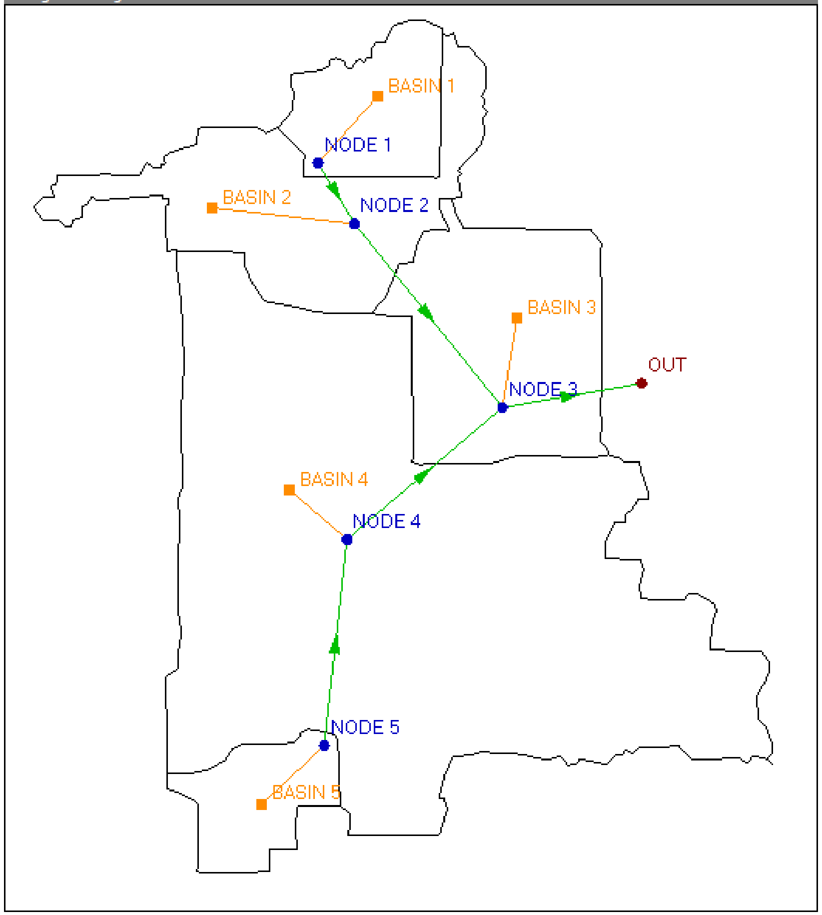


Custom Reports



Custom Reports

Background Image: Nodal Network



Nodal Network

Impervious: 1 - dcia [Set]

Land Cover Zone	% Impervious	% DCIA	% Direct	Ia Impervious [in]	Ia Pervious [in]
CEMETARY (10-00)	10.00	0.00	0.00	0.000	0.000
CHURCH (50-10)	50.00	10.00	0.00	0.000	0.000
COMMERCIAL (60-30)	60.00	30.00	0.00	0.000	0.000
COMMERCIAL (75-50)	75.00	50.00	0.00	0.000	0.000
GRASS	0.00	0.00	0.00	0.000	0.000
POND	0.00	0.00	0.00	0.000	0.000
ROAD ROW (50-00)	50.00	0.00	0.00	0.000	0.000
ROAD ROW (50-50)	50.00	50.00	0.00	0.000	0.000
ROAD ROW (90-90)	90.00	90.00	0.00	0.000	0.000
SCHOOL (60-00)	60.00	0.00	0.00	0.000	0.000
SFR (38-00)	38.00	0.00	0.00	0.000	0.000
SFR (38-19)	38.00	19.00	0.00	0.000	0.000
WOODS	0.00	0.00	0.00	0.000	0.000

Impervious Lookup Table

Custom Reports

3

Curve Number: 1 - dcia [Set]		
Land Cover Zone	**Soil Zone**	**Curve Number [dec]**
CEMETARY (10-00)	A	39.0
CEMETARY (10-00)	C	74.0
CEMETARY (10-00)	C/D	80.0
CEMETARY (10-00)	D	80.0
CHURCH (50-10)	A	39.0
CHURCH (50-10)	C	74.0
CHURCH (50-10)	C/D	80.0
CHURCH (50-10)	D	80.0
COMMERCIAL (60-30)	A	39.0
COMMERCIAL (60-30)	C	74.0
COMMERCIAL (60-30)	C/D	80.0
COMMERCIAL (60-30)	D	80.0
COMMERCIAL (75-50)	A	39.0
COMMERCIAL (75-50)	C	74.0
COMMERCIAL (75-50)	C/D	80.0
COMMERCIAL (75-50)	D	80.0
GRASS	A	39.0
GRASS	C	74.0
GRASS	C/D	80.0
GRASS	D	80.0
POND	A	98.0
POND	C	98.0
POND	C/D	98.0
POND	D	98.0
ROAD ROW (50-00)	A	39.0
ROAD ROW (50-00)	C	74.0
ROAD ROW (50-00)	C/D	80.0
ROAD ROW (50-00)	D	80.0
ROAD ROW (50-50)	A	39.0
ROAD ROW (50-50)	C	74.0
ROAD ROW (50-50)	C/D	80.0
ROAD ROW (50-50)	D	80.0
ROAD ROW (90-90)	A	39.0
ROAD ROW (90-90)	C	74.0
ROAD ROW (90-90)	C/D	80.0
ROAD ROW (90-90)	D	80.0
SCHOOL (60-00)	A	39.0
SCHOOL (60-00)	C	74.0
SCHOOL (60-00)	C/D	80.0
SCHOOL (60-00)	D	80.0
SFR (38-00)	A	39.0
SFR (38-00)	C	74.0
SFR (38-00)	C/D	80.0
SFR (38-00)	D	80.0
SFR (38-19)	A	39.0
SFR (38-19)	C	74.0
SFR (38-19)	C/D	80.0

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4

Land Cover Zone	Soil Zone	Curve Number [dec]
SFR (38-19)	D	80.0
WOODS	A	30.0
WOODS	C	55.0
WOODS	C/D	70.0
WOODS	D	77.0

Curve Number Lookup Table

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Custom Reports

Manual Basin: BASIN 2

Manual Basin Input Data

Scenario:	Manual Basins
Node:	NODE 2
Hydrograph Method:	NRCS Unit Hydrograph
Infiltration Method:	Curve Number
Time of Concentration:	24.0000 min
Max Allowable Q:	0.00 cfs
Time Shift:	0.0000 hr
Unit Hydrograph:	UH484
Peaking Factor:	484.0
Area:	21.0370 ac

Land Cover – Soil Breakdown

Area [ac]	Land Cover Zone	Soil Zone	Rainfall Name
3.1884	SFR (38-00)	A	
1.2798	SFR (38-00)	C	
1.1721	COMMERCIAL (75-50)	A	
0.6520	GRASS	C	
1.1359	GRASS	A	
0.5475	WOODS	C	
4.2523	WOODS	A	
0.5108	SFR (38-19)	A	
0.1298	ROAD ROW (50-50)	A	
0.2468	POND	C	
0.0362	POND	A	
1.0425	POND	D	
0.0043	GRASS	D	
1.9679	COMMERCIAL (60-30)	A	
3.7071	ROAD ROW (90-90)	A	
0.3150	ROAD ROW (90-90)	C	
0.8203	ROAD ROW (50-00)	A	
0.0283	CHURCH (50-10)	A	

Comment:

Manual Basin Runoff Summary [Manual Basins]

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
BASIN 2	04-inch	25.17	12.0833	4.00	1.51	21.0370	72.8	38.32	23.58
BASIN 2	06-inch	44.34	12.0833	6.00	2.61	21.0370	67.9	38.32	23.58
BASIN 2	08-inch	66.94	12.0833	8.00	3.89	21.0370	65.0	38.32	23.58
BASIN 2	10-inch	92.57	12.0833	10.00	5.30	21.0370	63.0	38.32	23.58

Manual Basin Runoff Summary

Node: NODE 2

Node Input Data

Scenario:	Manual Basins
Type:	Stage/Area
Base Flow:	0.00 cfs
Initial Stage:	85.09 ft
Warning Stage:	93.60 ft

Stage – Area Table

Stage [ft]	Area [ac]	Area [ft2]
85.09	0.0006	25
85.20	0.0007	30
85.40	0.0009	39
85.60	0.0011	49
85.80	0.0031	133
86.00	0.0040	174
86.20	0.0126	550
86.40	0.0344	1500
86.60	0.0861	3750
86.80	0.1768	7700
87.00	0.3237	14100
87.20	0.4568	19900
87.40	0.5642	24575
87.60	0.6858	29875
87.80	0.7868	34275
88.00	0.8936	38925
88.20	0.9716	42325
88.40	1.0359	45125
88.60	1.0795	47025
88.80	1.1186	48725
89.00	1.1559	50350
89.20	1.1886	51775
89.40	1.2207	53175
89.60	1.2397	54000
89.80	1.2557	54700
90.00	1.2741	55500
90.20	1.2956	56435
90.40	1.3120	57150
90.60	1.3275	57825
90.80	1.3493	58775
91.00	1.3642	59425
91.20	1.3843	60300
91.40	1.4067	61275
91.60	1.4262	62125
91.80	1.4486	63100
92.00	[illegible]	64325
92.20	1.5042	65525
92.40	1.5266	66500
92.60	1.5674	68275
92.80	1.6265	70850
93.00	1.6896	73600
93.20	1.7717	77175

Custom Reports

7

Stage [ft]	Area [ac]	Area [ft2]
93.40	1.9043	82950
93.60	2.0564	89575
93.80	2.2584	98375
94.00	2.5052	109125
94.20	2.7606	120250
94.40	3.0676	133625
94.60	3.3924	147775
94.80	3.7397	162900
95.00	4.0680	177200
95.20	4.3796	190775
95.40	4.6654	203225
95.60	4.8841	212750
95.80	5.0786	221225
96.00	5.2732	229700
96.20	5.4195	236075
96.40	5.5762	242900
96.60	5.7478	250375
96.80	5.8833	256275
97.00	[illegible]	261450
[illegible]	[illegible]	267125
[illegible]	6.2489	272200
97.60	6.3631	277175
97.80	[illegible]	281600
98.00	6.5393	284850
98.20	6.6024	287600
98.40	6.6334	288950
98.60	6.6626	290225
98.80	6.6816	291050
99.00	6.6937	291576
99.20	6.6937	291576

Stage – Area Table (cont')

Comment:

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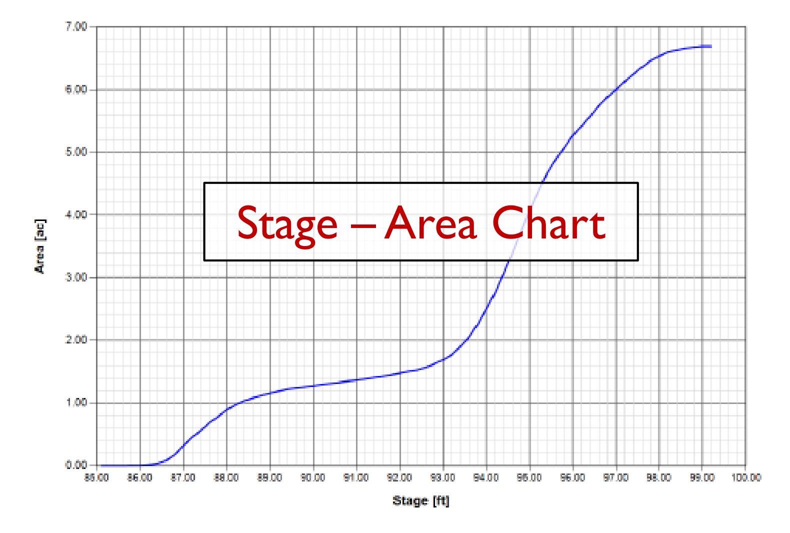
8

Node: NODE 2 Scenario: Manual Basins



Node Max Conditions [Manual Basins]

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]
NODE 2	04-inch	93.60	89.73	0.0010	25.17	0.00	54463
NODE 2	06-inch	93.60	91.52	0.0010	44.34	0.00	61804
NODE 2	08-inch	93.60	93.55	0.0010	66.94	0.00	87756
NODE 2	10-inch	93.60	93.86	0.0010	124.53	5.20	101831

Node Max Conditions

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Custom Reports

7

Stage [ft]	Area [ac]	Area [ft2]
98.60	6.6626	290225
98.80	6.6816	291050
99.00	6.6937	291576
99.20	6.6937	291576

Comment:

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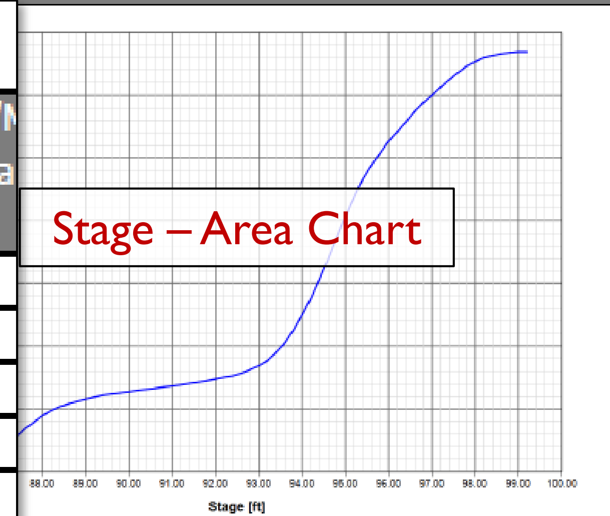
Node Max Conditions [Manual Basins]

Node Name	Sim Name	Warning Stage [ft]	Max Stage [ft]	Min/M Delta [ft]
NODE 2	04-inch	93.60	89.73	
NODE 2	06-inch	93.60	91.52	
NODE 2	08-inch	93.60	93.55	
NODE 2	10-inch	93.60	93.86	

8

Node: NODE 2 Scenario: Manual Basins



Stage – Area Chart

Node Max Conditions [Manual Basins]

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]
NODE 2	04-inch	93.60	89.73	0.0010	25.17	0.00	54463
NODE 2	06-inch	93.60	91.52	0.0010	44.34	0.00	61804
NODE 2	08-inch	93.60	93.55	0.0010	66.94	0.00	87756
NODE 2	10-inch	93.60	93.86	0.0010	124.53	5.20	101831

Node Max Conditions

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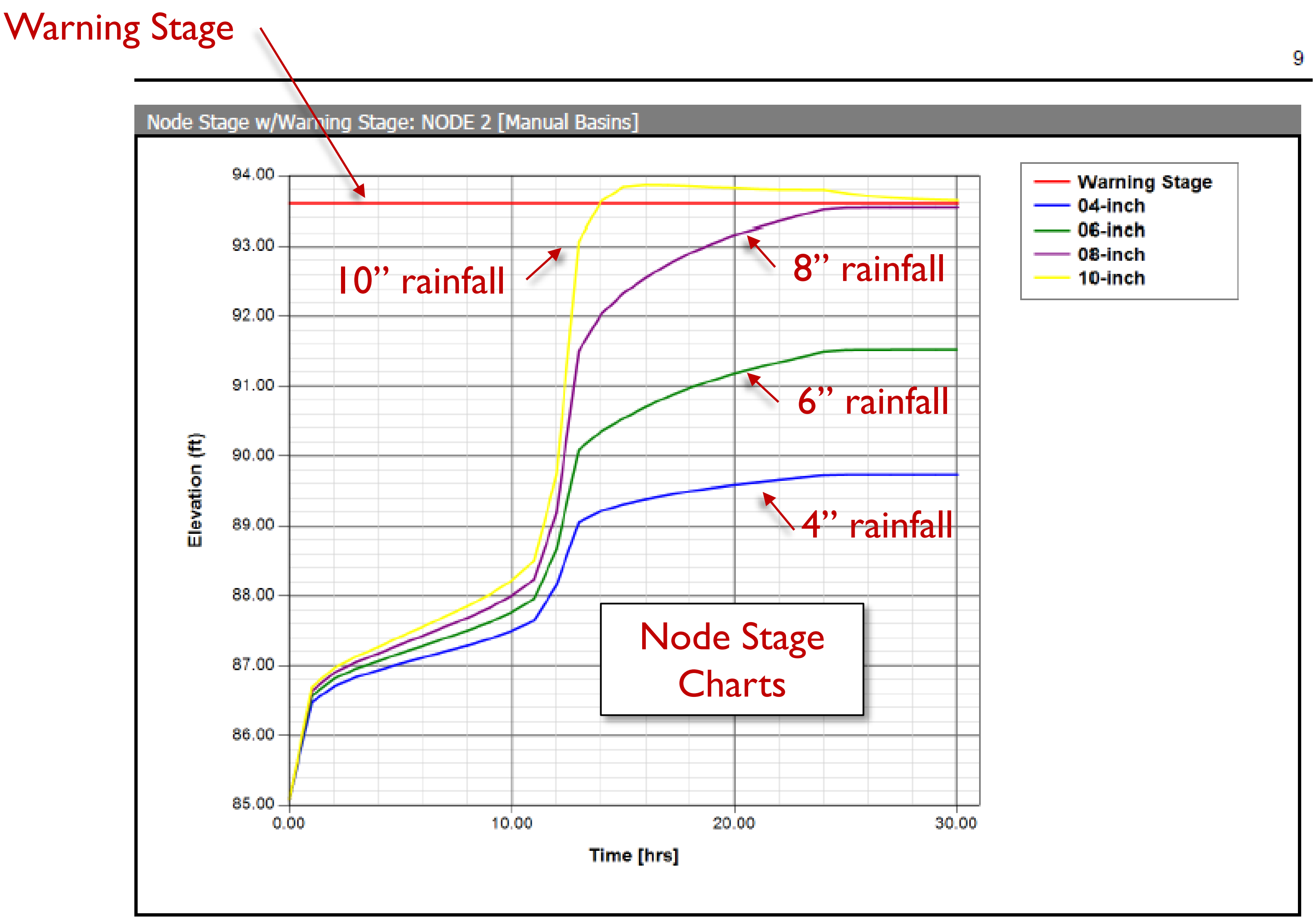
Custom Reports

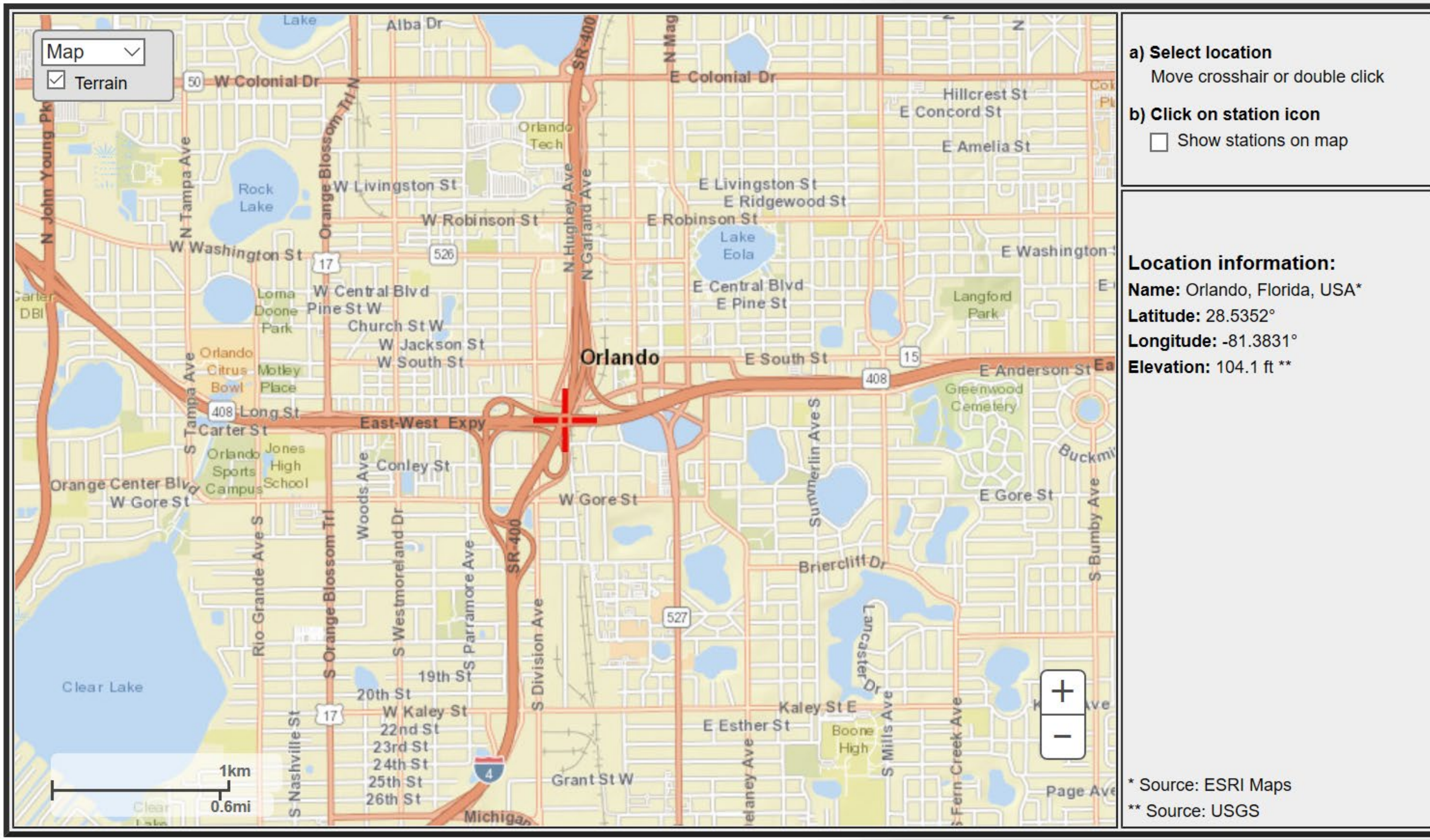


Example #2

NOAA Atlas 14

FDOT Critical Storm Analysis

NOAA Atlas 14



NOAA Atlas 14

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

NOAA Atlas 14, Volume 9, Version 2

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.456** (0.385-0.545)	**0.527** (0.445-0.632)	**0.639** (0.538-0.769)	**0.726** (0.607-0.879)	**0.838** (0.667-1.05)	**0.918** (0.713-1.18)	**0.993** (0.741-1.32)	**1.06** (0.754-1.47)	**1.15** (0.778-1.65)	**1.20** (0.795-1.79)
10-min	**0.667** (0.564-0.799)	**0.772** (0.652-0.926)	**0.936** (0.787-1.13)	**1.06** (0.888-1.29)	**1.23** (0.977-1.54)	**1.34** (1.05-1.72)	**1.45** (1.08-1.93)	**1.56** (1.10-2.15)	**1.68** (1.14-2.42)	**1.76** (1.17-2.62)
15-min	**0.814** (0.688-0.974)	**0.942** (0.796-1.13)	**1.14** (0.960-1.37)	**1.30** (1.08-1.57)	**1.50** (1.19-1.87)	**1.64** (1.27-2.10)	**1.77** (1.32-2.36)	**1.90** (1.35-2.63)	**2.05** (1.39-2.95)	**2.15** (1.42-3.20)
30-min	**1.39** (1.18-1.66)	**1.59** (1.34-1.90)	**1.90** (1.60-2.28)	**2.14** (1.79-2.59)	**2.45** (1.96-3.07)	**2.68** (2.08-3.44)	**2.89** (2.16-3.84)	**3.09** (2.19-4.28)	**3.33** (2.26-4.81)	**3.50** (2.31-5.21)
60-min	**1.86** (1.58-2.23)	**2.14** (1.81-2.57)	**2.57** (2.16-3.10)	**2.91** (2.43-3.52)	**3.34** (2.66-4.18)	**3.65** (2.83-4.67)	**3.93** (2.93-5.23)	**4.20** (2.98-5.81)	**4.52** (3.07-6.52)	**4.74** (3.13-7.05)
2-hr	**2.34** (1.99-2.78)	**2.70** (2.29-3.21)	**3.25** (2.75-3.88)	**3.68** (3.09-4.42)	**4.22** (3.39-5.25)	**4.61** (3.61-5.87)	**4.97** (3.73-6.56)	**5.31** (3.79-7.30)	**5.71** (3.90-8.17)	**5.98** (3.97-8.84)
60-day	**18.7** (17.0-20.8)	**20.7** (18.7-23.0)	**23.7** (21.4-26.5)	**26.0** (23.3-29.3)	**29.0** (24.8-33.7)	**31.0** (25.9-37.0)	**32.9** (26.4-40.7)	**34.6** (26.4-44.6)	**36.6** (26.6-49.1)	**37.8** (26.8-52.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipita... uration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not ... recipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: Precipitation frequency estimates | Submit

csv file export

NOAA Atlas 14

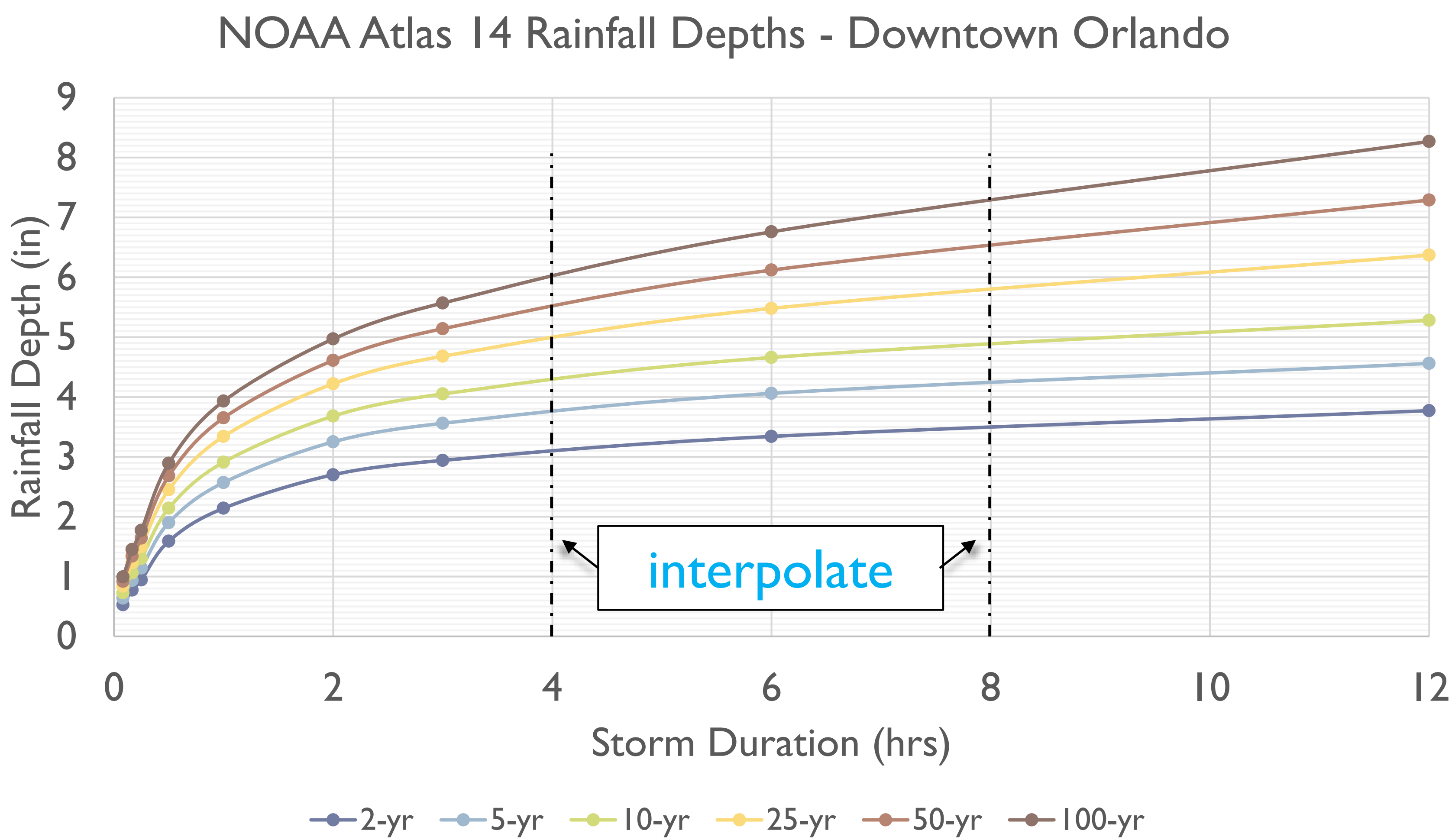
FDOT Critical Storm Analysis

PRECIPITATION FREQUENCY ESTIMATES										
by duration for ARI (years):	1	2	5	10	25	50	100	200	500	1000
5-min:	0.456	0.527	0.639	0.726	0.838	0.918	0.993	1.06	1.15	1.2
10-min:	0.667	0.772	0.936	1.06	1.23	1.34	1.45	1.56	1.68	1.76
15-min:	0.814	0.942	1.14	1.3	1.5	1.64	1.77	1.9	2.05	2.15
30-min:	1.39	1.59	1.9	2.14	2.45	2.68	2.89	3.09	3.33	3.5
60-min:	1.86	2.14	2.57	2.91	3.34	3.65	3.93	4.2	4.52	4.74
2-hr:	2.34	2.7	3.25	3.68	4.22	4.61	4.97	5.31	5.71	5.98
3-hr:	2.54	2.94	3.56	4.05	4.68	5.14	5.57	5.98	6.48	6.83
6-hr:	2.9	3.34	4.06	4.66	5.48	6.12	6.76	7.41	8.28	8.94
12-hr:	3.33	3.77	4.56	5.28	6.37	7.29	8.27	9.34	10.9	12.1
24-hr:	3.8	4.28	5.21	6.11	7.53	8.78	10.2	11.7	13.9	15.8
2-day:	4.31	4.93	6.11	7.25	9.04	10.6	12.3	14.2	17	19.3
3-day:	4.74	5.43	6.72	7.95	9.89	11.6	13.4	15.4	18.4	20.8
4-day:	5.14	5.85	7.19	8.46	10.4	12.2	14	16.1	19.1	21.6
7-day:	6.2	6.94	8.31	9.6	11.6	13.3	15.2	17.2	20.2	22.6
10-day:	7.17	7.96	9.38	10.7	12.7	14.4	16.2	18.2	21.1	23.4
20-day:	10	11.1	12.8	14.4	16.6	18.3	20.1	22	24.6	26.6
30-day:	12.5	13.8	16	17.7	20.1	22	23.8	25.6	28	29.8
45-day:	15.8	17.5	20.1	22.2	24.9	26.8	28.7	30.4	32.6	34.1
60-day:	18.7	20.7	23.7	26	29	31	32.9	34.6	36.6	37.8

missing 4-hr and 8-hr durations

NOAA Atlas 14

FDOT Critical Storm Analysis



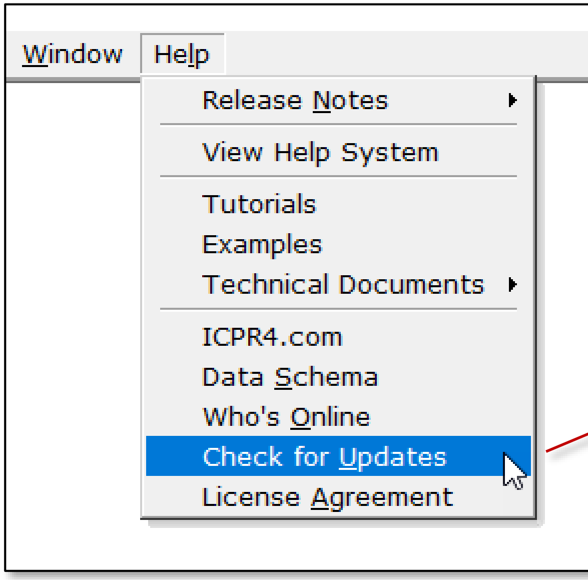
NOAA Atlas 14

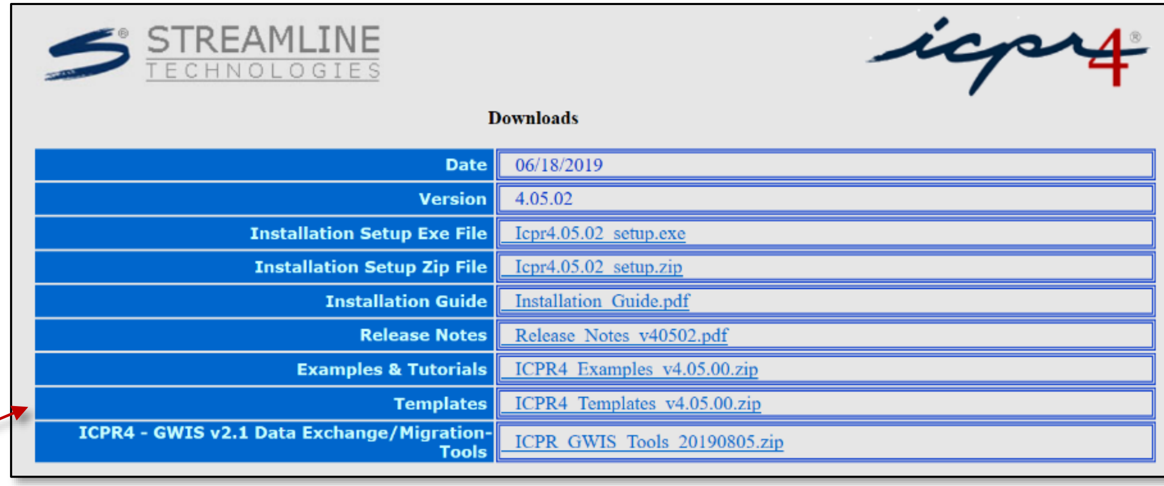
FDOT Critical Storm Analysis

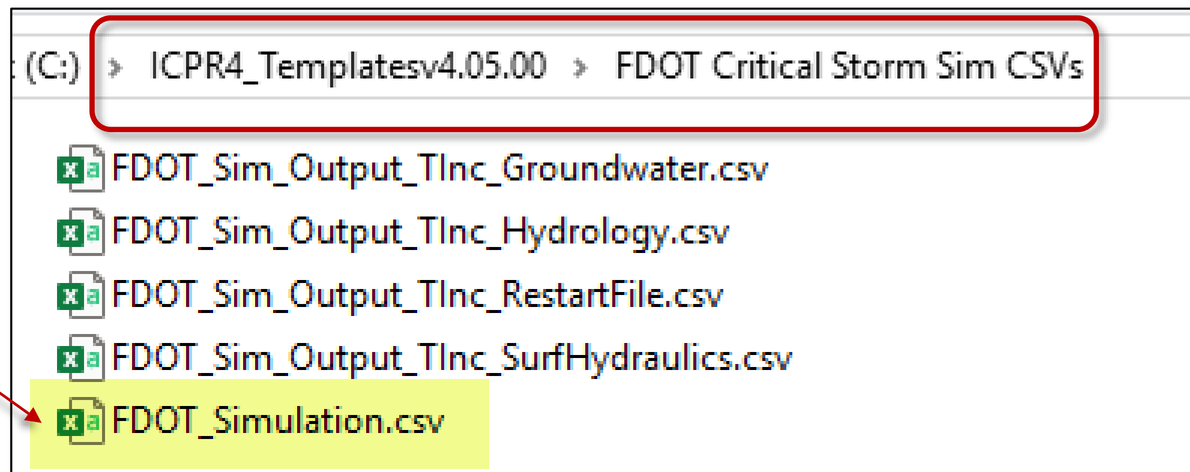
Duration (hr)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
1	2.14	2.57	2.91	3.34	3.65	3.93
2	2.7	3.25	3.68	4.22	4.61	4.97
4	3.1	3.75	4.3	5	5.5	6
8	3.5	4.23	4.9	5.8	6.52	7.3
24	4.28	5.21	6.11	7.53	8.78	10.2
72	5.43	6.72	7.95	9.89	11.6	13.4
168	6.94	8.31	9.6	11.6	13.3	15.2
240	7.96	9.38	10.7	12.7	14.4	16.2

NOAA Atlas 14

FDOT Critical Storm Analysis







open this file in Excel

NOAA Atlas 14

FDOT Critical Storm Analysis

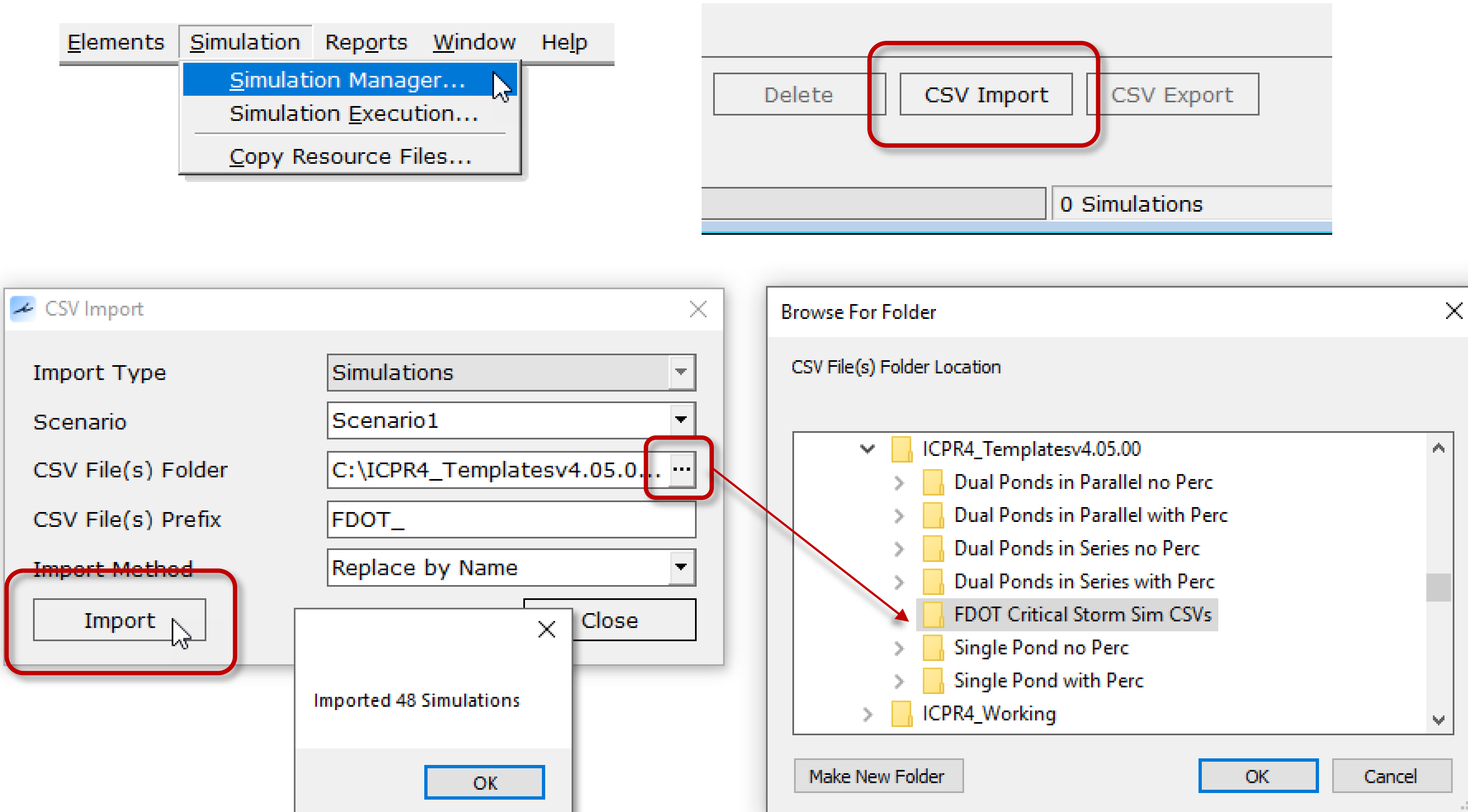
Columns “BB” and “BC”

	BB	BC
	RainfallName	RainfallAmount
	~FDOT-1	2.14
	~FDOT-2	2.7
	~FDOT-4	3.1
2-yr →	~FDOT-8	3.5
	~FDOT-24	4.28
	~FDOT-72	5.43
	~FDOT-168	6.94
	~FDOT-240	7.96
	~FDOT-1	2.57
	~FDOT-2	3.25
	~FDOT-4	3.75
5-yr →	~FDOT-8	4.23
	~FDOT-24	5.21
	~FDOT-72	6.72
	~FDOT-168	8.31
	~FDOT-240	9.38
	~FDOT-1	2.91
	~FDOT-2	3.68
10-yr →	~FDOT-4	4.3
	~FDOT-8	4.9

1. copy and paste rainfall depths into column “BC”
2. click “file > save” & close the file
3. import the csv files in the simulation manager

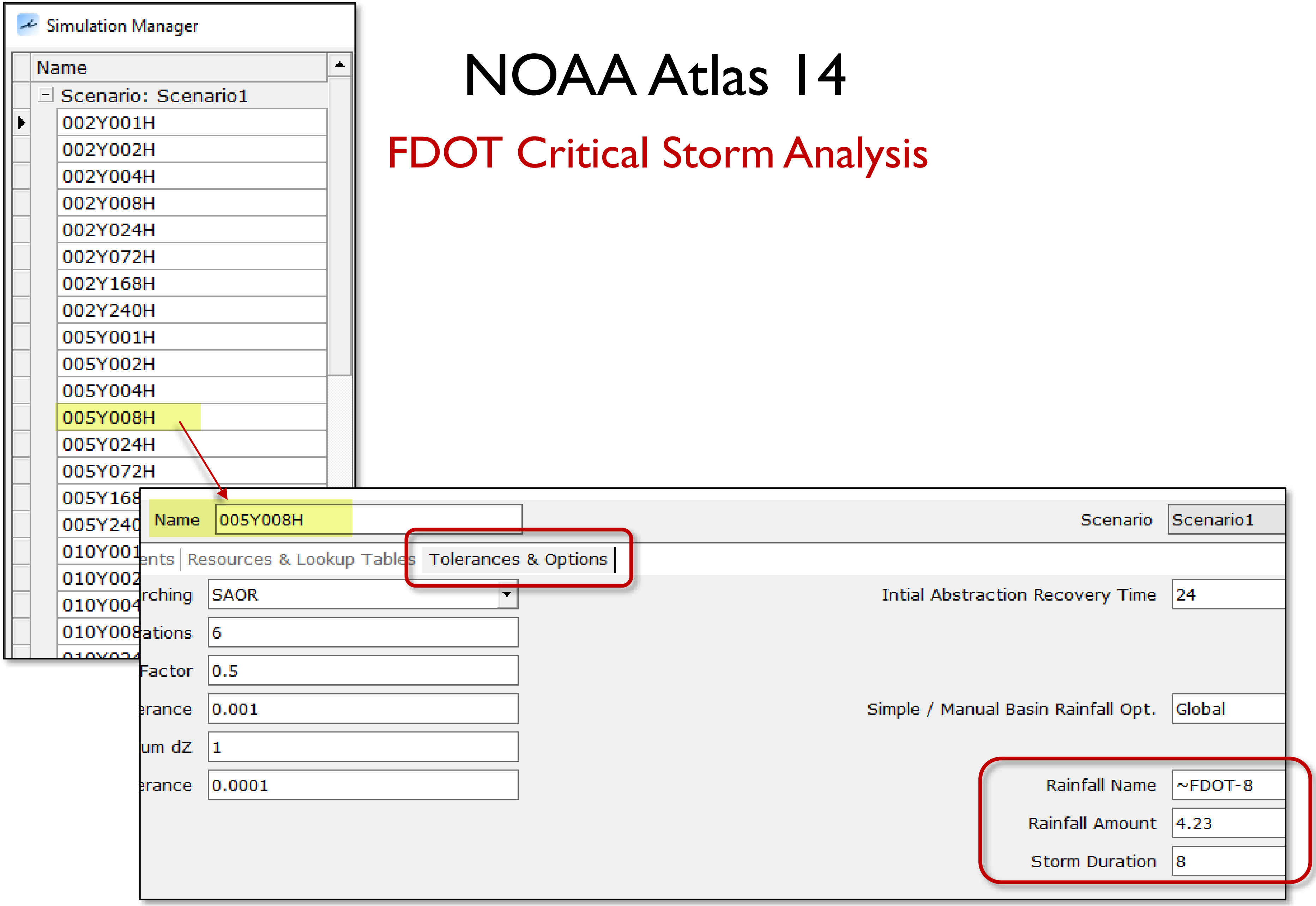
NOAA Atlas 14

FDOT Critical Storm Analysis



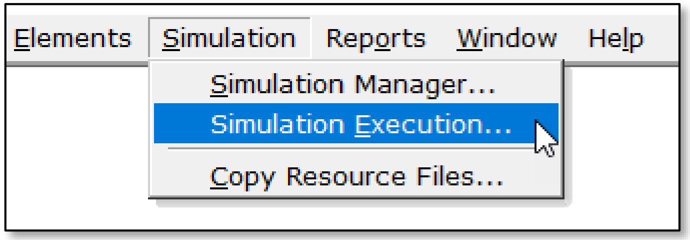
NOAA Atlas 14

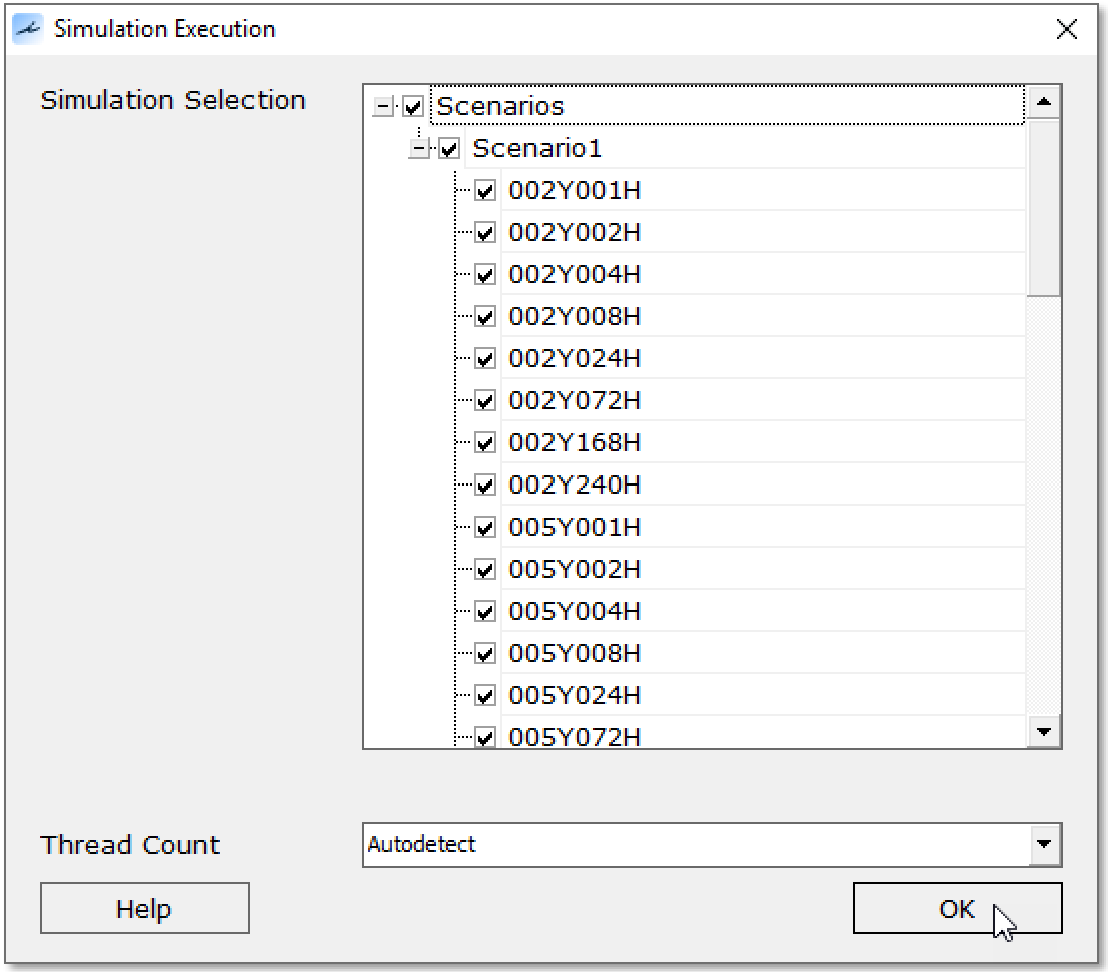
FDOT Critical Storm Analysis



NOAA Atlas 14

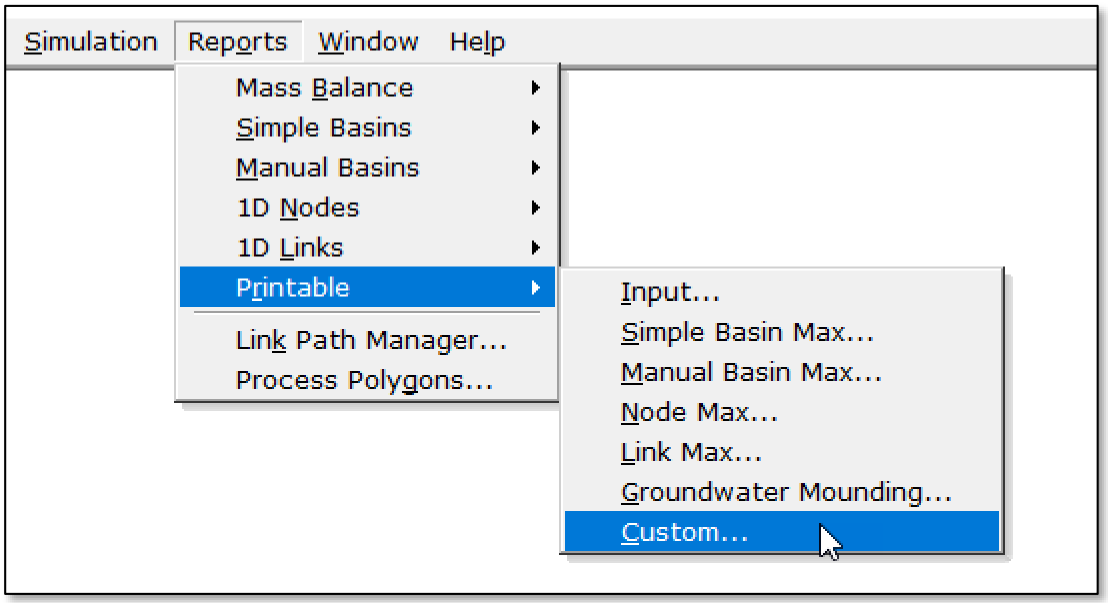
FDOT Critical Storm Analysis





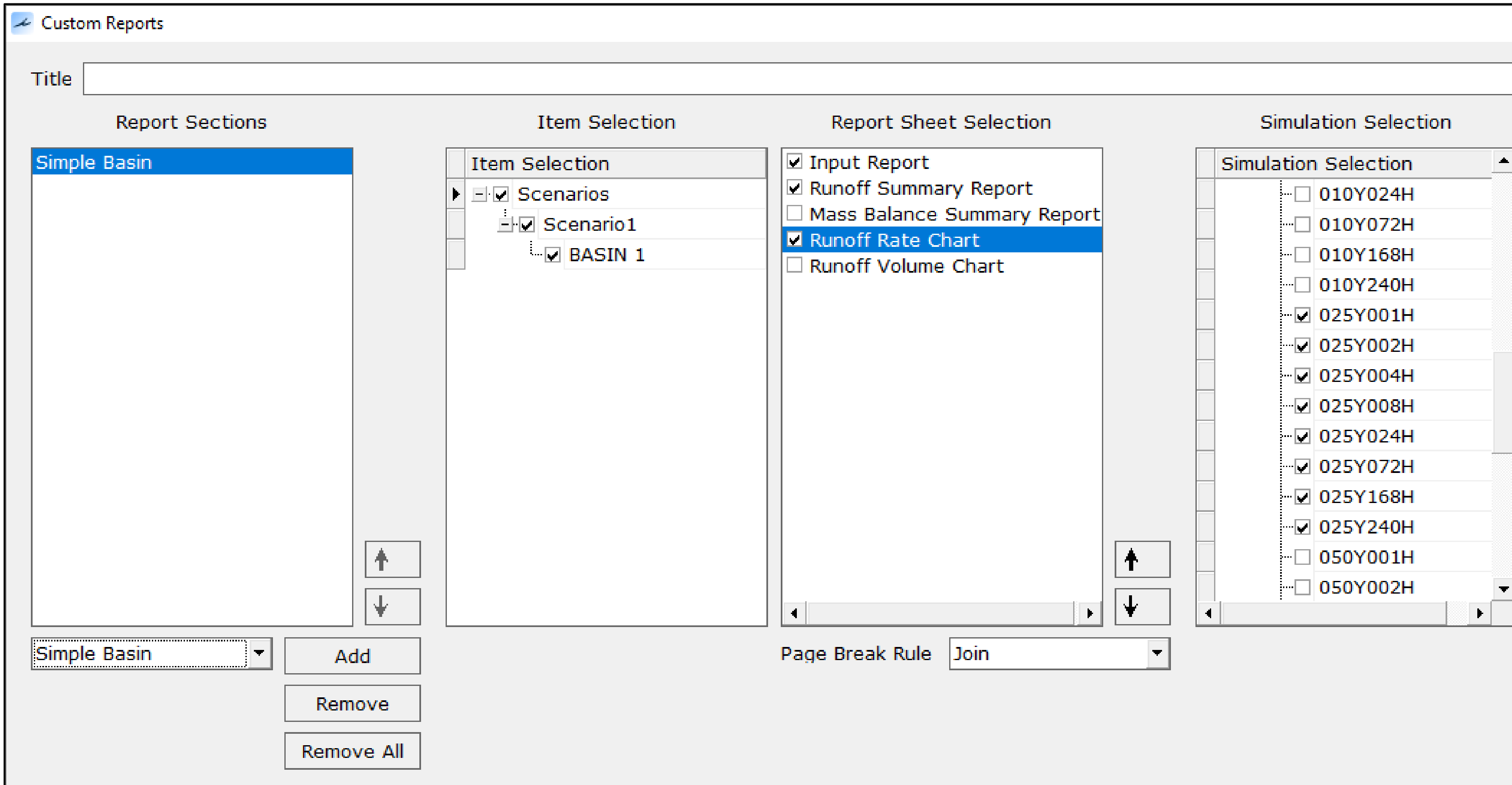
NOAA Atlas 14

FDOT Critical Storm Analysis



NOAA Atlas 14

FDOT Critical Storm Analysis



NOAA Atlas 14

FDOT Critical Storm Analysis

1

Simple Basin: BASIN 1	
Scenario:	Scenario1
Node:	ZZ
Hydrograph Method:	NRCS Unit Hydrograph
Infiltration Method:	Curve Number
Time of Concentration:	30.0000 min
Max Allowable Q:	0.00 cfs
Time Shift:	0.0000 hr
Unit Hydrograph:	GAMMA
Peaking Factor:	300.0
Area:	25.0000 ac
Curve Number:	75.0
% Impervious:	0.00
% DCIA:	0.00
% Direct:	0.00
Rainfall Name:	

Comment:

NOAA Atlas 14

FDOT Critical Storm Analysis

Simple 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
BASIN 1	025Y001H	36.93	0.9333	3.34	1.19	25.0000	75.0	0.00	0.00
BASIN 1	025Y002H	37.60	1.1500	4.22	1.83	25.0000	75.0	0.00	0.00
BASIN 1	025Y004H	34.52	2.6167	5.00	2.45	25.0000	75.0	0.00	0.00
BASIN 1	025Y008H	36.86	4.1000	5.80	3.11	25.0000	75.0	0.00	0.00
BASIN 1	025Y024H	13.47	12.0667	7.53	4.62	25.0000	75.0	0.00	0.00
BASIN 1	025Y072H	11.13	60.0000	9.89	6.77	25.0000	75.0	0.00	0.00
BASIN 1	025Y168H	8.07	160.0000	11.60	8.38	25.0000	75.0	0.00	0.00
BASIN 1	025Y240H	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00

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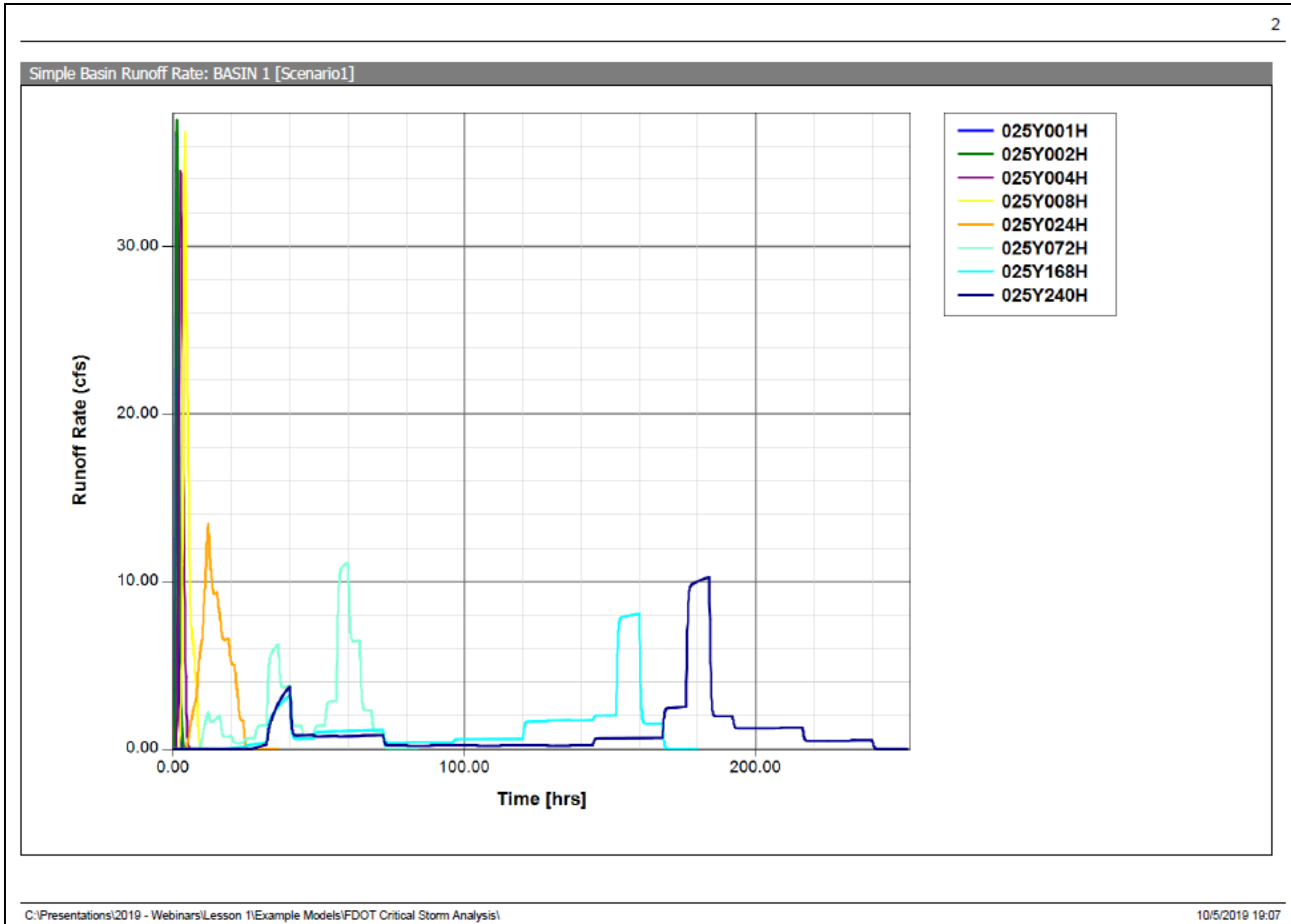
Simple Basin Runoff Summary [Scenario1]

Basin Name	Sim Name	Max Flow [cfs]	Time to Max Flow [hrs]	Total Rainfall [in]
BASIN 1	025Y001H	36.93	0.9333	3.34
BASIN 1	025Y002H	37.60	1.1500	4.22
BASIN 1	025Y004H	34.52	2.6167	5.00
BASIN 1	025Y008H	36.86	4.1000	5.80
BASIN 1	025Y024H	13.47	12.0667	7.53
BASIN 1	025Y072H	11.13	60.0000	9.89
BASIN 1	025Y168H	8.07	160.0000	11.60
BASIN 1	025Y240H	10.26	184.0000	12.70

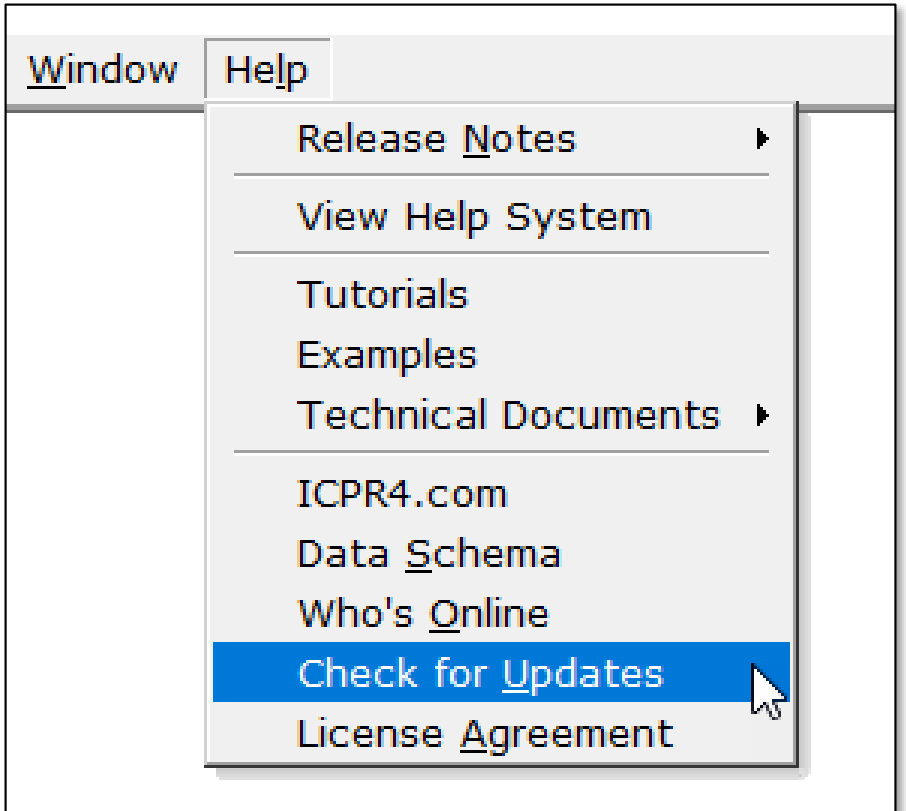
NOAA Atlas 14

FDOT Critical Storm Analysis



Next Webinar – Lesson 2: Hydraulics, Part 1

Wednesday October 23, 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"
in about a week or so.

support@icpr4.com