111 TOTAL (INCLUDING NAME)

Student Name: SOLUTION (+1) FALL 2014

CE 3354 Engineering Hydrology Exam 2, Fall 2014[1]

1. Figure 1 is a flood frequency curve for somewhere in Texas. Using the curve answer the following questions:

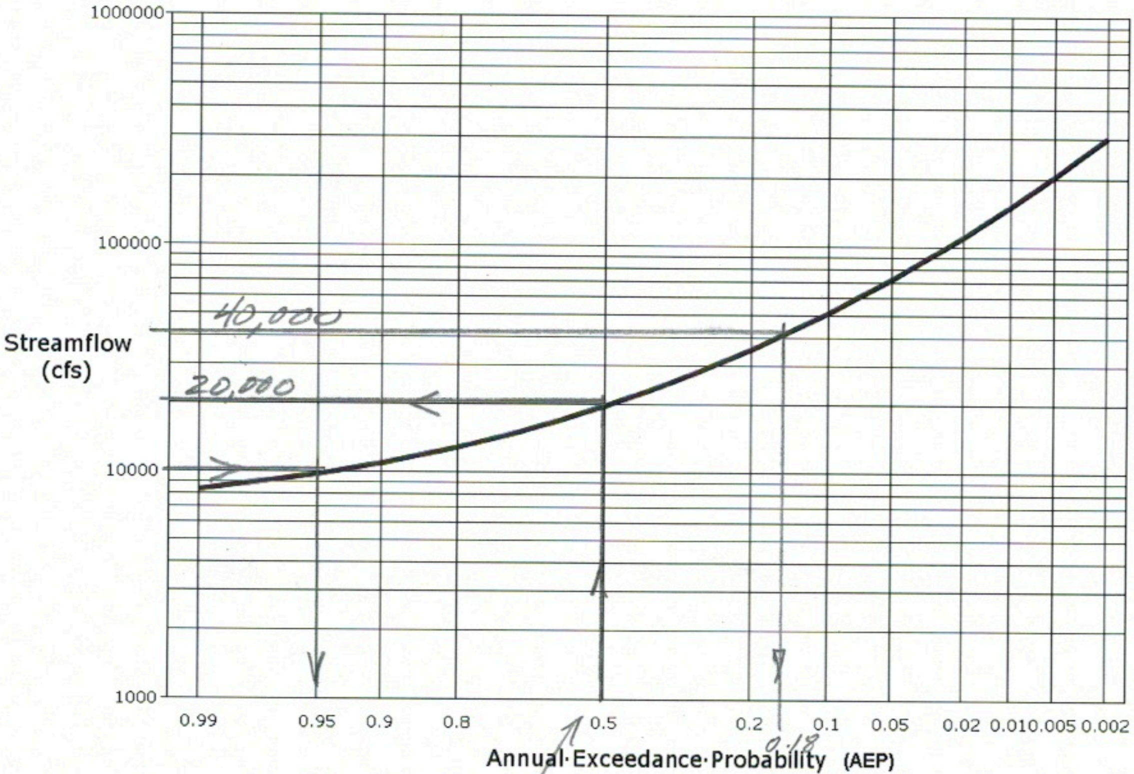

Figure 1: Flood frequency curve for a gaging station

(a) What is the median (50% probability) streamflow magnitude indicated by the curve?

20,000 cfs (+2; value; units)

(b) What is the probability of observing a discharge of magnitude of 10,000 CFS or **more** indicated by the diagram?

0.95 or 95% (+1 value)

(c) What is the probability of observing a discharge of magnitude 40,000 CFS or **less** indicated by the diagram? (+2; value; logic or arithmetic)

40,000 or more is 0.18 ∴ 40,000 or less is 1 − 0.18 = 0.82 (or 82%)

[1]Students should write their name on all sheets of paper. Students are permitted to use Laptops, Tablets, and smart phones for **browsing** the internet to help answer questions. Students are permitted to use their own notes and the textbook to help answer questions.

6 pts this page

2. Figure 2 is a topographic map of a small drainage basin. The drawn contour interval is 20 feet. Many of the contours are labeled.

   A stormwater detention structure (dam) is to be is built on the Eastern portion of the basin, near the outlet shown on Figure 2. The purpose of the detention structure is to reduce the peak discharge downstream of the structure.

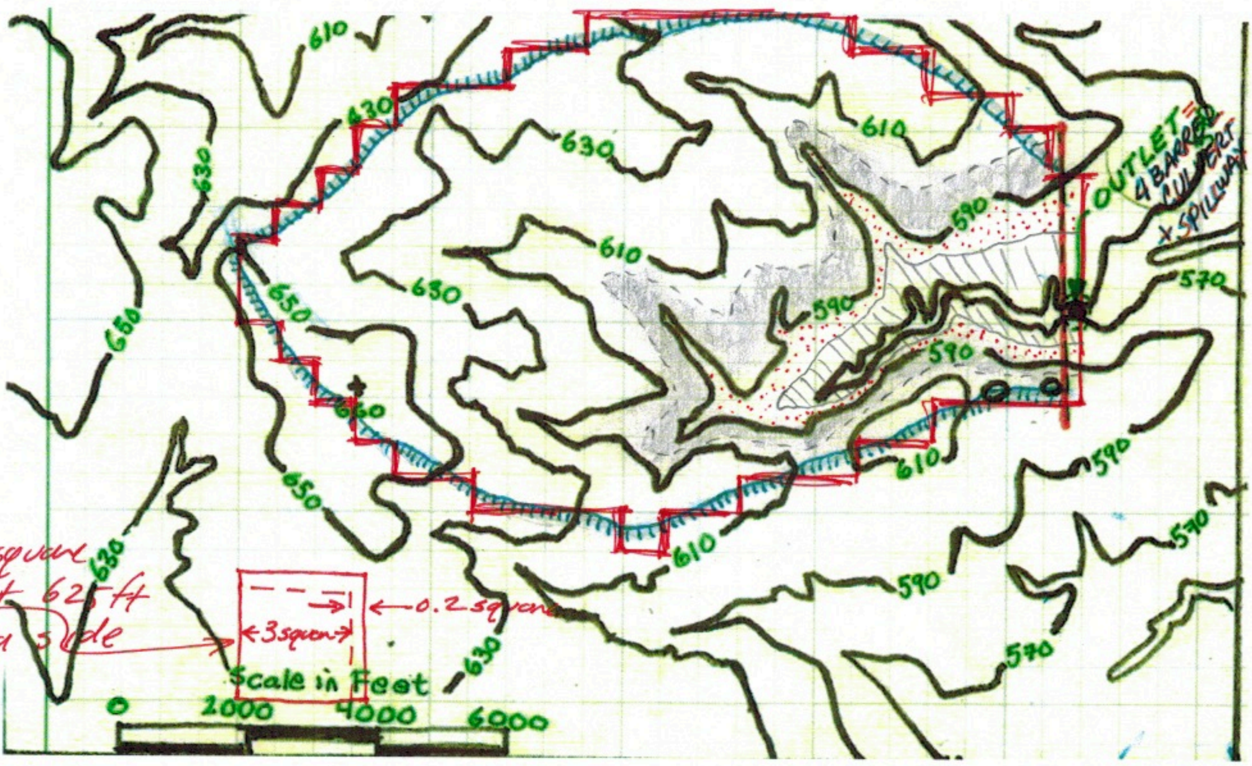

Figure 2: Topographic Map of a portion of the Earth. Elevations and linear distances are in *feet*. North (by convention) is up.

The dam spillway crest (elevation at which water will go over the top of the dam) is 595 *feet*. The dam also has 4 parallel, 2-foot diameter, 100-foot long culverts at its base to drain the detention structure, this culvert system is similar in appearance as the system depicted in Figure 3 The culverts are laid on a slope of 0.006. Manning's n for each culvert is 0.018. The entrance and exit coefficients are unity (1). The alignment of the dam is depicted by the vertical dashed line segment next to the outlet.

(a) Estimate the drainage area in square feet of the drainage basin. The boundary is already drawn on the map.

180 - 220 OK range

[square] $= 625 \times 625 = 390{,}625\ ft^2$ (+3; show logic how area & squares relate; value; units)

~ 205 squares $\times$ $390{,}625\ ft^2/sq = 80{,}078{,}125\ ft^2$ (+2; square count; conversion arithmetic) (+2 value, units)

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Figure 3: Multiple-barrel outlet structure

(b) Convert the drainage area from square feet into acres.

$80{,}078{,}125 ft^2 \frac{1 ac}{43560 ft^2} = 1838.3 ac.$ (1640 ↕ 2000 OK range)

(+3; conversion arithmetic, value; units)

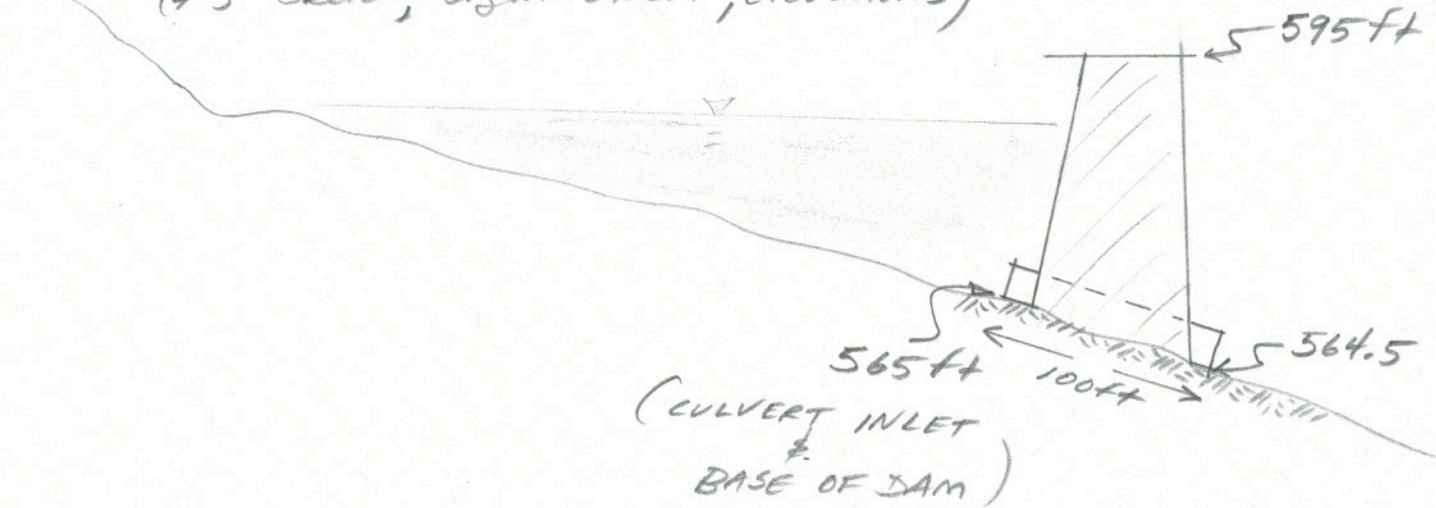
(c) Convert the drainage area from acres into square miles.

$1838.3 ac \frac{1 mi^2}{640 ac} = 2.872 mi^2$ (2.4 ↕ 3.2 OK range)

(+3; conversion arithmetic; value; units)

(d) The water surface area when the dam impounds water to a water surface elevation of 565 *feet* is assumed to be essentially zero. Sketch an elevation (side) view of the reservoir and outlet works – indicate elevations on the sketch of the base of the dam, the spillway crest, the culvert inlet elevation, and culvert outlet elevation.

(+5 sketch; length culvert; elevations)



12 pts this page

(e) Estimate the water surface area when the dam impounds water to a water surface elevation of 570 *feet*.

~ 8/3 cells (+4 cell count (any); conversion; value; unit)

$\frac{8}{3} \times 390{,}625 ft^2 = 1{,}041{,}666 ft^2 \cdot \frac{1 ac.}{43{,}560 ft^2} = 23.9 ac$

(f) Estimate the water surface area when the dam impounds water to a water surface elevation of 580 *feet*. (+4)

$\sim 15 \text{ cells} \times 390{,}625 ft^2 = 5{,}859{,}375 ft^2 \cdot \frac{1 ac.}{43{,}560 ft^2} = 137.5 ac$

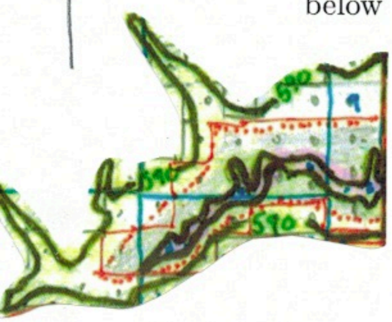
(g) Estimate the water surface area when the dam impounds water to a water surface elevation of 590 *feet*. (+4)

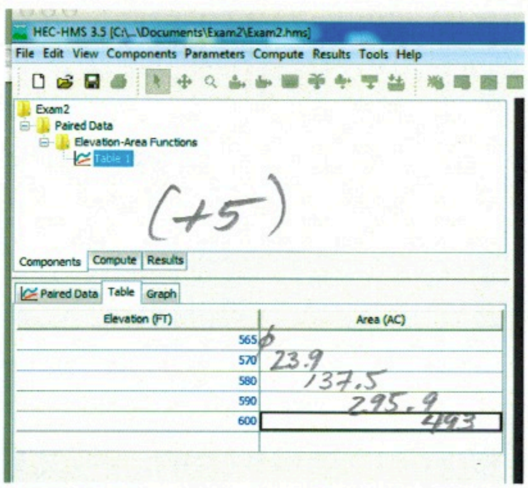
$\sim 33 \text{ cells} \times 390{,}625 ft^2 = 12{,}890{,}625 ft^2 \frac{1 ac.}{43{,}560 ft^2} = 295.9 ac$

(h) Estimate the water surface area when the dam impounds water to a water surface elevation of 600 *feet*. (+4)

$\sim 55 \text{ cells} \times 396{,}625 ft^2 = 21{,}484{,}375 ft^2 \cdot \frac{1 ac.}{43{,}560 ft^2} = 493 ac.$

(i) Use these estimates to complete the Elevation-Area Function Table in Figure 4 below





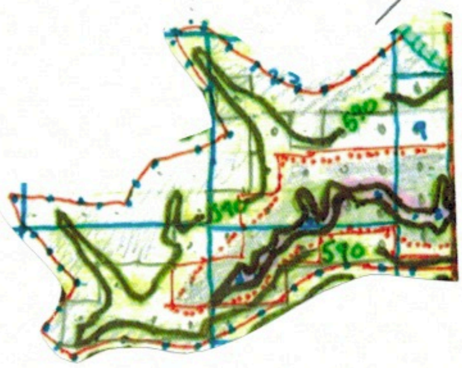


Figure 4: Elevation-Area Function Data Entry Dialog from HEC-HMS

3. Figure 5 is a tabulation of an observed storm and runoff for the drainage area depicted by the map in Figure 2 before installation of the detention facility.

TIME-HOURS	ACC-RAIN-INCHES	OBSERVED-FLOW-CFS	
0	0.000	0.00	
1	0.000	0.00	
2	0.000	0.00	
3	0.000	0.00	
4	0.000	0.00	
5	0.000	0.00	
6	0.000	0.00	
7	0.000	0.00	
8	0.101	1.40	·3600 sec = 5,026
9	0.106	0.31	·3600 sec = 1,116
10	0.111	0.31	·3600 sec = 1,116
11	0.115	0.31	·3600 sec = 1,116
12	0.120	0.31	·3600 sec = 1,116
13	0.120	0.40	·3600 sec = 1,424
14	0.150	0.40	·3600 sec = 1,424
15	0.750	24.66	·3600 sec = 88,768
16	2.750	588.23	·3600 sec = 2,117,634
17	2.940	808.70	·3600 sec = 2,911,331
18	3.030	154.28	·3600 sec = 555,398
19	3.030	94.68	·3600 sec = 340,834
20	3.030	27.56	·3600 sec = 99,212
21	3.090	36.13	·3600 sec = 130,067
22	3.210	19.65	·3600 sec = 70,730
23	3.300	7.00	·3600 sec = 25,206
24	3.300	0.00	

+17 pts if show work here or show shortcut/logic

$\Sigma = 6,351,526.2$

Figure 5: Cumulative rainfall for a 24-hour period on watershed determined for Figure 2

(a) Estimate the total **volume** of runoff in cubic feet from the storm.

VOLUME = [Σ OBS. FLOW (CFS)] [3600 sec] = 6,351,526.2 ft^3

Δt distributes because all 1hr.
If Δt varies, then must add row by row result of Q*Δt = ΔVol

(+2; value; units)

20 pts this page

(b) Convert the estimate of runoff volume from cubic feet into watershed inches.

Depth = Volume / area

$$\frac{6{,}351{,}526.2\ ft^3}{80{,}078{,}125\ ft^2} = 0.079\ ft \cdot \frac{12\ in}{ft}$$

$= 0.95$ inches

(+5; formula; arithmetic; conversion; value; units)

(c) Using the runoff volume in watershed inches, estimate the value of S in the SCS equation (8.6.5 in Textbook);

P	S	P_e
3.30	1.37	1.27
3.30	3.3	1.17
3.30	3.9	0.98
3.30	4.0	0.96 ~ 0.95 Use this row
3.30		

$$P_e = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (1)$$

(+3; result; logic or statement how get S)

(d) Using the value of S just computed, estimate the value of CN in the CN equation (8.6.6 in Textbook);

$$S = \frac{1000}{CN} - 10 \qquad (2)$$

$CN = \frac{1000}{S+10}$ (Algebra)

(+3; result; algebra; round to whole value)

$$CN = \frac{1000}{4.0+10} = 70.92$$

Use 71

12 pts this page

(e) Use the estimate to complete the data entry dialog depicted in Figure 6 below:

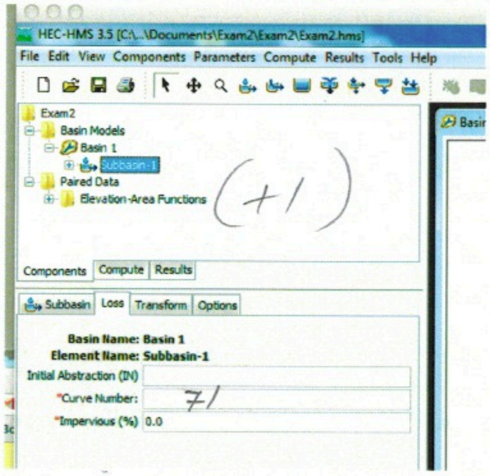
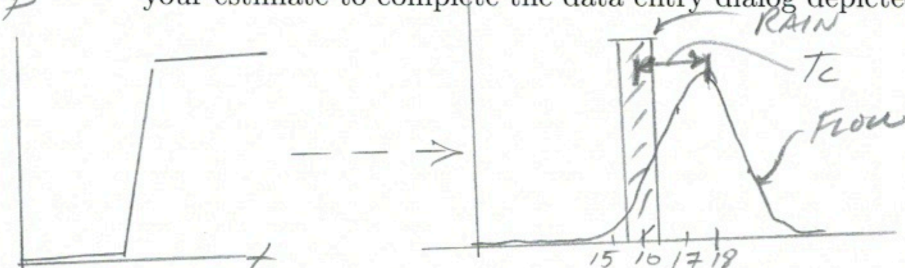
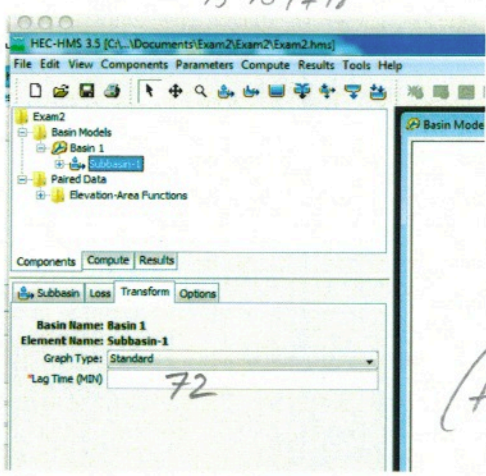


Figure 6: Loss Model Data Entry Dialog from HEC-HMS

(f) Describe how to estimate basin lag time from the observation time series and use your estimate to complete the data entry dialog depicted in Figure 7 below:





$t_{lag} \approx 0.6\, t_c$

$t_c = 2\,hrs = 120\,min$

$0.6(120) = 72\,min$

Use 72

(+3; result; logic

Figure 7: Transform Model Data Entry Dialog from HEC-HMS

4. A HEC-HMS model must have three components to run. Circle the three components required for any HEC-HMS model to run in Figure 8

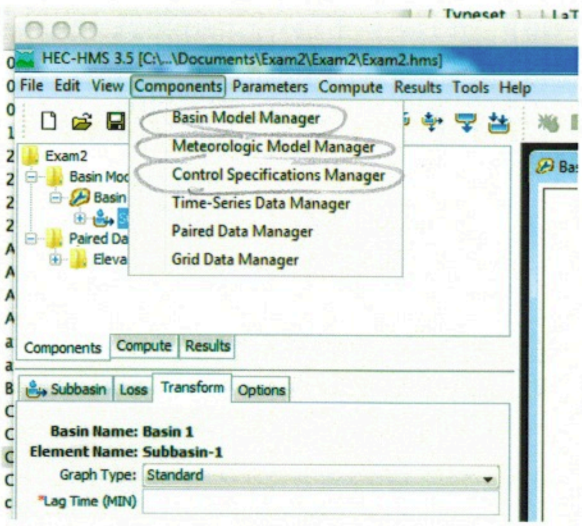


Figure 8: Components pull-down menu in HMS

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5. A connectivity diagram of a HEC-HMS model of the drainage basin depicted in Figure 2 **before** the installation of the detention facility is best represented by which figure below?

No reservoir → This one

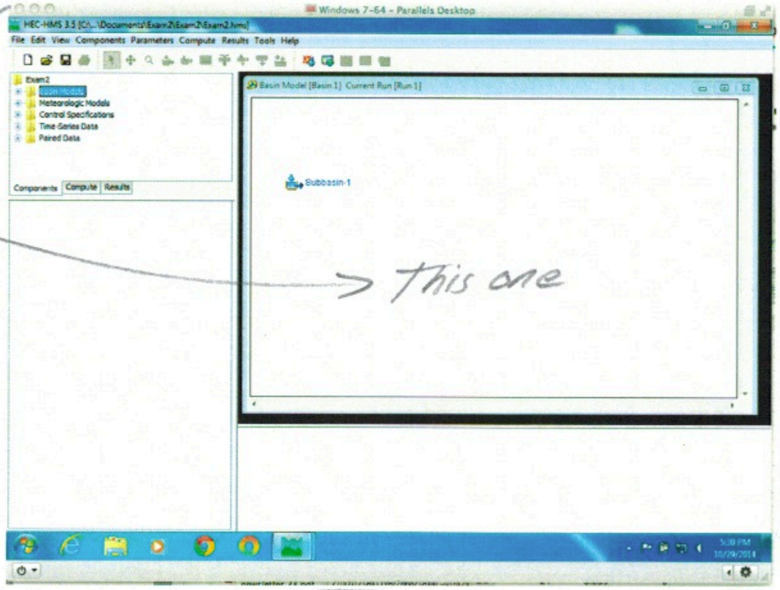


Figure 9: Model A

No reservoir "before" layout

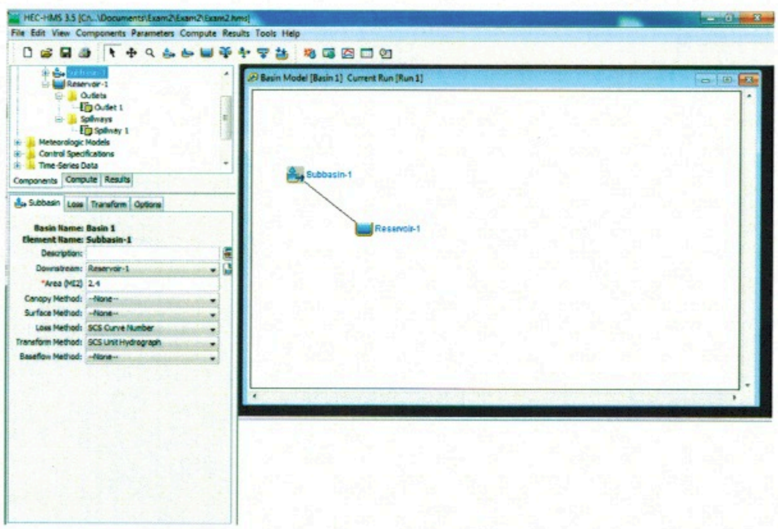


Figure 10: Model B

(+2 select; explain why select)

3 pts this page

6. A connectivity diagram of a HEC-HMS model of the drainage basin depicted in Figure 2 **after** the installation of the detention facility is best represented by which figure below?

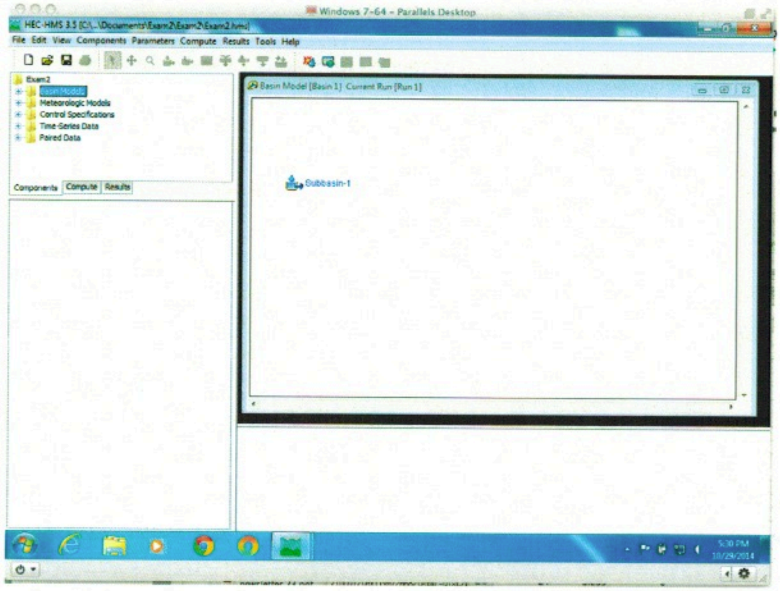
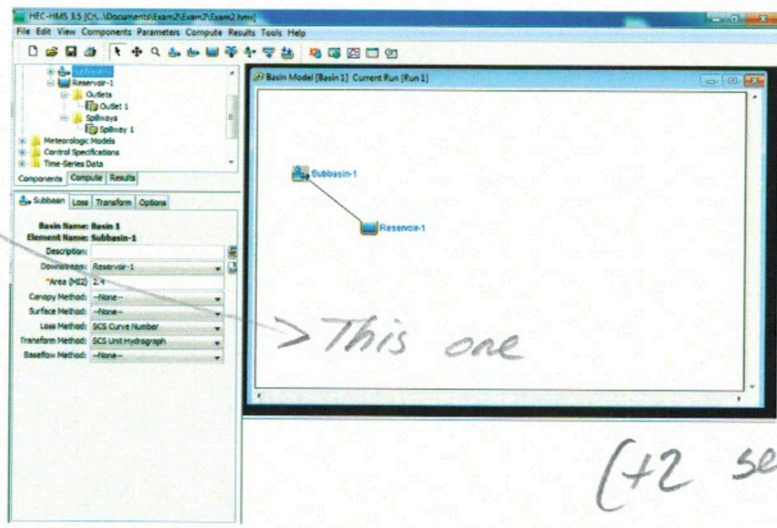


Figure 11: Model A



> This one

(+2 select; explain why)

Figure 12: Model B

Reservoir added; "after" conditions

3 pts this page

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7. Build the HEC-HMS model depicted as Model B. Use the estimates to parameterize the model and simulate the observed storm. Adjust CN and Lag Time so that the peak discharges in the simulated and observed time series are within 15 percent of each other. Adjust the overall simulation time (Control Specifications) so that the reservoir drains completely (2 days should be sufficient with the outlet works described earlier.).

   (a) What is the observed peak discharge at the outlet from the watershed (inlet to the reservoir) in cubic feet per second?

   808.7 cfs (firm) (+2 value; units)

   (b) What is the simulated peak discharge at the outlet from the watershed (inlet to the reservoir) in cubic feet per second?

   480 – 536 – 580 (+2 value, units) before change CN to match Qp

   720 – 804 – 880 (+1 if adjust) after CN to match Qp

   (c) When is the time to peak in your model at the outlet from the watershed (inlet to the reservoir) for the observed discharges?

   17:00 (elapsed time) (+1)

   (d) When is the time to peak in your model at the outlet from the watershed (inlet to the reservoir) for the ~~observed~~ simulated discharges?

   17:00 (elapsed time) (+1)

   (e) What is the simulated peak discharge at the outlet of the reservoir in cubic feet per second?

   80 – 99 – 120 (+2 value; units) before change CN

   80 – 107 – 120 (+1 extra if adjust) after change CN to match Qp

   (f) When is the simulated peak discharge at the outlet of the reservoir?

   20:00 (elapsed) (+1)

   (g) What is the maximum pool elevation of the reservoir for the storm?

   565 – 570 ft – 585 (+2 value; units)

   (h) How much is the peak discharge reduced by the reservoir?

   804
   – 107

   630 – 697 cfs – 770 (+2 value; units)

16 pts this page

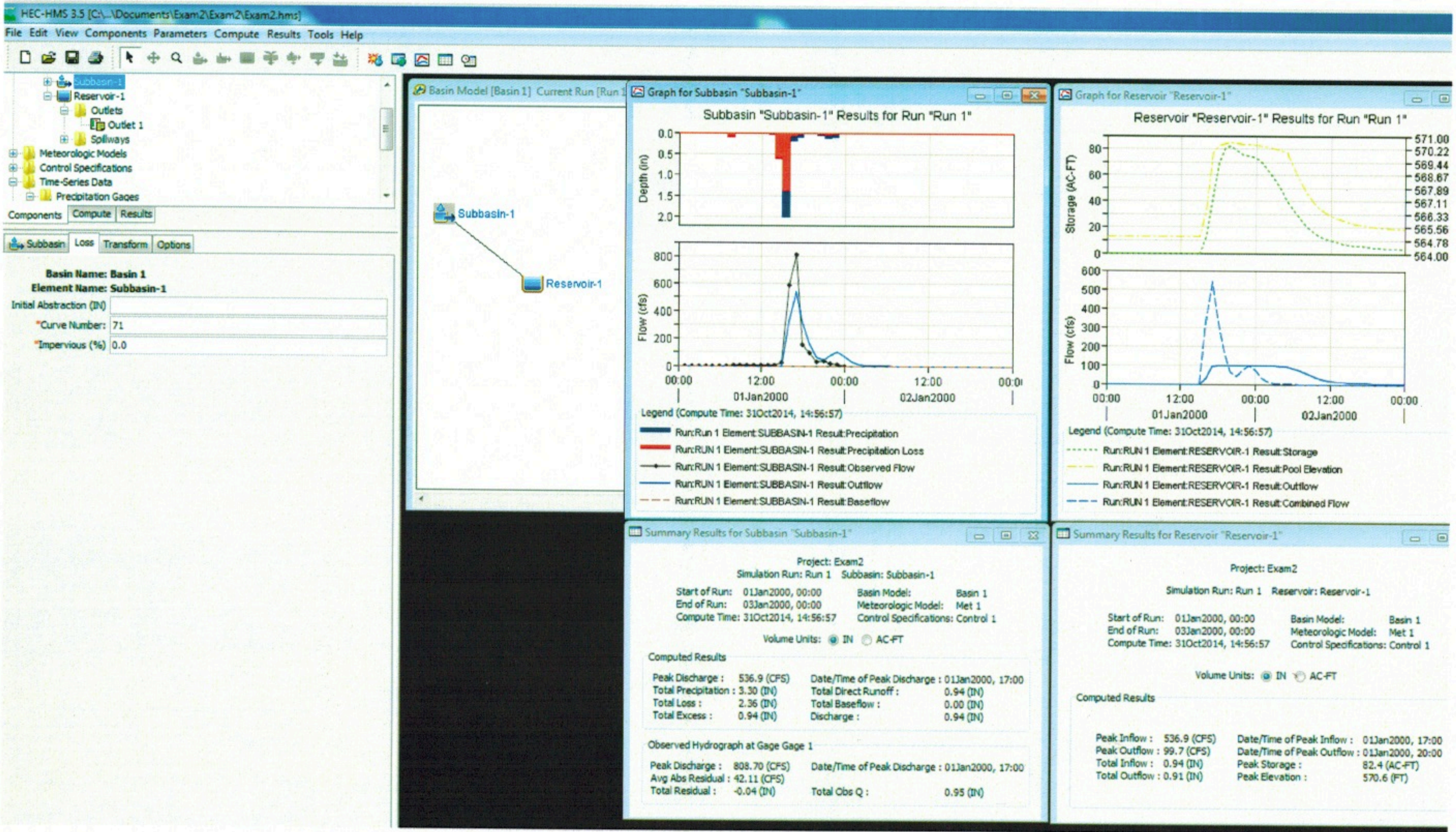

Figure 3. HEC-HMS DOT BEFORE MATCH

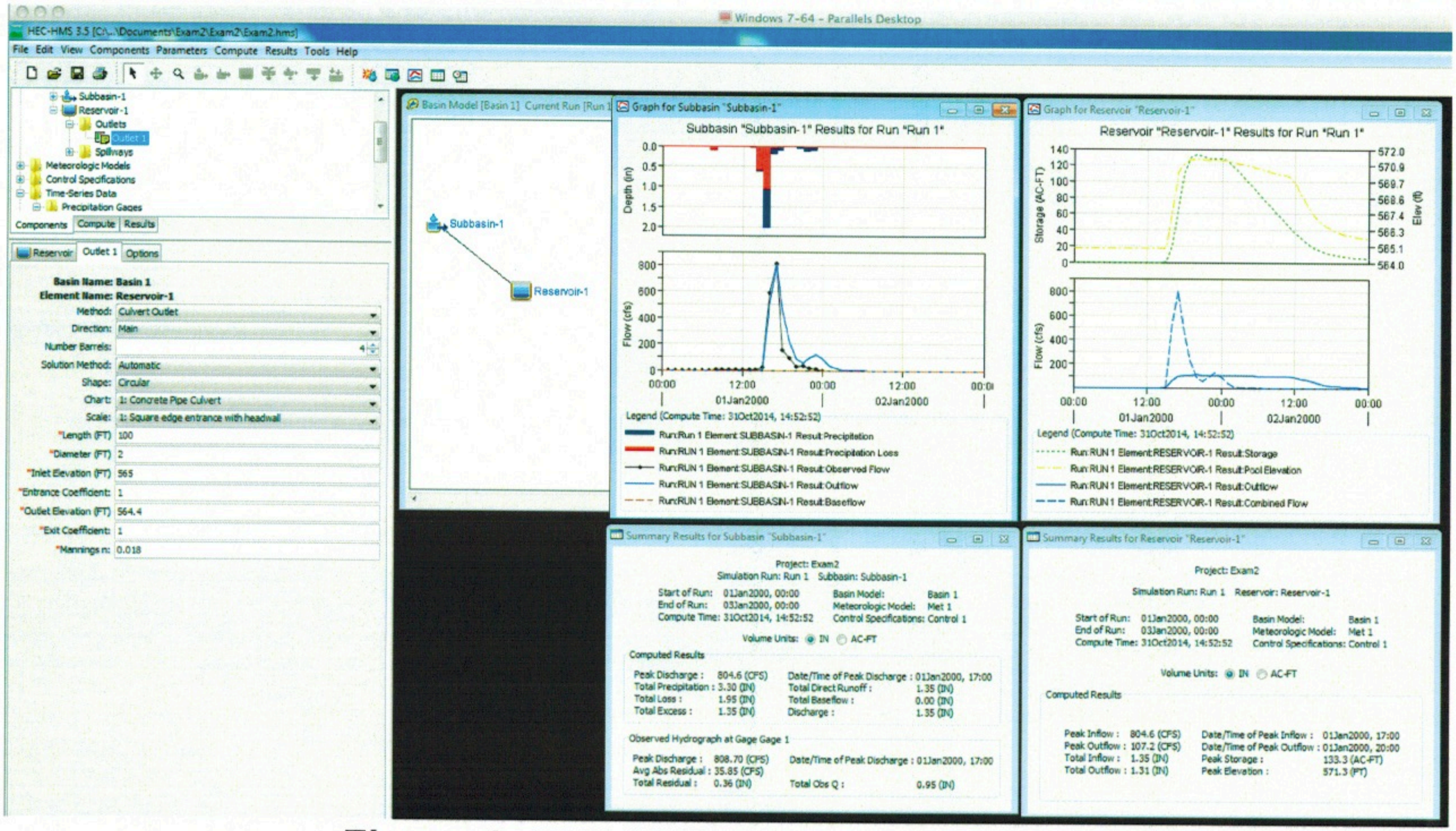

Figure 4. HEC-HMS DOT AFTER MATCH