CE 3354 ENGINEERING HYDROLOGY

LECTURE 16: UNIT HYDROGRAPHS

OUTLINE

- ES7 Solution Sketch
- HMS Workshop
  - Multiple Sub-Basins (using Lag Routing)

ES7 SOLUTION SKETCH

Problem 1 is to use two different unitgraphs and loss characteristics to estimate effects of urbanization in both volume produced and timing

1. An agricultural watershed was urbanized over a 20 year interval. A triangular one-hour unit hydrograph was developed for this watershed for an excess rainfall duration of one hour.

   Before urbanization, the average infiltration rate and other losses was 0.30 in/hr.

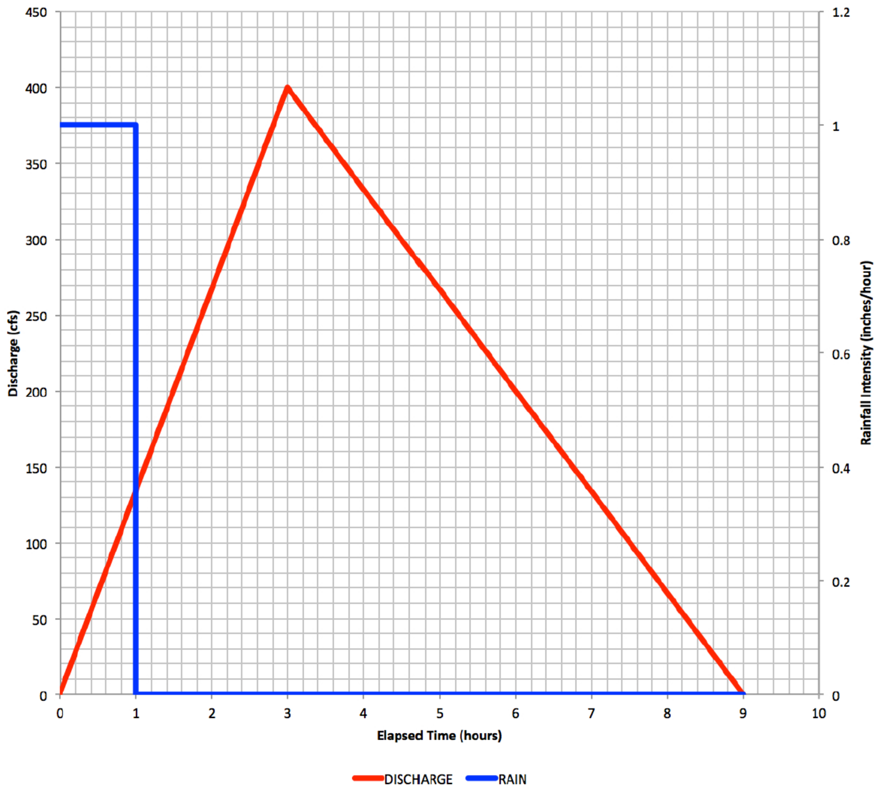
   Figure 1 is the unit hydrograph had a peak discharge of 400 cfs/in occurring at 3 hours, and a base time of 9 hours.

After urbanization the loss rate was reduced to 0.15 in/hr and the peak discharge of the unit hydrograph was increased to 600 cfs/in occurring at 1 hour, and the base time was reduced to 6 hours. Figure 2 is the unit hydrography with a peak discharge of 600 cfs occurring at 1 hours, and a time base of 6 hours.

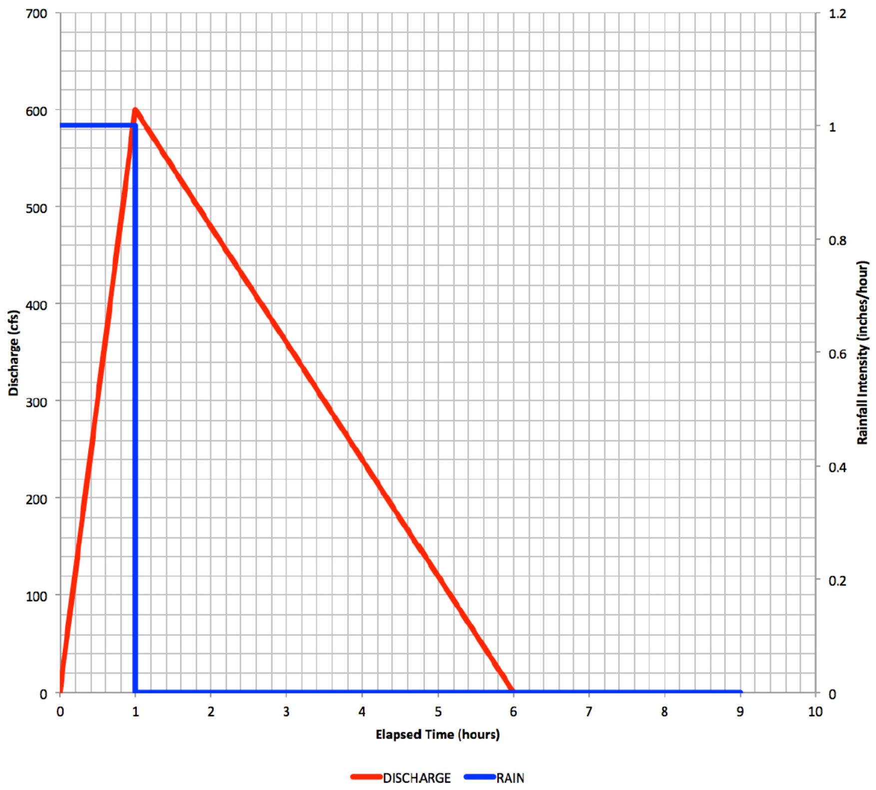
For a two hour storm in which 1 inch of rain fell in the first hour and 0.5 inch in the second hour, determine the direct runoff hydrographs before and after urbanization.[1]

ES7 SOLUTION SKETCH

Problem 1 is to use two different unitgraphs and loss characteristics to estimate effects of urbanization in both volume produced and timing



Pre-Development



Post-Development

ES7 SOLUTION SKETCH

Problem 1 is to use two different unitgraphs and loss characteristics to estimate effects of urbanization in both volume produced and timing

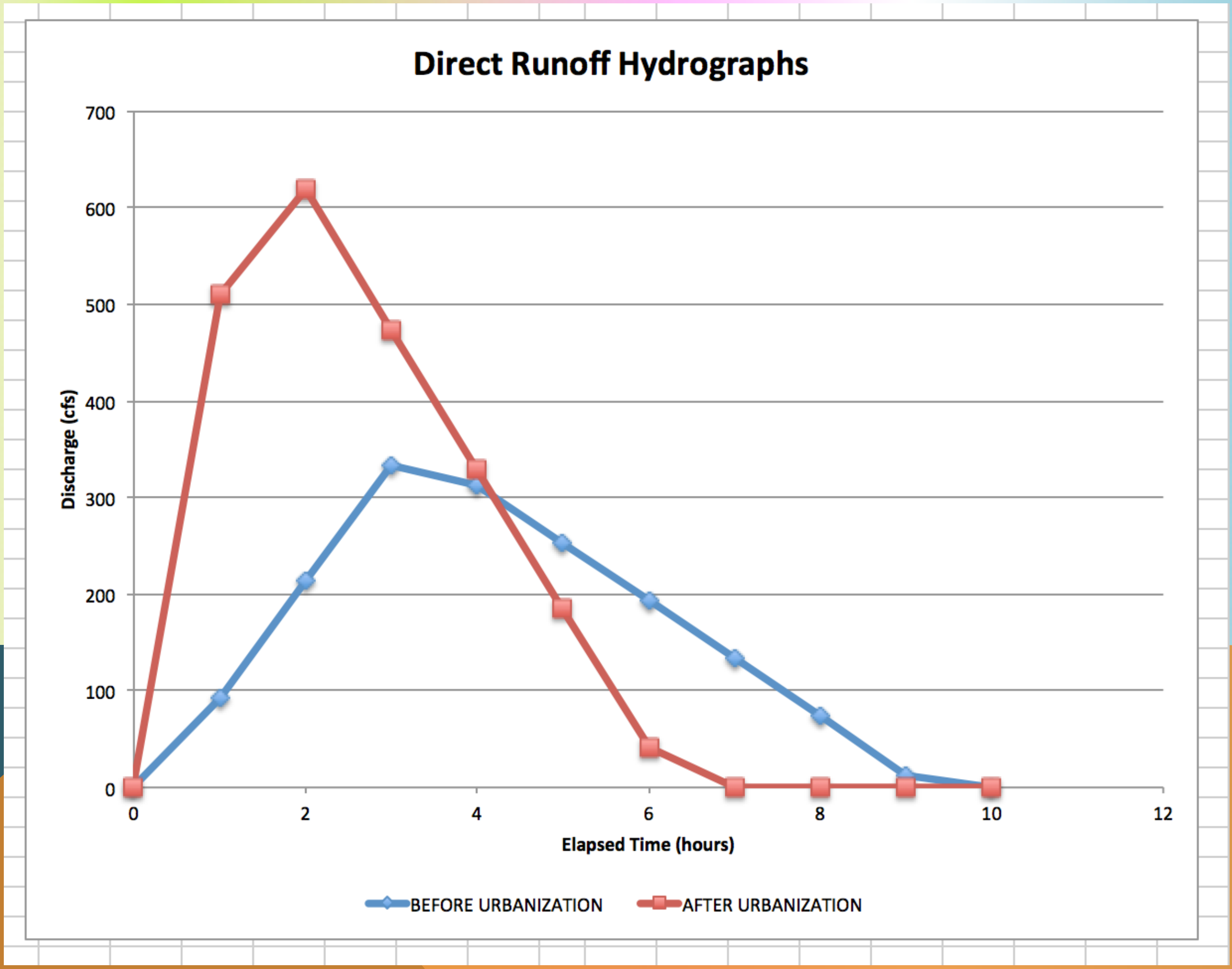
Solution – build the linear system [P][U]=[Q] plot the two cases for [New P]

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	BEFORE URBANIZATION						DESIGN STORM														
2	TIME	RAW RAIN	EXCESS RAIN	UNITGRAPH		TIME	RAW RAIN	EXCESS RAIN		[P]											[P]*[U]
3	0	1	0.7	0		0	1	0.7		0.7	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	133.3		1	0.5	0.2		0.2	0.7	0	0	0	0	0	0	0	0	0	93.33
5	2	0	0	266.7		2	0	0		0	0.2	0.7	0	0	0	0	0	0	0	0	213.3
6	3	0	0	400		3	0	0		0	0	0.2	0.7	0	0	0	0	0	0	0	333.3
7	4	0	0	333.3		4	0	0		0	0	0	0.2	0.7	0	0	0	0	0	0	313.3
8	5	0	0	266.7		5	0	0		0	0	0	0	0.2	0.7	0	0	0	0	0	253.3
9	6	0	0	200		6	0	0		0	0	0	0	0	0.2	0.7	0	0	0	0	193.3
10	7	0	0	133.3		7	0	0		0	0	0	0	0	0	0.2	0.7	0	0	0	133.3
11	8	0	0	66.67		8	0	0		0	0	0	0	0	0	0	0.2	0.7	0	0	73.33
12	9	0	0	0		9	0	0		0	0	0	0	0	0	0	0	0.2	0.7	0	13.33
13	10	0	0	0		10	0	0		0	0	0	0	0	0	0	0	0	0.2	0.7	0
14	AFTER URBANIZATION						DESIGN STORM														
15	TIME	RAW RAIN	EXCESS RAIN	UNITGRAPH		TIME	RAW RAIN	EXCESS RAIN		[P]											[P]*[U]
16	0	1	0.85	0		0	1	0.85		85	0	0	0	0	0	0	0	0	0	0	0
17	1	0	0	600		1	0.5	0.35		0.35	0.85	0	0	0	0	0	0	0	0	0	510
18	2	0	0	480		2	0	0		0	0.35	0.85	0	0	0	0	0	0	0	0	618
19	3	0	0	360		3	0	0		0	0	0.35	0.85	0	0	0	0	0	0	0	474
20	4	0	0	240		4	0	0		0	0	0	0.35	0.85	0	0	0	0	0	0	330
21	5	0	0	120		5	0	0		0	0	0	0	0.35	0.85	0	0	0	0	0	186
22	6	0	0	0		6	0	0		0	0	0	0	0	0.35	0.85	0	0	0	0	42
23	7	0	0	0		7	0	0		0	0	0	0	0	0	0.35	0.85	0	0	0	0
24	8	0	0	0		8	0	0		0	0	0	0	0	0	0	0.35	0.85	0	0	0
25	9	0	0	0		9	0	0		0	0	0	0	0	0	0	0	0.35	0.85	0	0
26	10	0	0	0		10	0	0		0	0	0	0	0	0	0	0	0	0.35	0.85	0

ES7 SOLUTION SKETCH

Problem 1 is to use two different unitgraphs and loss characteristics to estimate effects of urbanization in both volume produced and timing

Solution – build the linear system [P][U]=[Q] plot the two cases for [New P]



ES7 SOLUTION SKETCH

Problem 2 is to construct a unitgraph from an observed storm using the linear regression approach

Solution

- Get volume balance using the loss model
- Build and solve the normal equations (the linear system $[[P]^T[P][P]^T]^{-1}[Q]=[U]$)
- Plot Result

ES7 SOLUTION SKETCH

Problem 2 is to construct a unitgraph from an observed storm using the linear regression approach

Solution

- Get volume balance using the loss model

	A	B	C	D	E	F	G	H	I
1	TIME (HRS)	RAIN (INCHES)	DIRECT RUNOFF (CFS)		RAW RAIN VOLUME (CUBIC FEET)	RUNOFF VOLUME (CUBIC FEET)		EXCESS RAIN (INCHES)	EXCESS RAIN (CUBIC FEET)
2	0.5	0.28	32		4572986.88	57600		0.14433638	2357315.65
3	1	0.12	67		1959851.52	120600		0	0
4	1.5	0.13	121		2123172.48	217800		0	0
5	2	0.14	189		2286493.44	340200		0.00433638	70822.209
6	2.5	0.18	279		2939777.28	502200		0.04433638	724106.049
7	3	0.14	290		2286493.44	522000		0.00433638	70822.209
8	3.5	0.07	237		1143246.72	426600		0	0
9	4		160		0	288000		0	0
10	4.5		108		0	194400		0	0
11	5		72		0	129600		0	0
12	5.5		54		0	97200		0	0
13	6		44		0	79200		0	0
14	6.5		33		0	59400		0	0
15	7		28		0	50400		0	0
16	7.5		22		0	39600		0	0
17	8		20		0	36000		0	0
18	8.5		18		0	32400		0	0
19	9		16		0	28800		0	0
20									
21				TOTAL	17312021.8	3222000			3223066.12
22									
23				RUNOFF/RAIN		0.18611344	RUNOFF/EXCESS RAIN		0.99966922
24									
25				LOSS RATE		0.13566362	<= ADJUST UNTIL RUNOFF/EXCESS RAIN = 1		
26									

=IF(B2>0,IF(B2-F25>0,B2-F25,0),0)

=C2*3600*0.5

=B2*(7.03*640*43560/12)

=F21/E21

ES7 SOLUTION SKETCH

Problem 2 is to construct a unitgraph from an observed storm using the linear regression approach

Solution

- Build and solve the normal equations (the linear system $[[P]^T[P][P]^T]^{-1}[Q]=[U]$)
  - Negative values are an annoyance, try SOLVER to force non-negative solution

=MMULT(MINVERSE(MMULT(TRANSPOSE(E2:V19),E2:V19)),MMULT(TRANSPOSE(E2:V19),C2:C19))

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	TIME (HRS)	EXCESS RAIN (INCHES)	DIRECT RUNOFF (CFS)		[P]																			[U]	[Q*]
2	0.5	0.14433638	32		0.1443	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		221.7	32
3	1	0	67		0	0.1443	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		464.2	67
4	1.5	0	121		0	0	0.1443	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		838.3	121
5	2	0.00433638	189		0.0043	0	0	0.1443	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1302.8	189
6	2.5	0.04433638	279		0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0	0	0	0	0	0	0		1850.9	279
7	3	0.00433638	290		0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0	0	0	0	0	0		1834.8	290
8	3.5	0	237		0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0	0	0	0	0		1331.4	237
9	4	0	160		0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0	0	0	0		627.5	160
10	4.5	0	108		0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0	0	0		85.4	108
11	5	0	72		0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0	0		-160.4	72
12	5.5	0	54		0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0	0		-108.8	54
13	6	0	44		0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0	0		69.5	44
14	6.5	0	33		0	0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0	0		188.4	33
15	7	0	28		0	0	0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0	0		244.0	28
16	7.5	0	22		0	0	0	0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0	0		188.6	22
17	8	0	20		0	0	0	0	0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0	0		114.8	20
18	8.5	0	18		0	0	0	0	0	0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443	0		57.4	18
19	9	0	16		0	0	0	0	0	0	0	0	0	0	0	0	0.0043	0.0443	0.0043	0	0	0.1443		24.6	16

ES7 SOLUTION SKETCH

Problem 2 is to construct a unitgraph from an observed storm using the linear regression approach

Solution

- Build and solve the normal equations (the linear system $[[P]^T[P][P]^T]^{-1}[Q]=[U]$)
  - Negative values are an annoyance, try SOLVER to force non-negative solution (not much better)

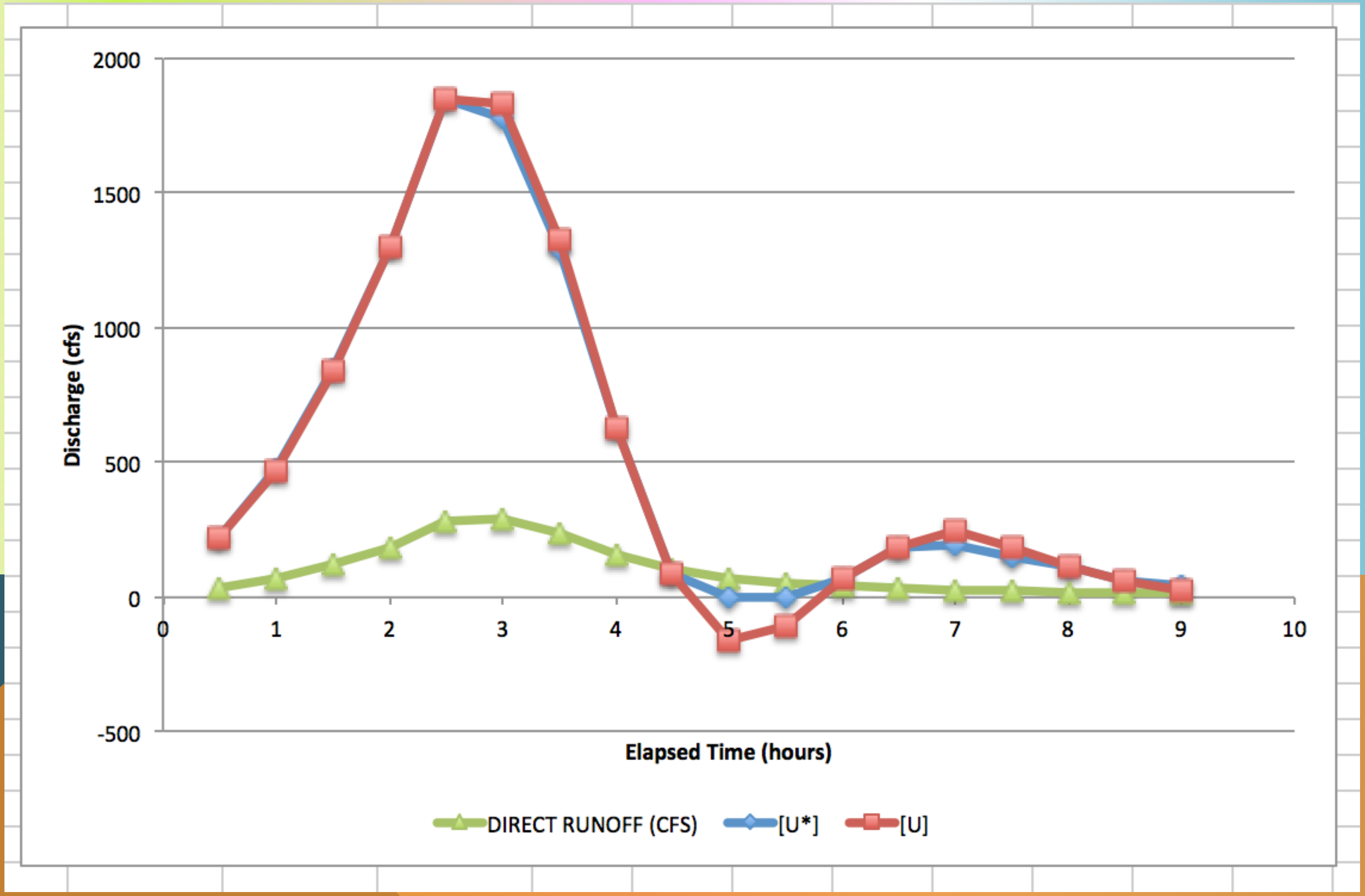
Negative UH weights -- try Solver			
	[U*]	[Q*-solver]	[SE]
	224.349	32.3817666	0.14574575
Solver:	479.713	69.2400865	5.01798769
1) Compute SE from ([P][U*]-[Q_obs])	850.148	122.70722	2.91460034
2) Compute SSE by sum(above)	1304.59	189.273066	0.07456485
3) Use solver to min SSE, by changing	1845.44	278.391811	0.36989355
3.A) Force NON-Negative [U*]	1782.74	283.241852	45.6725664
	1293.6	232.143616	23.5844655
	623.929	159.585644	0.17169086
	88.6252	108.000002	3.4982E-12
	0	92.6521668	426.511993
	0	67.7898147	190.158989
	71.6621	44.0000423	1.7859E-09
	182.663	32.999879	1.463E-08
	191.328	27.9999706	8.6238E-10
	150.269	22.0000078	6.1463E-11
	111.064	19.9999321	4.6098E-09
	60.6986	18.0000802	6.4268E-09
	42.079	16.0000567	3.2116E-09
		[SSE] =>	694.622498

ES7 SOLUTION SKETCH

Problem 2 is to construct a unitgraph from an observed storm using the linear regression approach

Solution

- Plot Result

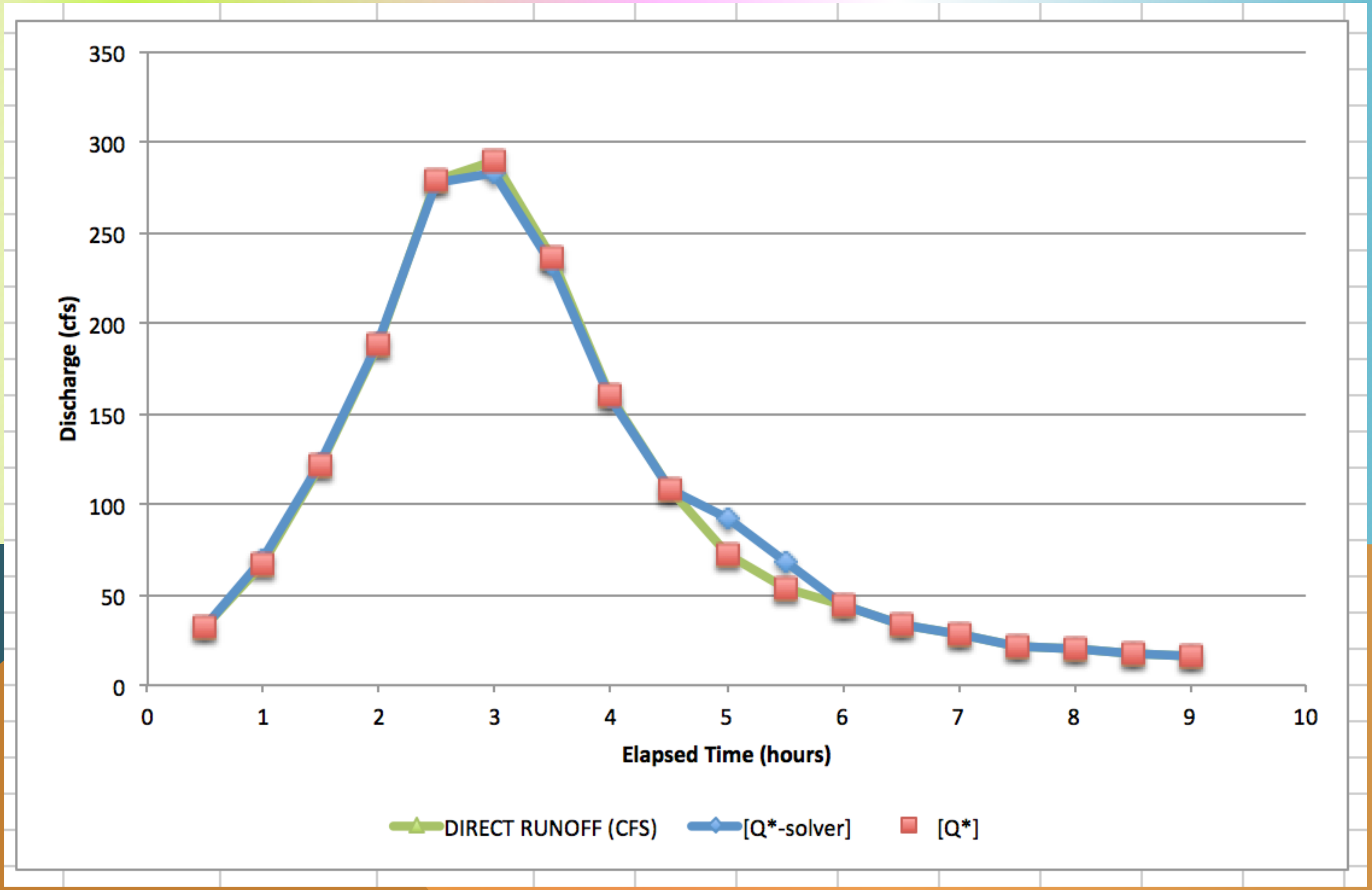


ES7 SOLUTION SKETCH

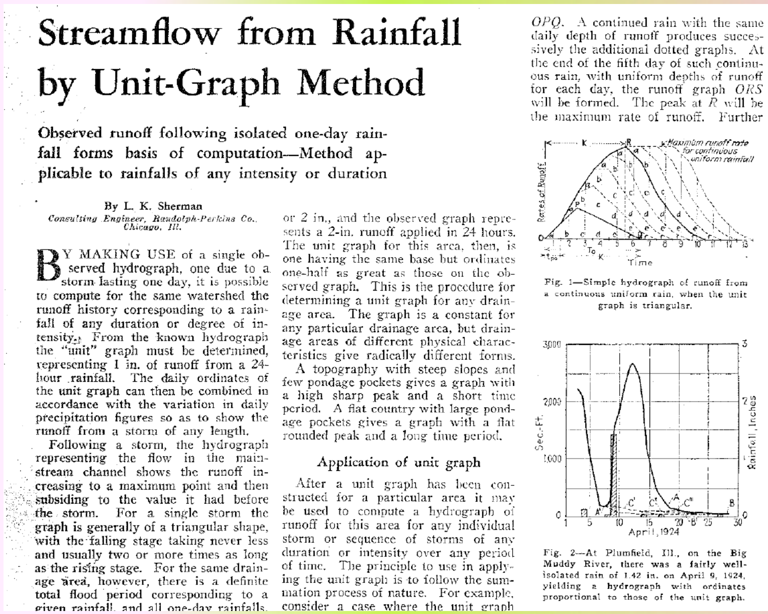
Problem 2 is to construct a unitgraph from an observed storm using the linear regression approach

Solution

- Plot Result: Both fit the observations OK



WHAT IS A UNIT HYDROGRAPH?



Streamflow from Rainfall by Unit-Graph Method

Observed runoff following isolated one-day rainfall forms basis of computation—Method applicable to rainfalls of any intensity or duration

By L. K. Sherman
Consulting Engineer, Randolph-Perkins Co., Chicago, Ill.

BY MAKING USE of a single observed hydrograph, one due to a storm lasting one day, it is possible to compute for the same watershed the runoff history corresponding to a rainfall of any duration or degree of intensity. From the known hydrograph the "unit" graph must be determined, representing 1 in. of runoff from a 24-hour rainfall. The daily ordinates of the unit graph can then be combined in accordance with the variation in daily precipitation figures so as to show the runoff from a storm of any length.

Following a storm, the hydrograph representing the flow in the main-stream channel shows the runoff increasing to a maximum point and then subsiding to the value it had before the storm. For a single storm the graph is generally of a triangular shape, with the falling stage taking never less and usually two or more times as long as the rising stage. For the same drainage area, however, there is a definite total flood period corresponding to a given rainfall, and all one-day rainfalls,

or 2 in., and the observed graph represents a 2-in. runoff applied in 24 hours. The unit graph for this area, then, is one having the same base but ordinates one-half as great as those on the observed graph. This is the procedure for determining a unit graph for any drainage area. The graph is a constant for any particular drainage area, but drainage areas of different physical characteristics give radically different forms.

A topography with steep slopes and few pondage pockets gives a graph with a high sharp peak and a short time period. A flat country with large pondage pockets gives a graph with a flat rounded peak and a long time period.

Application of unit graph

After a unit graph has been constructed for a particular area it may be used to compute a hydrograph of runoff for this area for any individual storm or sequence of storms of any duration or intensity over any period of time. The principle to use in applying the unit graph is to follow the summation process of nature. For example, consider a case where the unit graph

OPQ. A continued rain with the same daily depth of runoff produces successively the additional dotted graphs. At the end of the fifth day of such continuous rain, with uniform depths of runoff for each day, the runoff graph *ORS* will be formed. The peak at *R* will be the maximum rate of runoff. Further

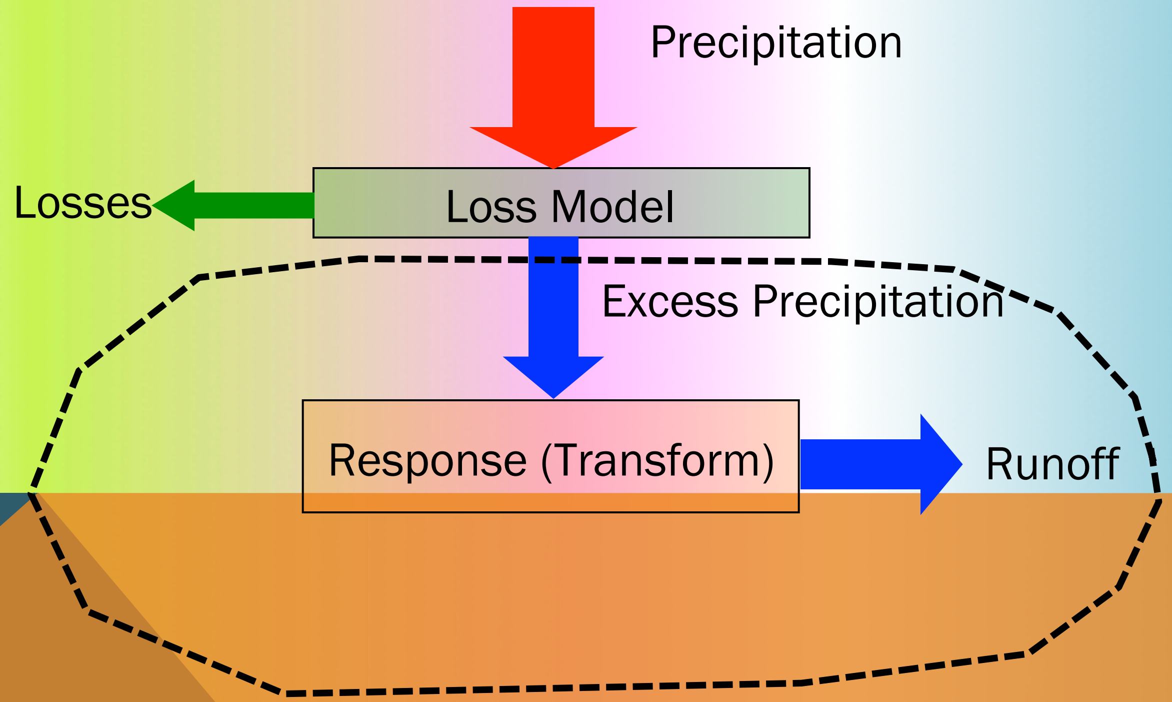
Fig. 1—Simple hydrograph of runoff from a continuous uniform rain, when the unit graph is triangular.

Fig. 2—At Plumfield, Ill., on the Big Muddy River, there was a fairly well-isolated rain of 1.42 in. on April 9, 1924, yielding a hydrograph with ordinates proportional to those of the unit graph.

- **Used to explain the time re-distribution of excess precipitation on a watershed**
- **Represents the response of the watershed at the outlet to a unit depth of EXCESS precipitation**
  - EXCESS implies some kind of loss model is applied to the raw precipitation
  - Time re-distribution implies some kind of transfer behavior is applied
- **L. K. Sherman 1932 is credited with seminal publication of the concept**
  - Read the document in AdditionalReadings

RESPONSE MODEL

Response models convert the excess precipitation signal into a direct runoff hydrograph at the point of interest



CE 3354 ENGINEERING HYDROLOGY

LECTURE 16: HEC-HMS WORKSHOP – ASH CREEK EXAMPLE

PURPOSE

Illustrate using HEC-HMS to develop a multiple sub-basin model

- Include routing concepts

LEARNING OBJECTIVES

Learn how to use HMS to construct a multiple sub-basin model

Learn how to supply lag-routing data

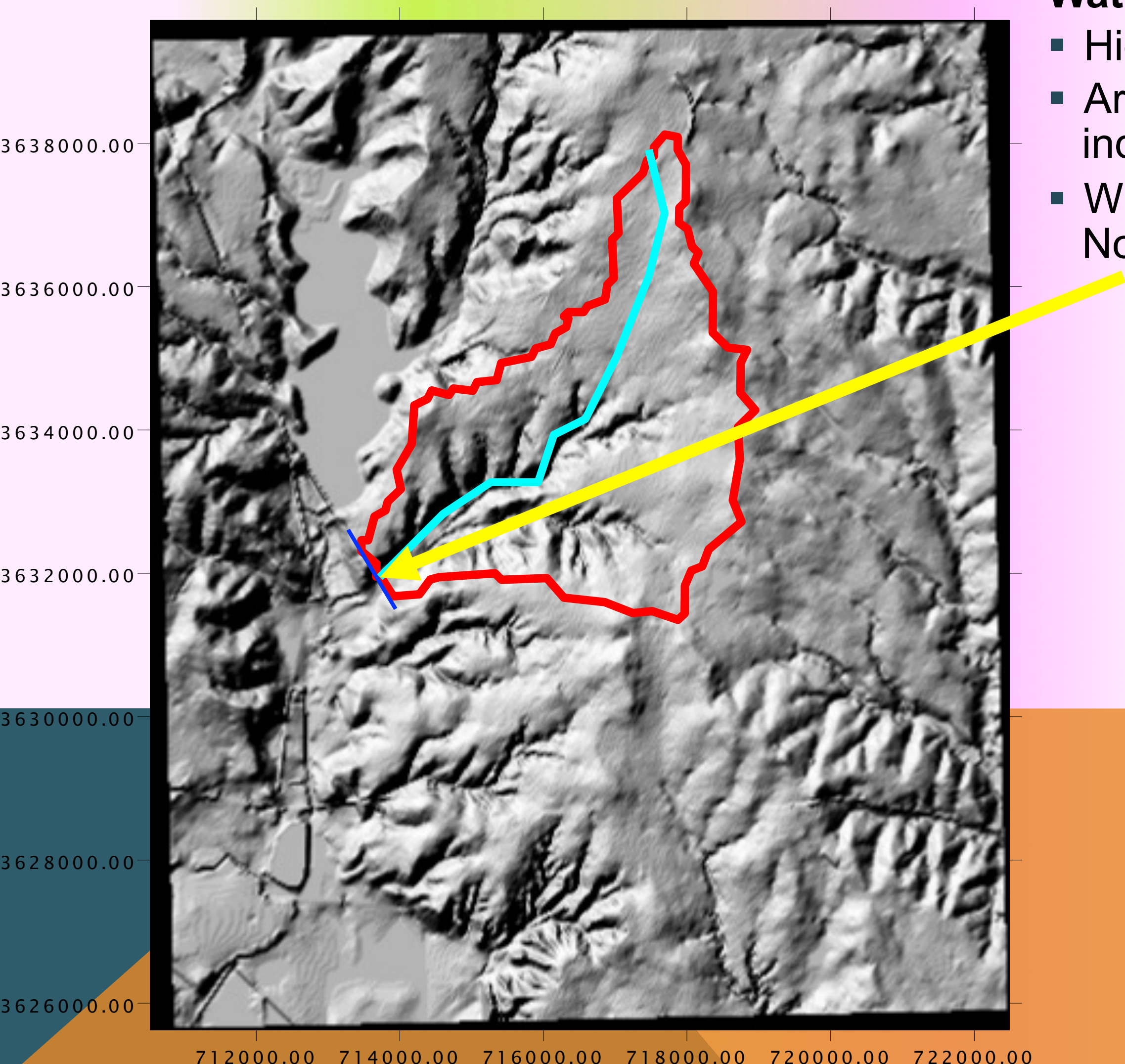
Learn how to estimate lag-routing times

PROBLEM STATEMENT

Simulate the response of the Ash Creek watershed at Highland Road for 20 May 1978 historical conditions.

- Use Example 3B as the base "model"
- Treat the watershed as comprised of multiple sub-basins.

BACKGROUND AND DATA



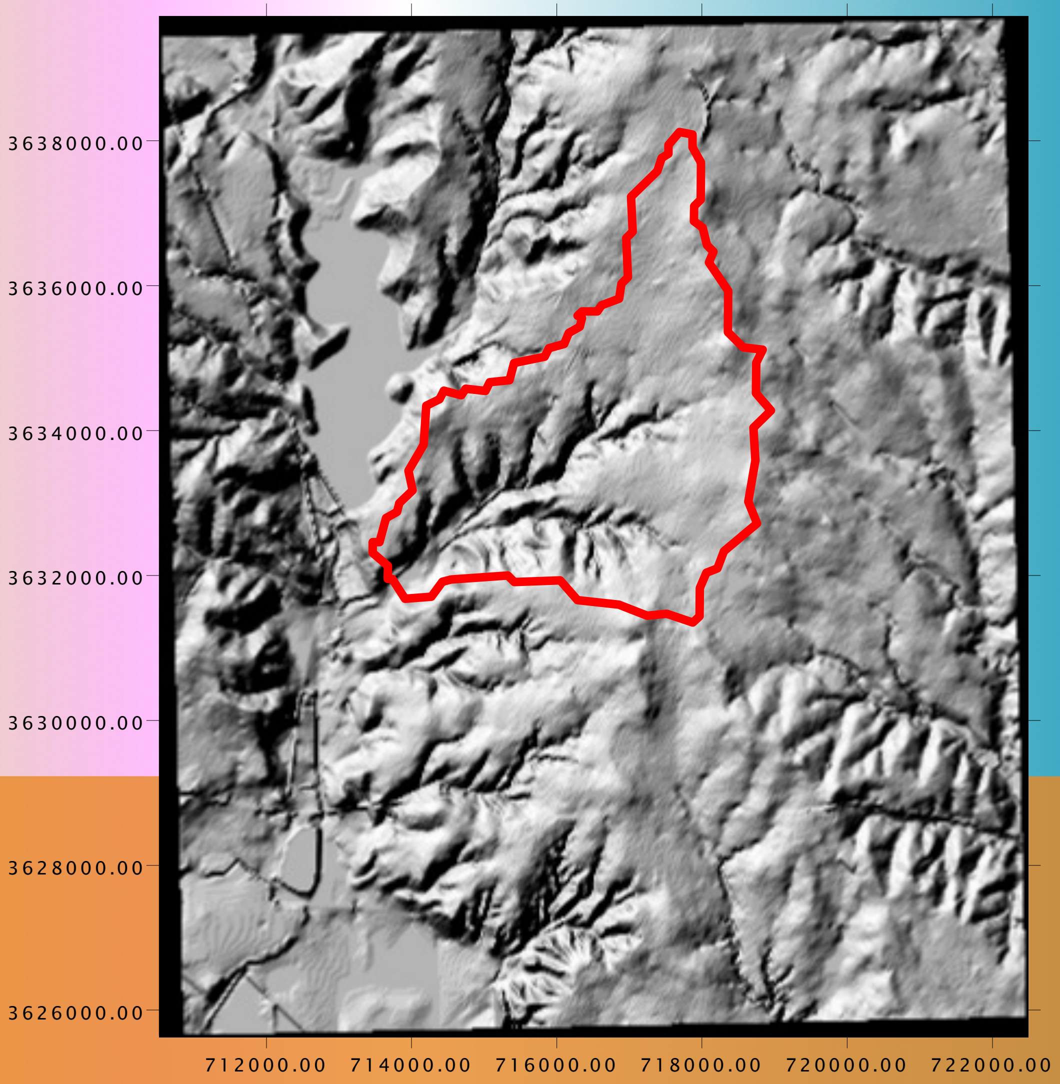
Watershed Outlet

- Highland Road and Ash Creek, Dallas, TX.
- Area is residential subdivisions, light industrial parks, and some open parkland.
- White Rock Lake is water body to the North-West

PHYSICAL PROPERTIES

Watershed Properties

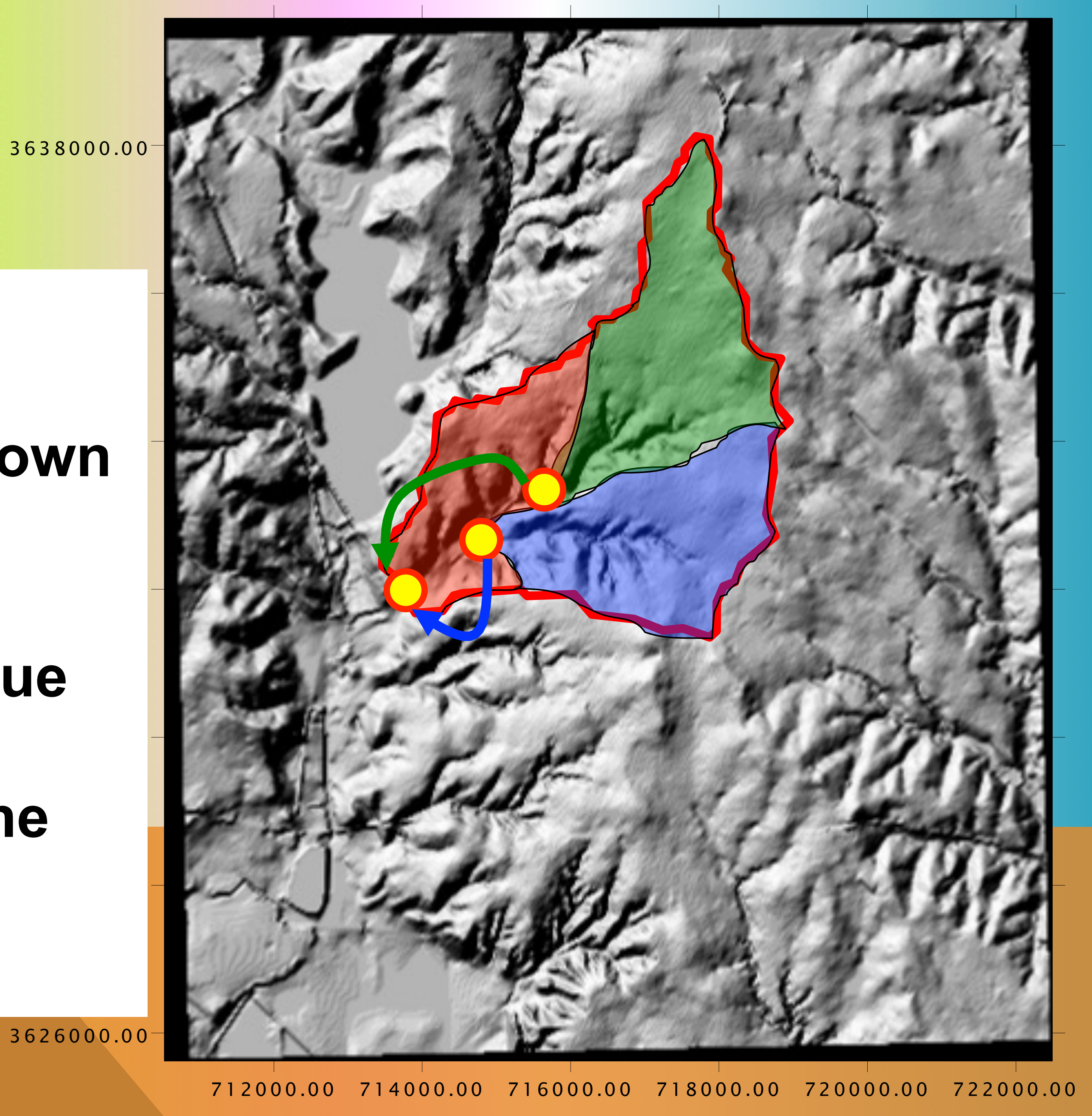
- AREA=6.92 mi2
- MCL=5.416 mi
- MCS=0.005595
- CN=86
- R=0



Consider the arbitrary scheme shown

- Green => Red
- Blue => Red

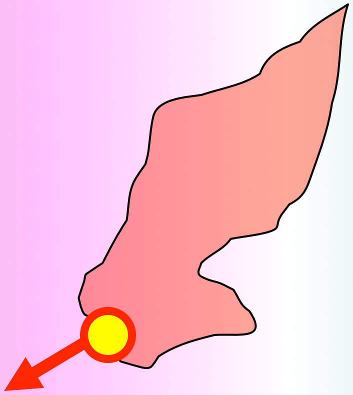
Green and Blue need to be routed to the outlet.



RED WATERSHED

Rainfall-Runoff for this sub-area directly to the outlet

- Unit hydrograph
  - AREA
  - Tc
- Loss model
  - CN



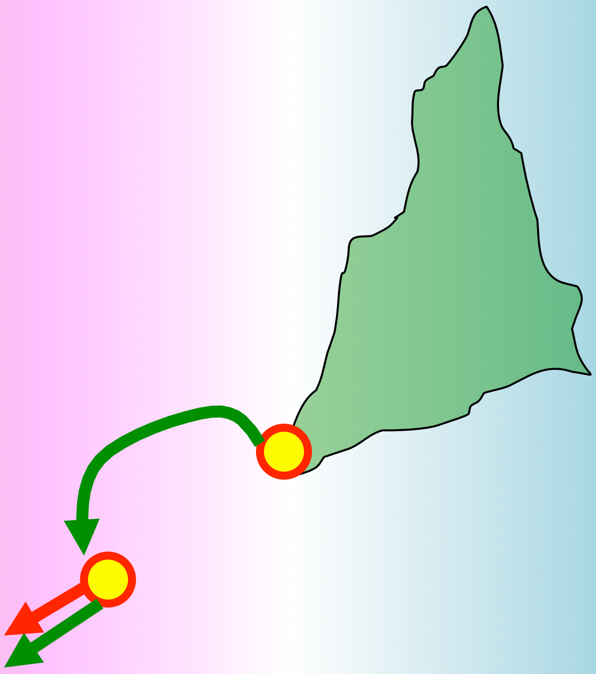
GREEN WATERSHED

Rainfall-runoff for this watershed directly to ITS outlet.

- Unit hydrograph
  - AREA
  - Tc
- Loss model
  - CN

Then "route" to the main outlet

- Tlag = Distance/Speed



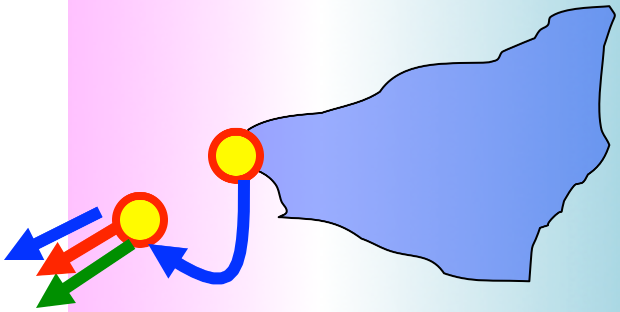
BLUE WATERSHED

Rainfall-runoff for this watershed directly to ITS outlet.

- Unit hydrograph
  - AREA
  - Tc
- Loss model
  - CN

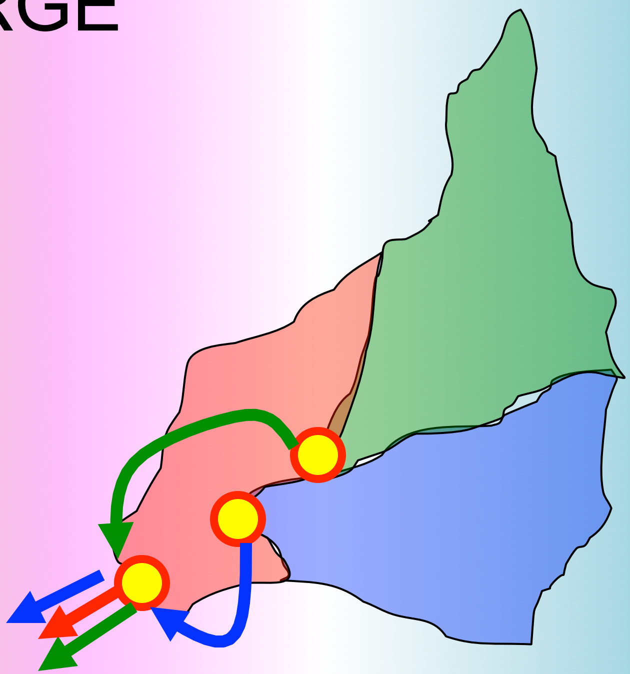
Then "route" to the main outlet

- Tlag = Distance/Speed



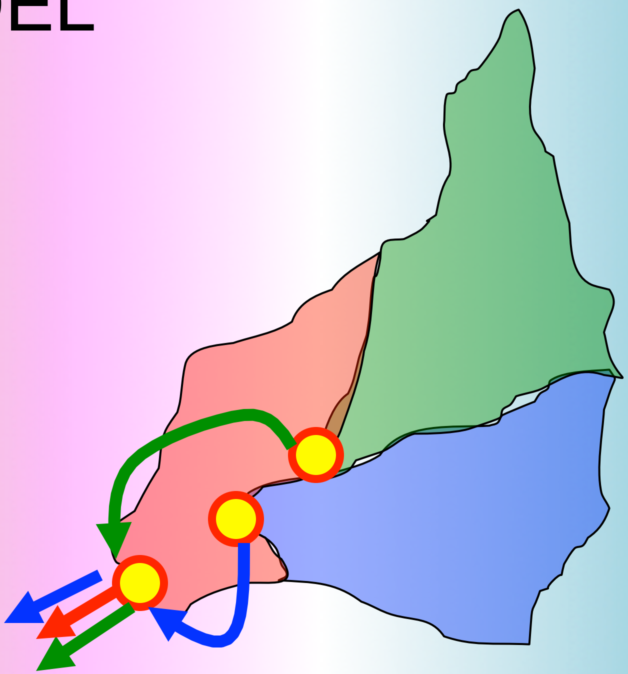
COMPOSITE DISCHARGE

- Contributions of each watershed combined at the outlet for the total discharge

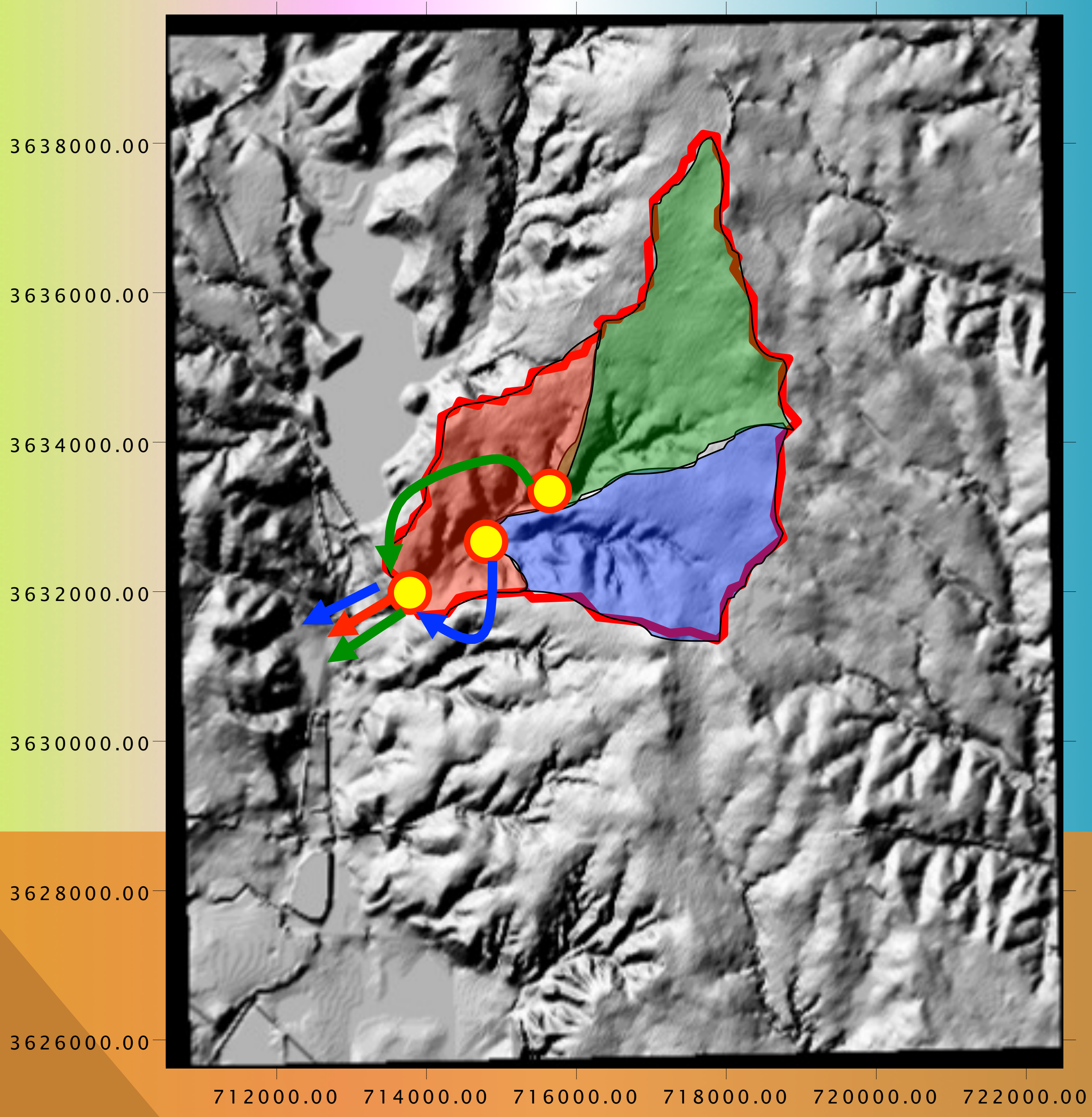


PREPARING THE MODEL

- Need area of each watershed sub-basin
- Need distances from Green and Blue outlets to main outlet



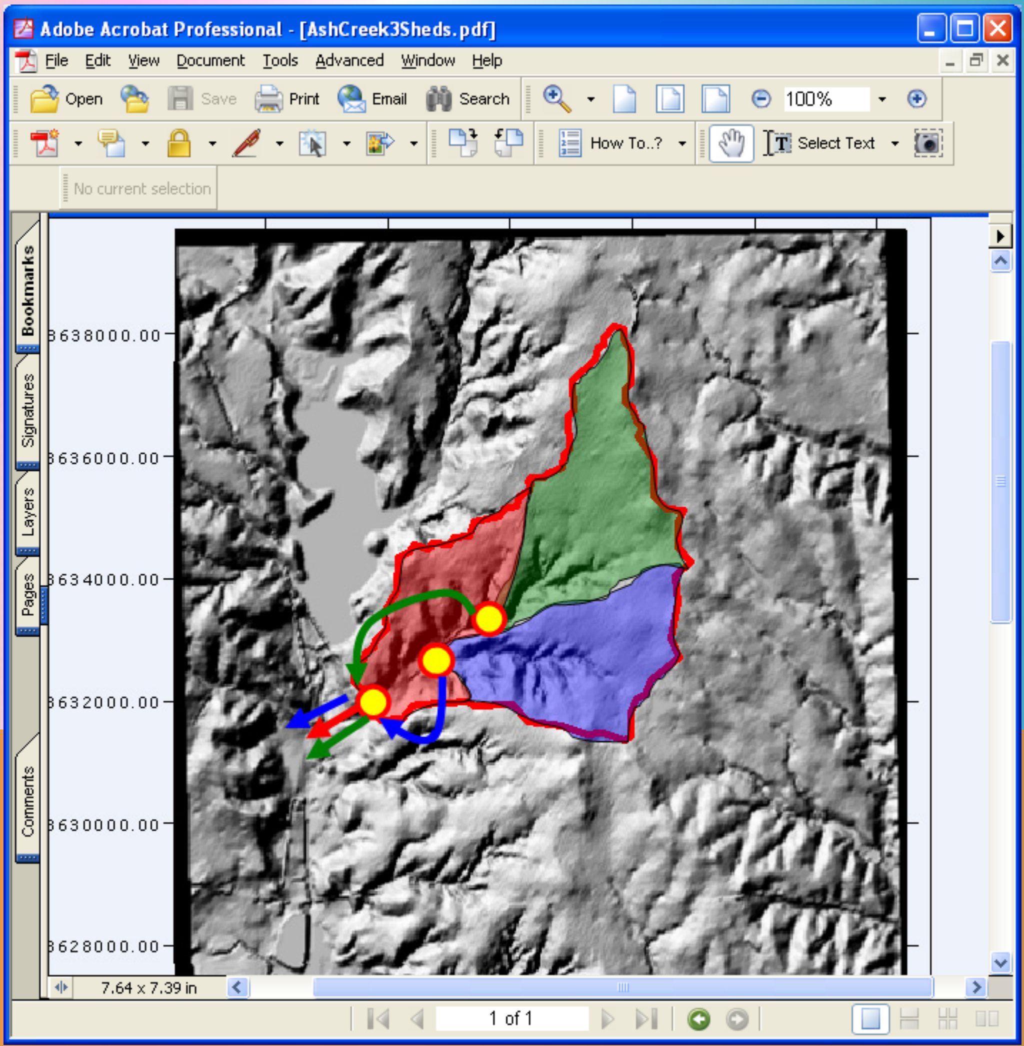
Prepare a PDF base map with drawings and use measuring tools.



EXAMPLE 5

Use measuring tools in acrobat.

- Known total area is 6.92 square miles, so we don’t need a reference rectangle.
- The left axis is UTM and is in meters. So distances stragihtforward

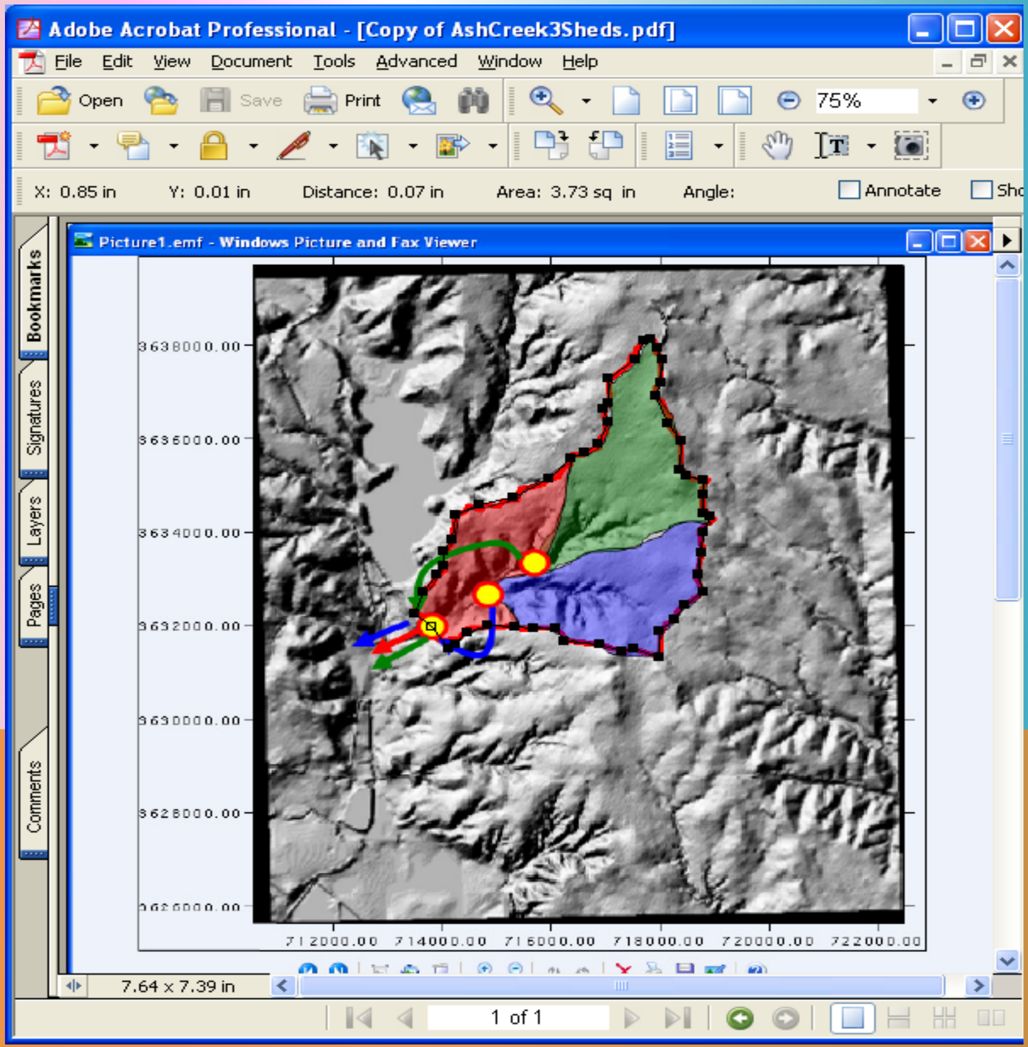


EXAMPLE 5

Use measuring tools in acrobat.

- 6.92 sq.mi = 3.73 sq.in
- 2000 m = 0.90 in (horizontal axis)
- 2000 m = 0.89 in (vertical axis)

Use these measurements to scale the sub-areas and stream channel distances.



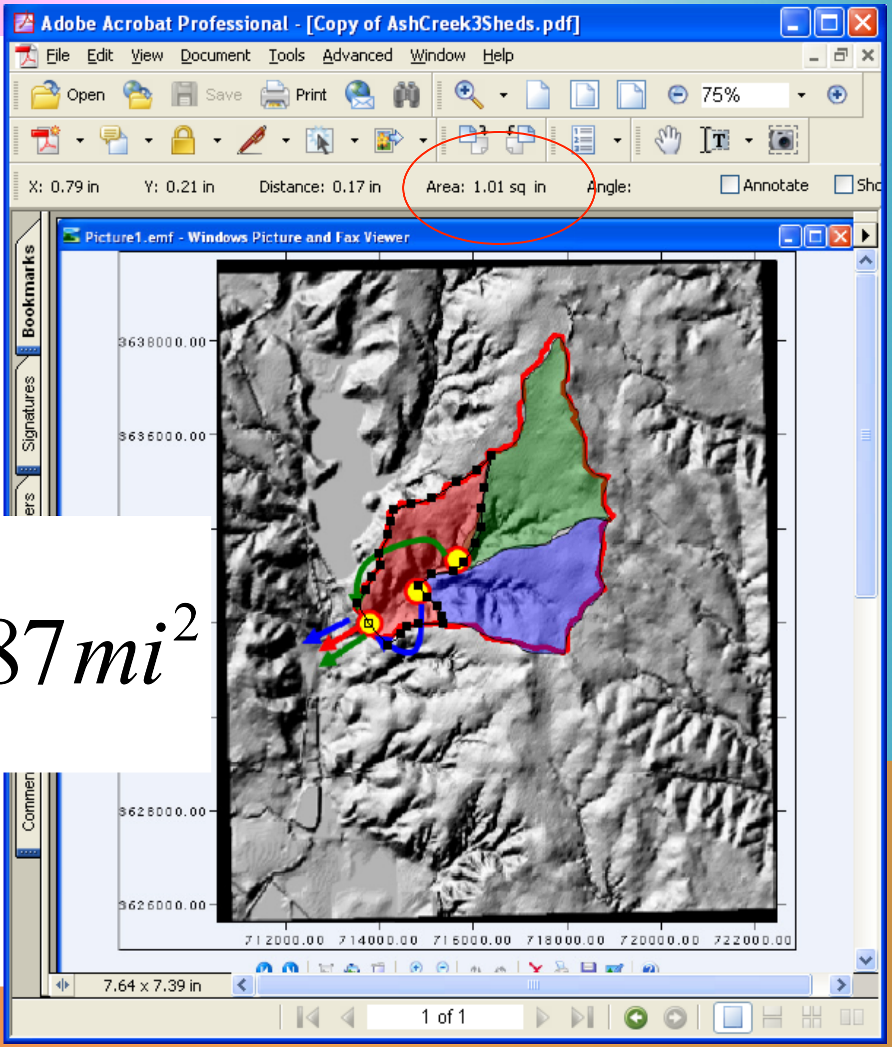
RED WATERSHED

Use measuring tools in acrobat.

- Area Measured = 1.01 sq.in.

Convert to sq. mi.

$$1.01in^2 \times \frac{6.92mi^2}{3.73in^2} = 1.87mi^2$$



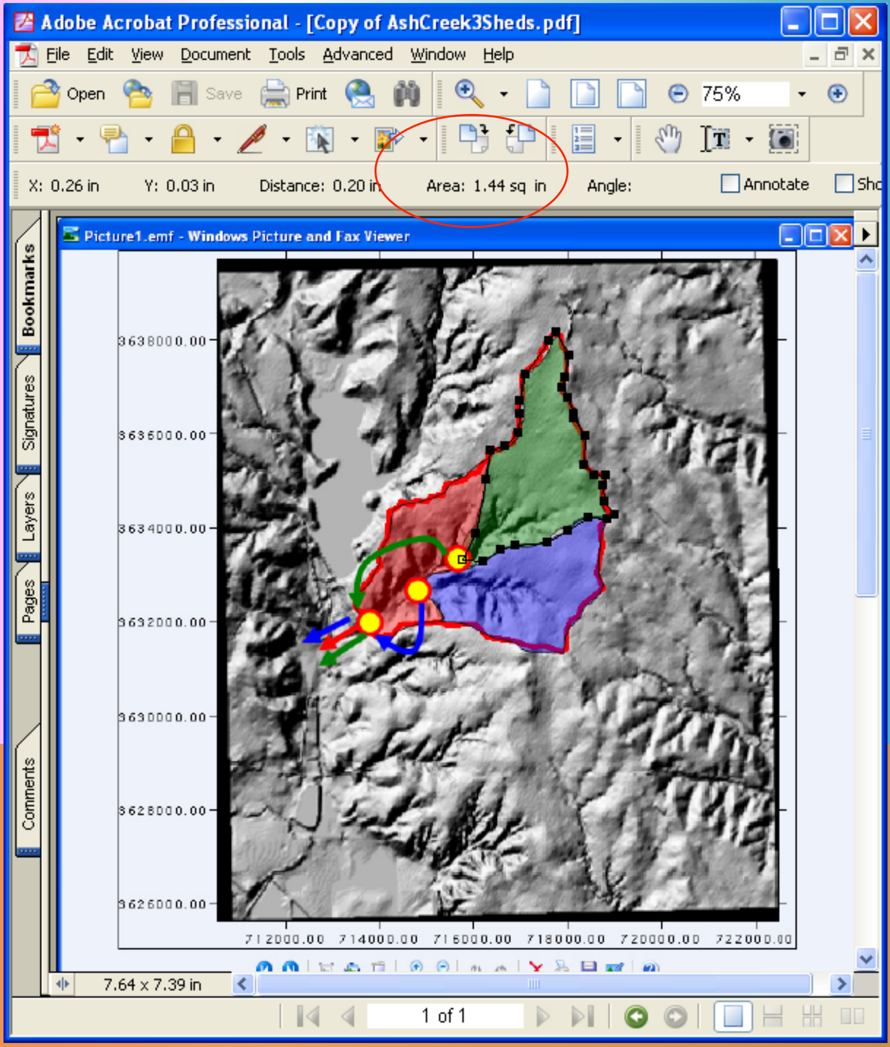
GREEN WATERSHED

Use measuring tools in acrobat.

- Measure = 1.44 sq.in.
- Convert to sq. mi.

$$1.44in^2 \times \frac{6.92mi^2}{3.73in^2} = 2.67mi^2$$

Distance from local outlet to the gage



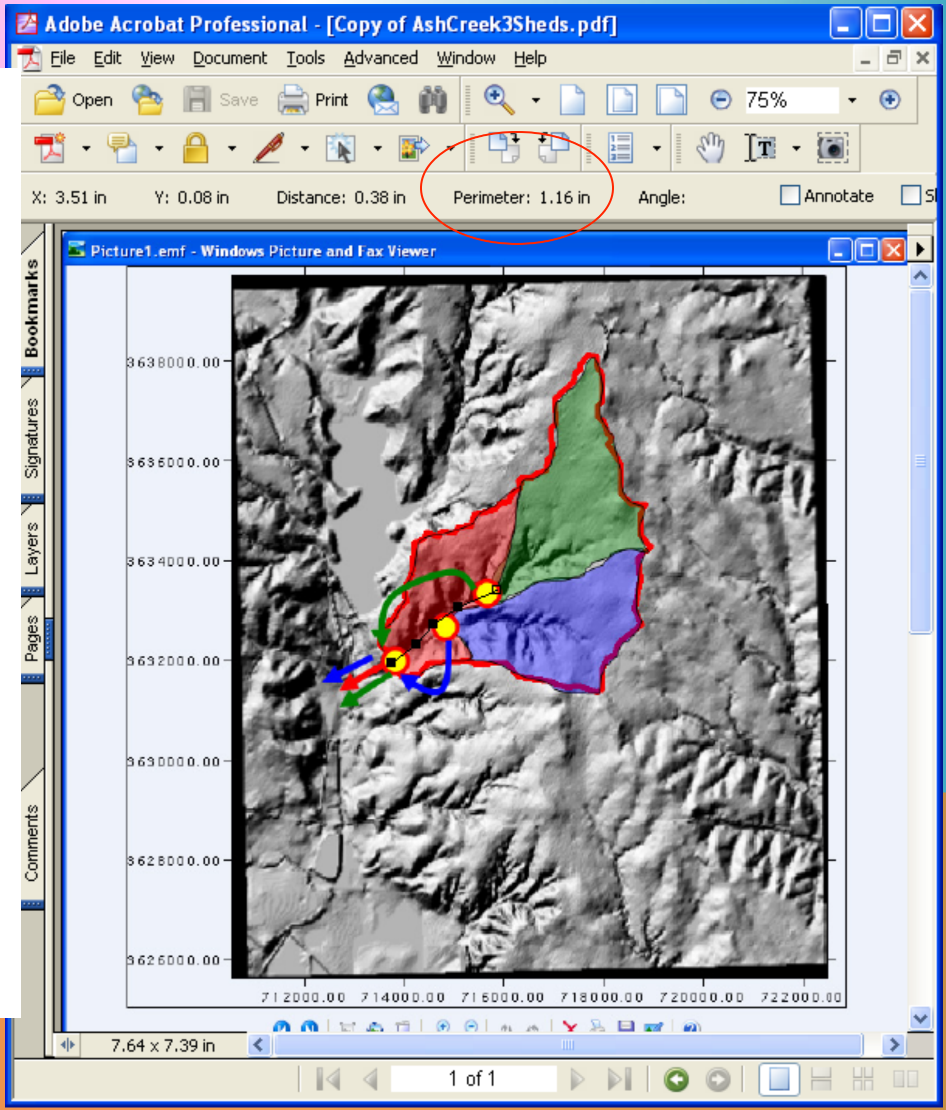
GREEN WATERSHED

Distance from local outlet to the gage

- Perimeter tool for polygon-type measurements
- Measure 1.16 in
- Convert

$$1.16in \times \frac{1000m}{0.90in} = 1288m$$

$$1288m \times \frac{3.28\,ft}{1m} = 4227\,ft$$



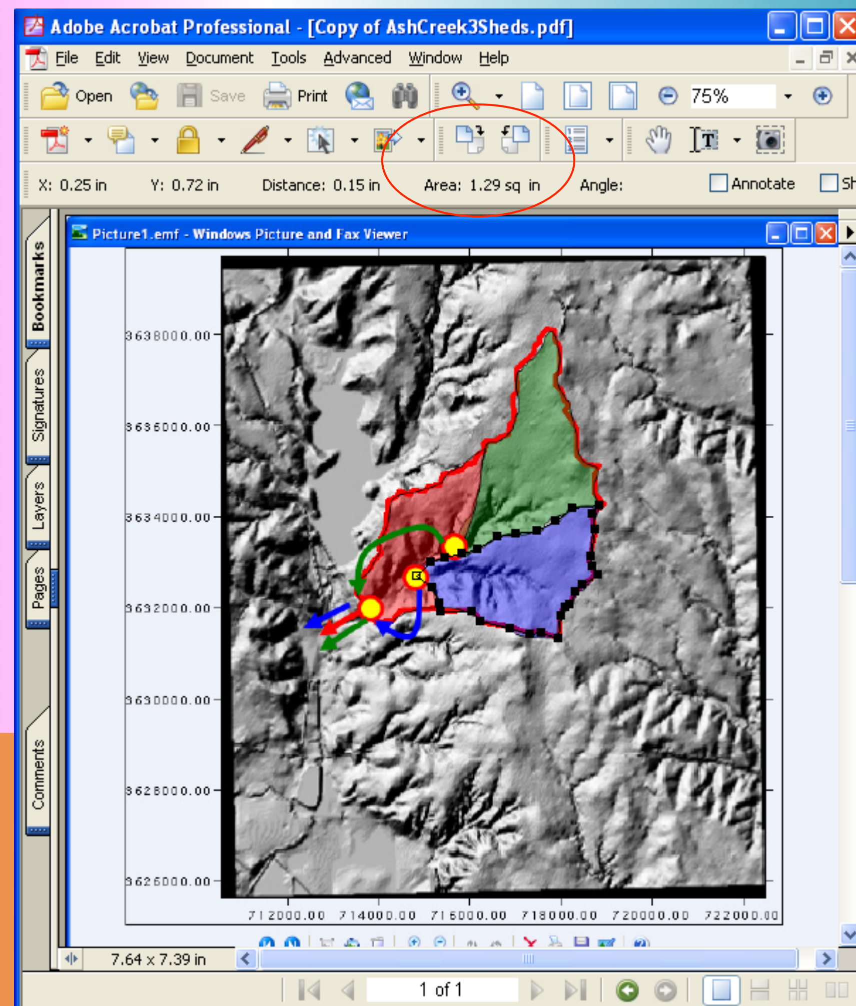
BLUE WATERSHED

Use measuring tools in acrobat.

- Measure = 1.44 sq.in.
- Convert to sq. mi.

$$1.29in^2 \times \frac{6.92mi^2}{3.73in^2} = 2.39mi^2$$

Distance from local outlet to the gage



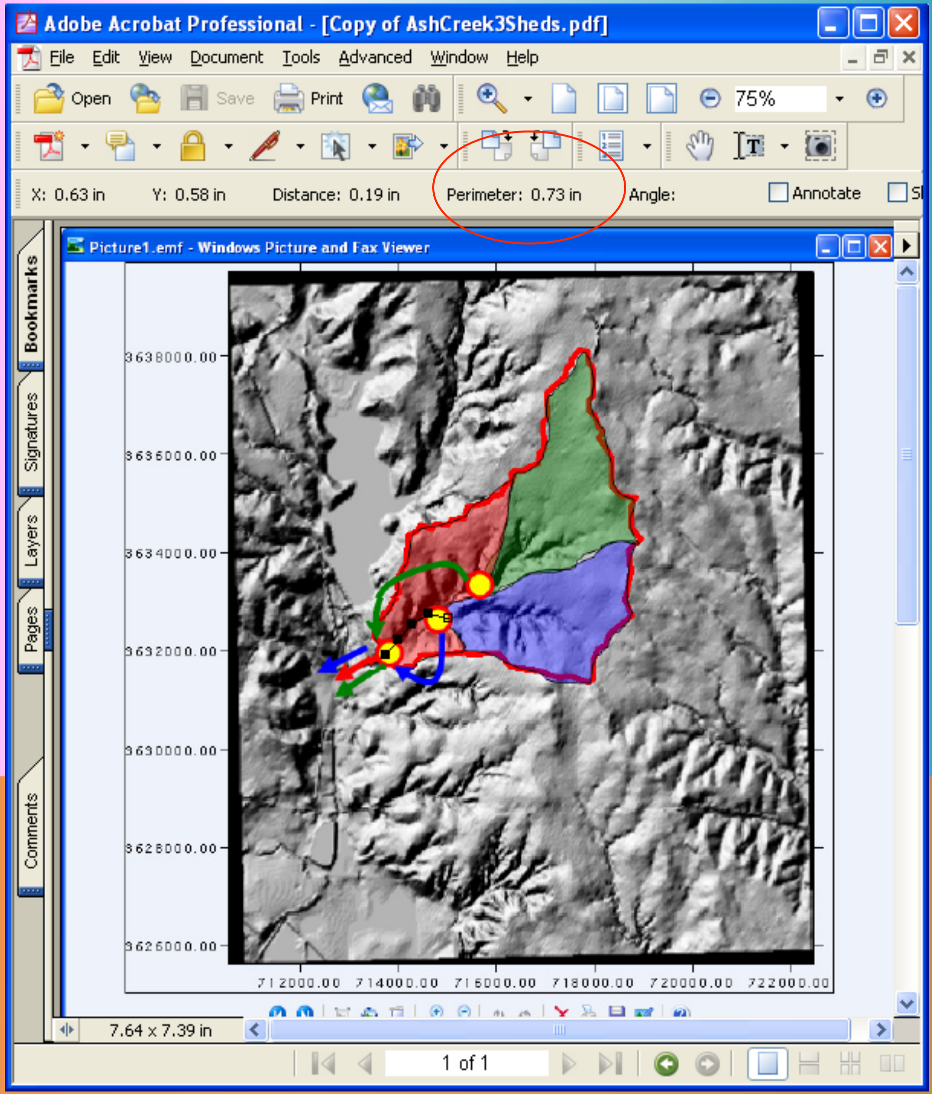
BLUE WATERSHED

Distance from local outlet to the gage

- Perimeter tool for polygon-type measurements
- Measure 0.73 in
- Convert

$$0.73in \times \frac{1000m}{0.90in} = 811m$$

$$811m \times \frac{3.28\,ft}{1m} = 2660\,ft$$



SUMMARIZE PROGRESS SO FAR

Sub-Basin ID	Property	Value
Red	AREA	1.87 sq.mi.
Red	CN	86
Red	Dist. To Outlet	0
Green	AREA	2.67sq.mi.
Green	CN	86
Green	Dist. To Outlet	4227ft
Blue	AREA	2.39sq.mi
Blue	CN	86
Blue	Dist. To Outlet	2660 ft

$$\sum A_{color} = 1.87 + 2.67 + 2.39 = 6.94 mi^2$$

Close enough (less than 1% overage), but could adjust by multiply each by 0.997

ADDITIONAL CONSIDERATIONS

The two distances to the outlet would also need an estimate of slope.

As a way to keep the example brief enough for the module, we will just assume the slope is close to the MCL reported in the earlier examples, that is S=0.0056

ADDITIONAL CONSIDERATIONS

Now need to estimate the routing information.

This example is simple lag routing, so we need a travel time from each sub-basin to the main outlet.

TxDOT research report 0-4695-2 has a method to estimate such a time.

- Use the application example at back of the report

TIME-PARAMETER ESTIMATION FOR APPLICABLE TEXAS WATERSHEDS

Meghan C. Roussel[1], David B. Thompson[2], Xing Fang[3], Theodore G. Cleveland[4], C. Amanda Garcia[1]

[1]U.S. Geological Survey, [2]Texas Tech University, [3]Lamar University, [4]University of Houston

Submitted to
Texas Department of Transportation

Research Report 0–4696–2

Department of Civil Engineering
College of Engineering
Lamar University
Beaumont, Texas 77710–0024

ESTIMATE LAG TIME FOR ROUTING

Use the values to estimate the lag time for the routing step

$$T_{green} = 0.0078 * (4227)^{0.770} (0.0055)^{(-0.385)}$$

$$T_{blue} = 0.0078 * (2660)^{0.770} (0.0055)^{(-0.385)}$$

These produce values of 37 and 26 minutes.

Ready to build a HEC-HMS model

The Kirpich Method

For channel-flow component of runoff, the Kirpich (1940) equation is

$$T_c = KL^{0.770} S^{-0.385},$$

where T_c is the time of concentration, in minutes; K is a units conversion coefficient, in which $K = 0.0078$ for traditional units and $K = 0.0195$ for SI units; L is the channel-flow length, in feet or meters as dictated by K; and S is the dimensionless main-channel slope.

Application

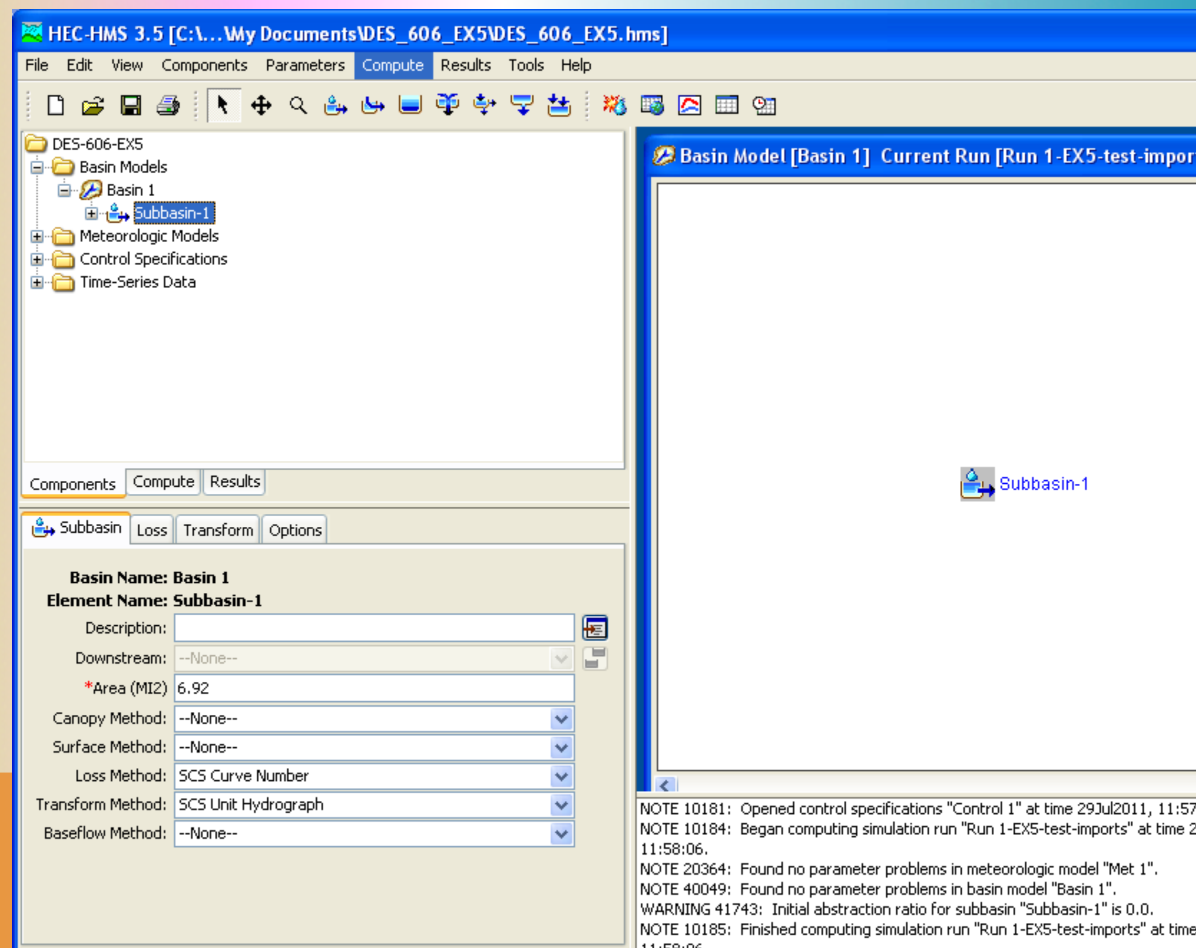
An example (shown below) illustrating

START HMS BUILD A MODEL

- New
- Can also
  - Import from another model

Verify the import

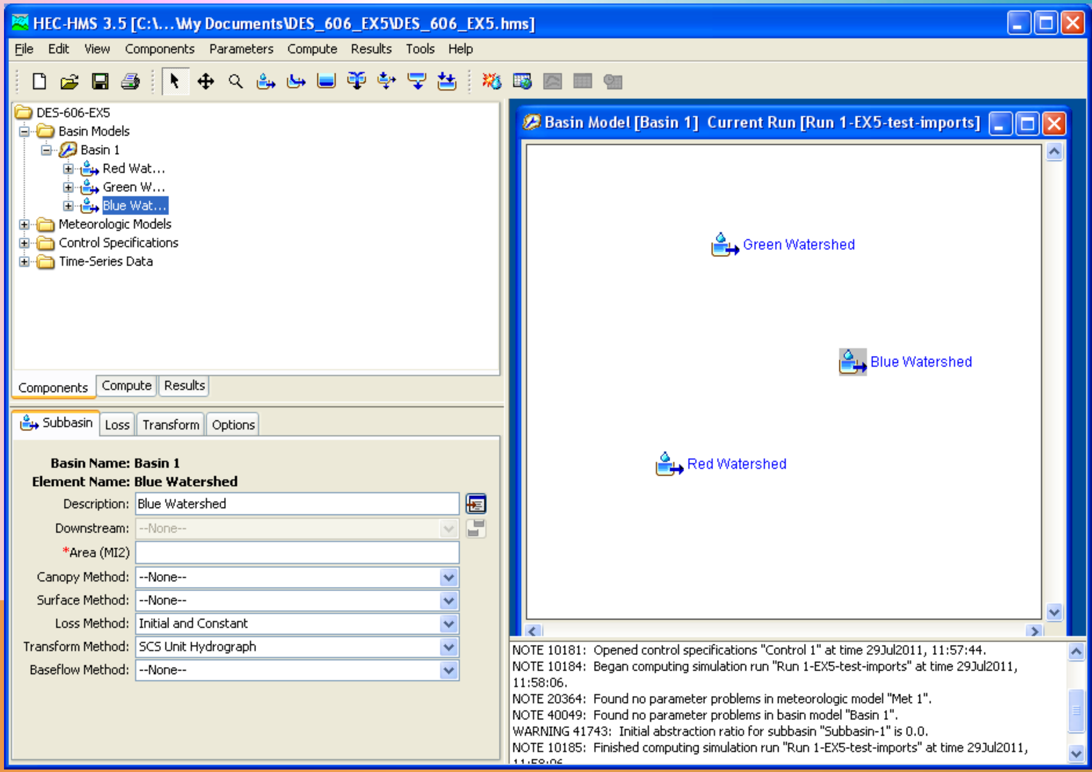
- Run and look for errors



EXAMPLE 6 – CLONE A PRIOR MODEL

Modify the basin model

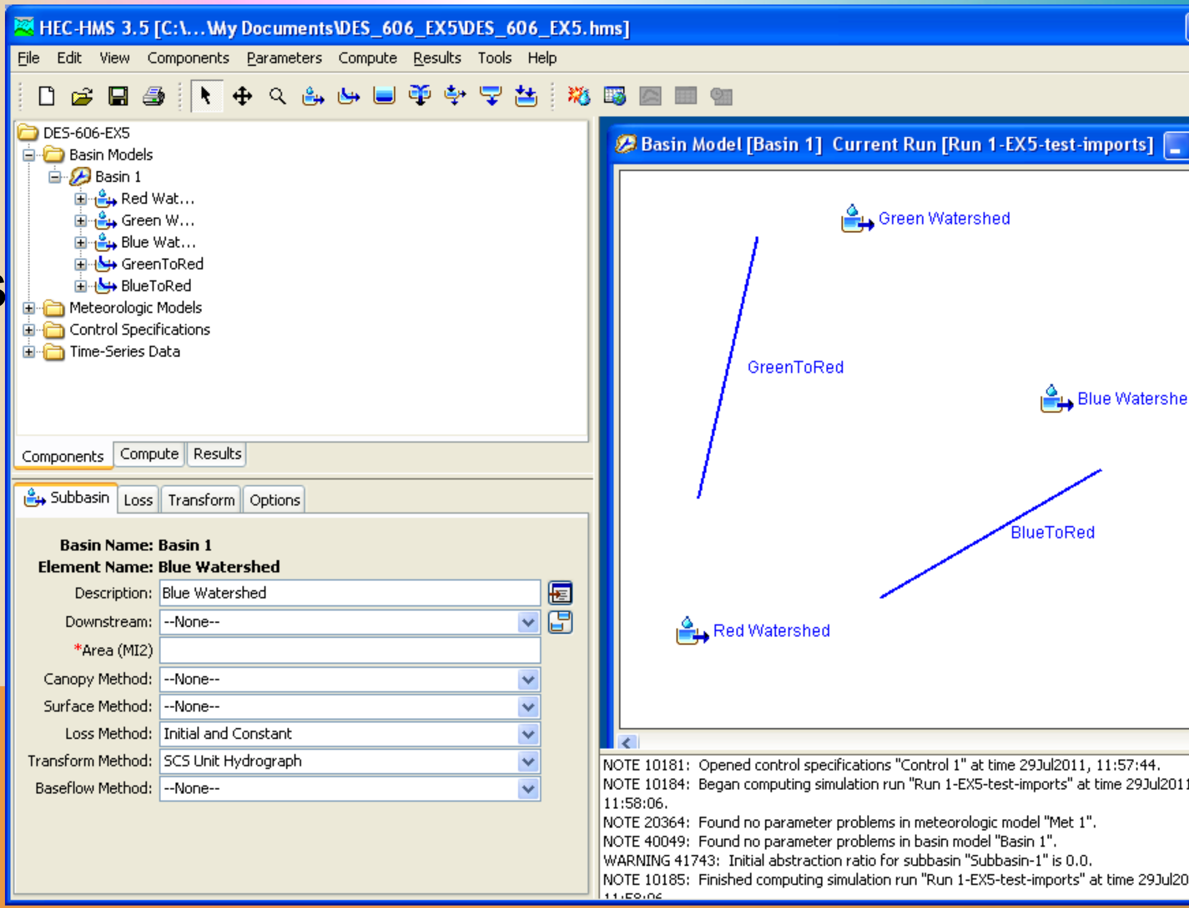
- Three sub-basins.



EXAMPLE 6 – CLONE A PRIOR MODEL

Modify the basin model

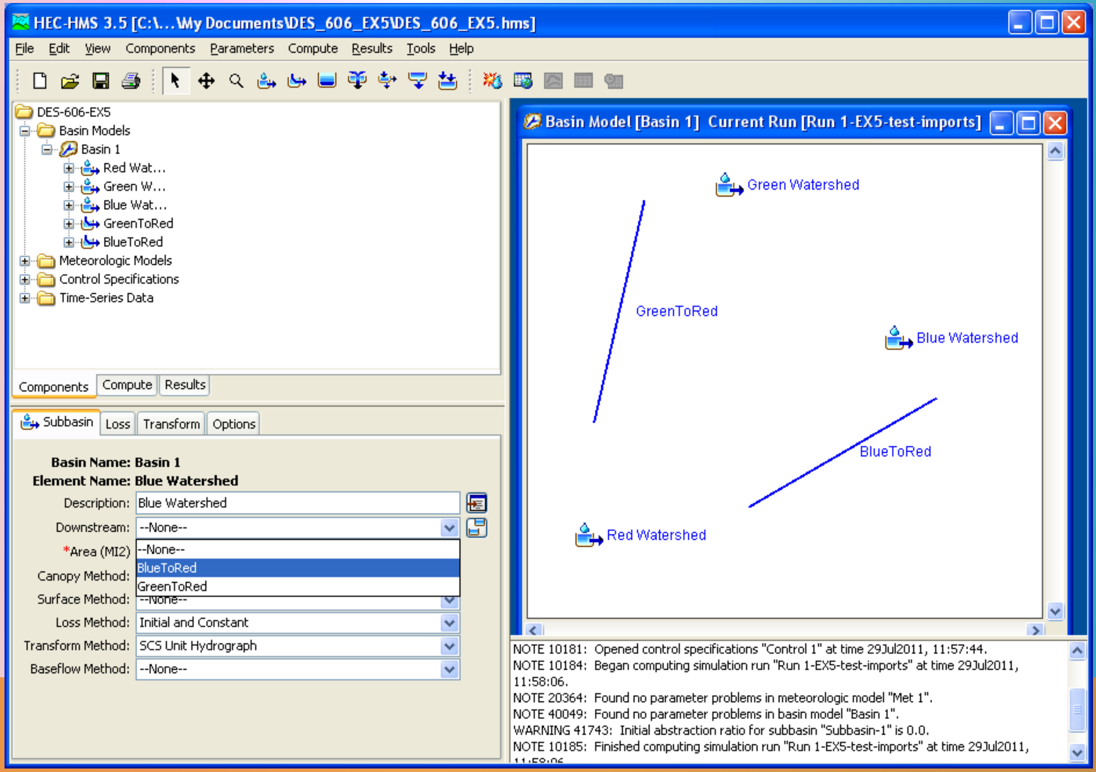
- Three sub-basins.
- Create routing elements (reaches)



EXAMPLE 6 – CLONE A PRIOR MODEL

Reaches

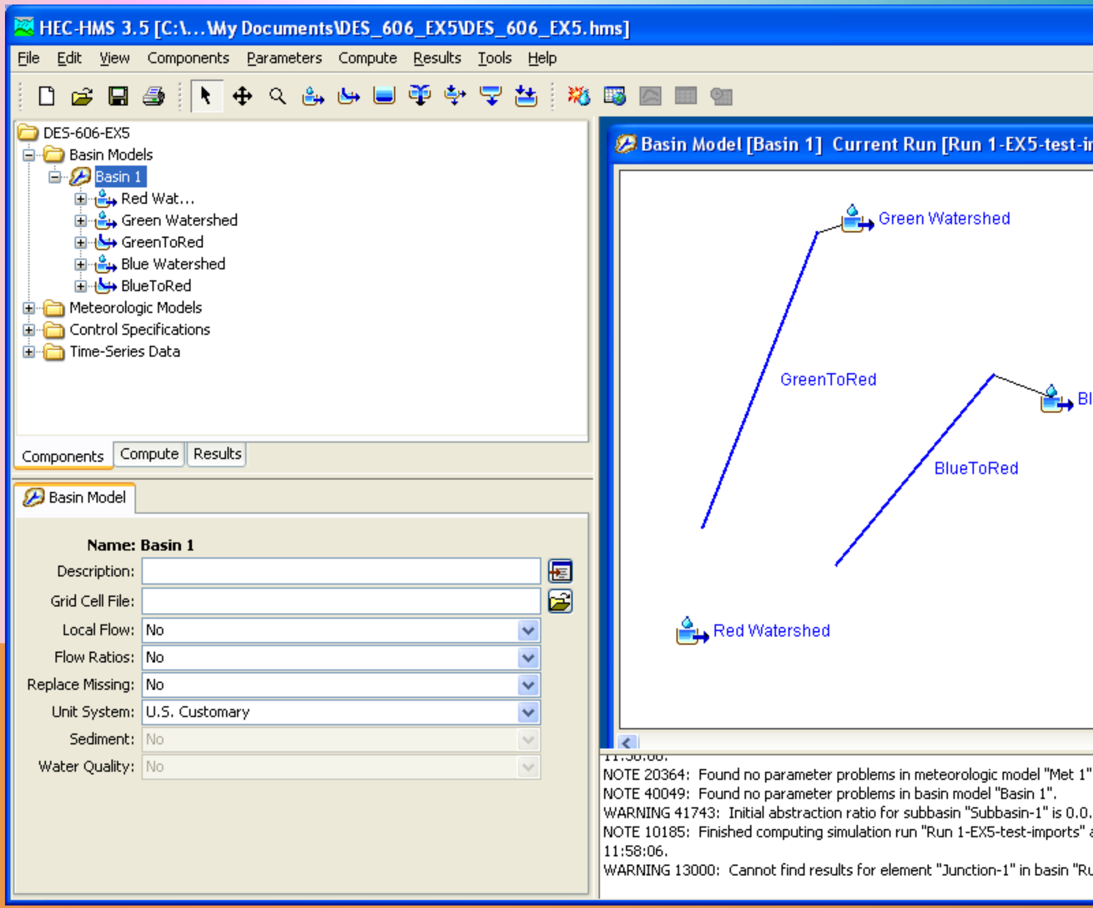
- Not connected, will supply connectivity in various “downstream” specifications.



EXAMPLE 6 – CLONE A PRIOR MODEL

Reaches

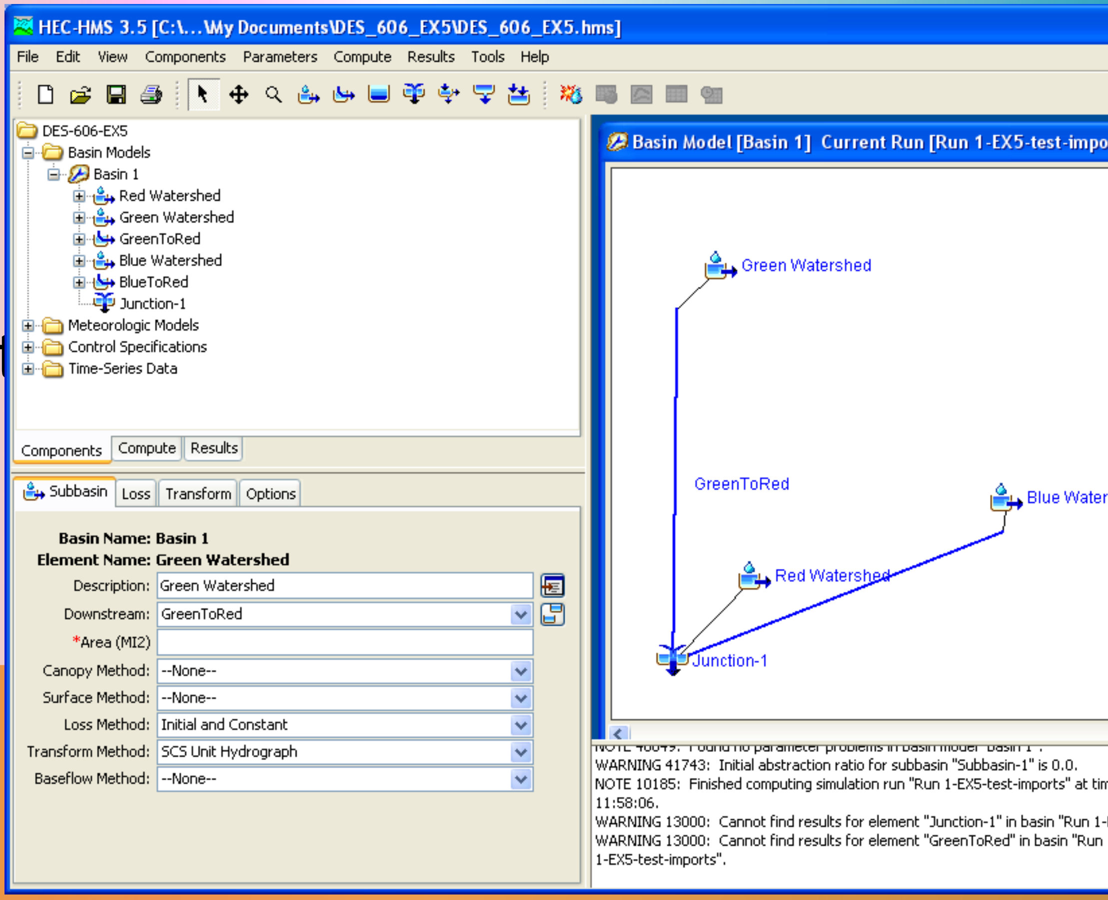
- Have Green and Blue reaches connected to their upstream elements, but they cannot connect to a watershed element
- Use a “Junction” element.



EXAMPLE 6 – CLONE A PRIOR MODEL

Connection Diagram

- After a bit of fussing, here is our hydrologic system.
- Watersheds (G&B) connect downstream to their reaches, than connect to the junction.
- Watershed (R) connects directly to the junction

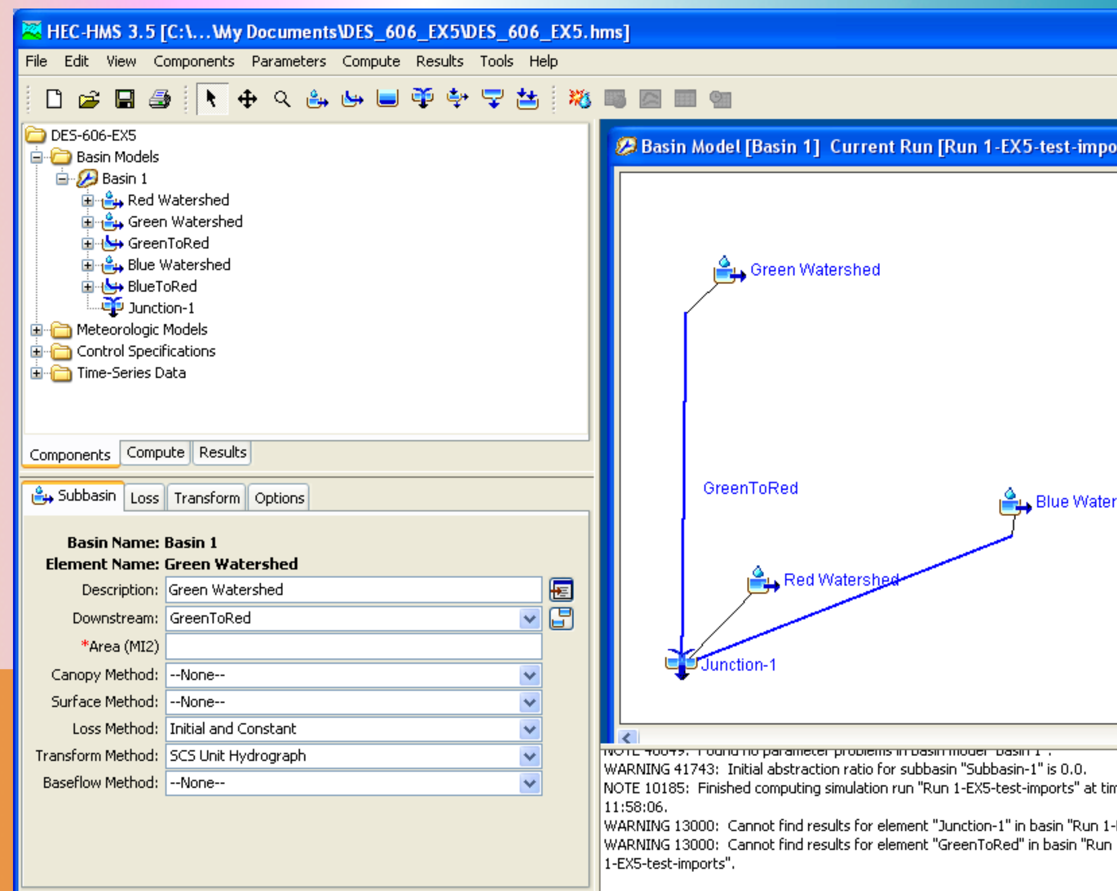


EXAMPLE 6 – CLONE A PRIOR MODEL

Now parameterize each element.

- Watersheds
- Reaches

Discover that we now need to re-estimate the watershed response times, as each sub-basin is now smaller.



EXAMPLE 6 – CLONE A PRIOR MODEL

Discover that we now need to re-estimate the watershed response times, as each sub-basin is now smaller.

- Use our methods for these “new” times

Resulting times are:

- RED: 41 minutes
- GREEN: 49 minutes
- BLUE: 46 minutes

EXAMPLE 6 – CLONE A PRIOR MODEL

Enter these times into the respective sub-basin Transform models

Update the Meterological Model

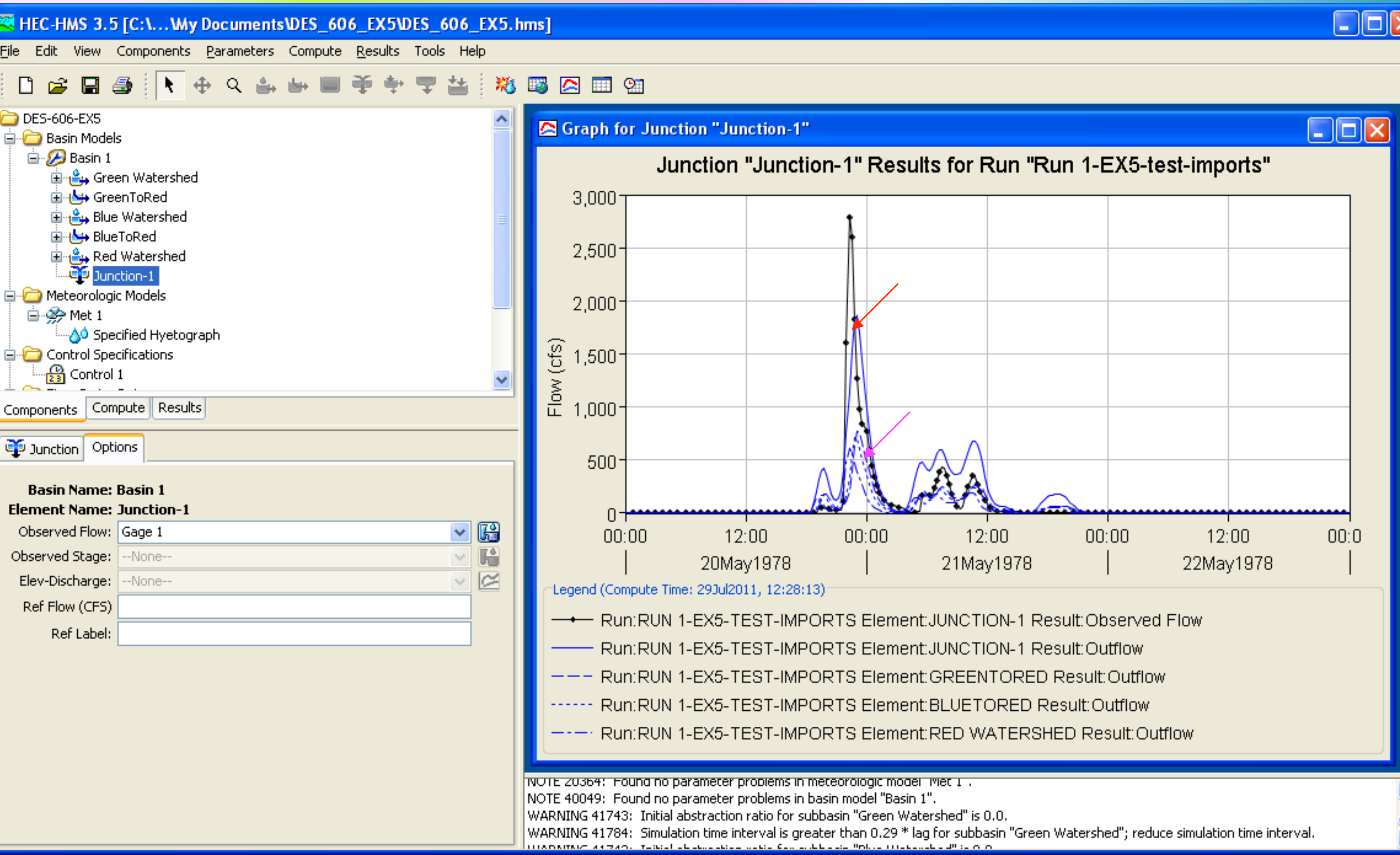
- Need all 3 sub-basins receiving rain from Gage 1

Move the “observed” flow to the junction so we can examine the output of the combined hydrographs.

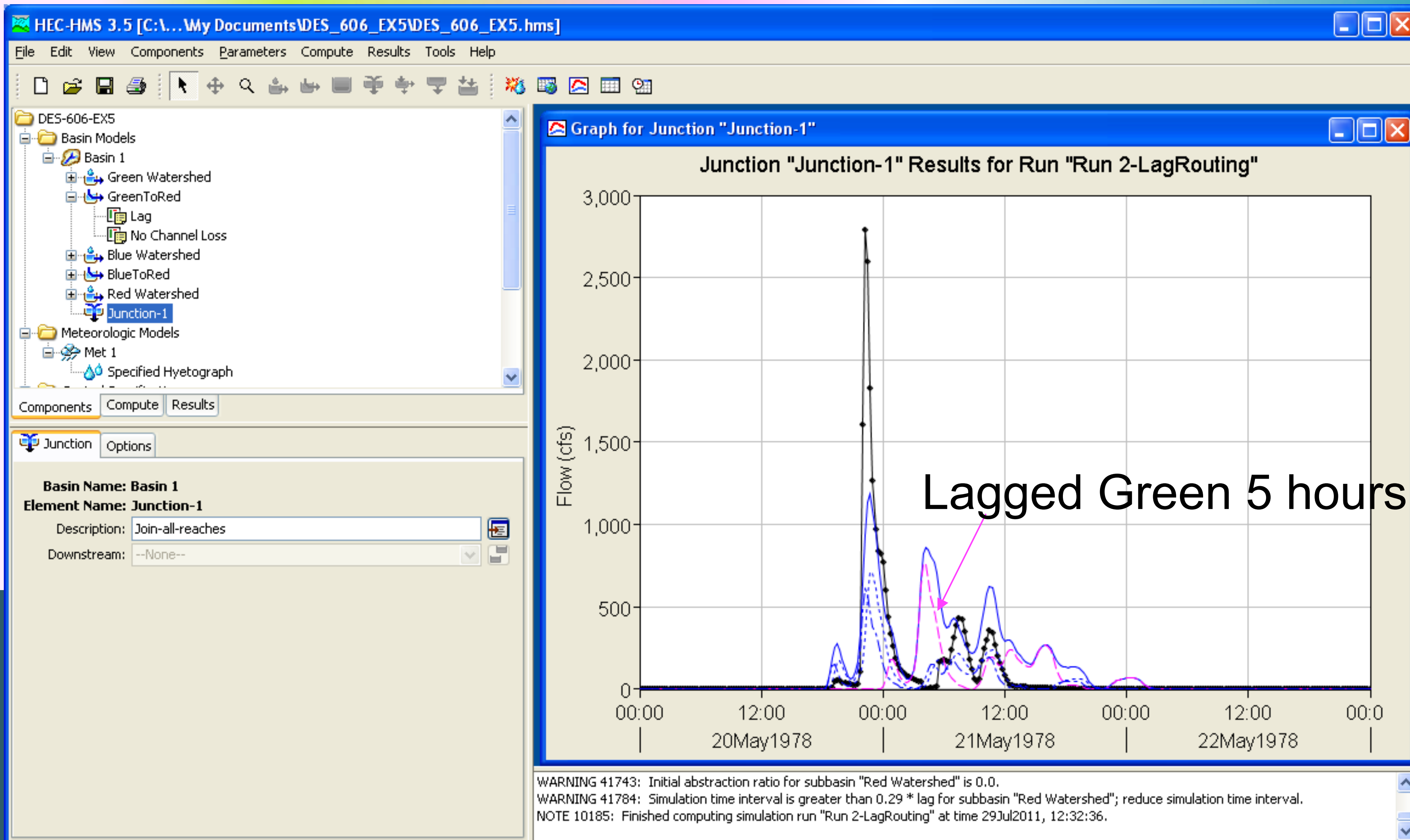
Run the model and diagnose warnings/errors

- Forgot to update the Loss models for the 2 new watersheds, so go back and fix and retry.
- Clean run, lets examine the output.

EXAMPLE 6 – LAG ROUTING



LONG ROUTING LAG GREENTORED



HEC-HMS EXAMPLE 6

Learning Summary

- Configured a multiple sub-basin model.
  - Introduce the "junction" element
  - Introduce the "reach" element
- Used external tools to measure sub-basis sizes and routing distances.
  - Calculations to determine scaled watershed areas
  - Calculations to determine routing distances (for lag routing)

HEC-HMS EXAMPLE 6

Learning Summary

- Used 0-4696-2 report to estimate lag routing time parameters.
  - Kerby-Kirpich variant.
  - Calculations to estimate lag times
- Used 0-4696-2 (“rule of thumb”) to estimate revised watershed characteristic times.
  - Sub-basins are smaller that original single-basin model, response time must be adjusted!

- The model here is almost the same layout as the Hardin Creek case except:
  - SCS reservoirs on North and West
  - Reservoir at the crossing

  BUT CLOSE

HEC-HMS EXAMPLE 6

Learning Summary

- Updated model components and ran several diagnosis tests
  - Run the model and let the program identify missing components
  - Go back to component editor and fix the missing items.
- Run the “multiple-basin” model and interpret results.

HEC-HMS EXAMPLE 6

Closing Remarks

- Examples 4 and 5 provide illustrations of how to construct and populate input for most HEC-HMS situations the analyst is likely to encounter.
- These examples are pedagogical in intent.

HEC-HMS requires a lot of external (to the program) thinking and preparation

- Assemble data reports before modeling if at all possible.

HEC-HMS EXAMPLE 6

Learn more

- HEC HMS user manual
- FHWA-NHI-02-001 Highway Hydrology

Next module

- Parametric Unit Hydrographs