82
+ 12 (EACH-O PGS)
+ 6 (PEER EVAL)
100

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CE 3354 Engineering Hydrology
Exam 3, Spring 2016

Students should write their name on all sheets of paper. Students are may use printed notes and book excerpts to help answer questions. Students are **NOT** permitted to use laptops, tablets, phones to access the internet or communicate during the exam.

1. Which of the following is a hyetograph (as used in this class)? hyeto → precip
   a) A record of infiltration rates (inches/hour) versus time.
   b) A record of cumulative rainfall depth (inches) versus time. +1
   c) A record of discharge rate (cubic feet/second) versus time.
   d) A and B
2. What is a hydrograph (as used in this class)? hydro → discharge
   a) A record of rainfall rates (inches/hour) versus time.
   b) A record of cumulative rainfall depth (inches) versus time.
   c) A record of discharge rate (cubic feet/second) versus time. +1
   d) A and B
3. What is excess precipitation? excess → after losses abstracted ∴ runoff
   a) The amount of precipitation that falls upon a watershed.
   b) The amount of runoff that is produced from a watershed. +1
   c) The equivalent depth of uniformly distributed precipitation.
   d) A and B
4. Hydrology is
   a) Study of the atmosphere, ocean, and surface waters
   b) The study of the occurrence, distribution, and movement of water above, on, and below the surface of the earth +1
   c) A study of the processes of evaporation, infiltration, and storage
   d) The study of the relationship between rainfall and runoff

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5. To what type of data series would we apply the Bulletin 17B procedure ?

a) Instantaneous discharge

b) Hourly rainfall

c) Annual maximum rainfall

+1 d) Annual maximum discharge

6. Rainfall behavior is expressed as a combination of

+1 a) depth or intensity, duration, and probability or frequency

DDF → depth, intensity + duration + frequency
IDF

b) intensity and probability or frequency

c) duration and probability or frequency

d) depth and duration

7. How can one calculate the Annual Exceedance Probability (AEP) from the Annual Return Interval (ARI)?

+1 a) $AEP = \frac{1\ yr}{ARI}$

b) $ARI = \frac{1\ yr}{AEP}$

c) $ARI = \frac{Rank_i}{N+1}$

d) Cannot

8. An annual recurrence interval of 100-years is equivalent to an AEP of what percent?

+1 a) 1-percent.

$AEP = \frac{1yr}{100yr} = 0.01 = 1\%$

b) 10-percent.

c) 50-percent.

d) 100-percent.

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9. What is a plotting position?

   a) The multiplicative inverse of relative frequency

   b) An estimate of probability associated with an observation based on its magnitude relative to the arithmetic mean

+1 c) An estimate of probability associated with an observation based on its position within a ranked sample set

   d) Location in a chart of a data pair

10. What is a flood frequency curve?

   a) A plot of discharge and time

+1 b) A plot of estimated exceedance probability and discharge

   c) A plot of the frequency and discharge

   d) A plot of the discharge magnitude and the Weibull plotting position

11. Rainfall intensity is

   a) instantaneous rainfall rate

   b) slope of the depth duration curve at a duration of one hour

+1 c) the ratio of accumulated depth to duration

   d) integral of the depth duration curve from 0 to 24 hours

12. In the rational equation, Q = CIA, the intensity, I, is

+1 a) the ratio of depth to the time of concentration

   b) the ratio of depth to watershed area

   the ratio of depth to storm duration

   d) the ratio of depth to watershed impervious cover

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13. Figure 1 is a screen capture of a HEC-HMS model run.

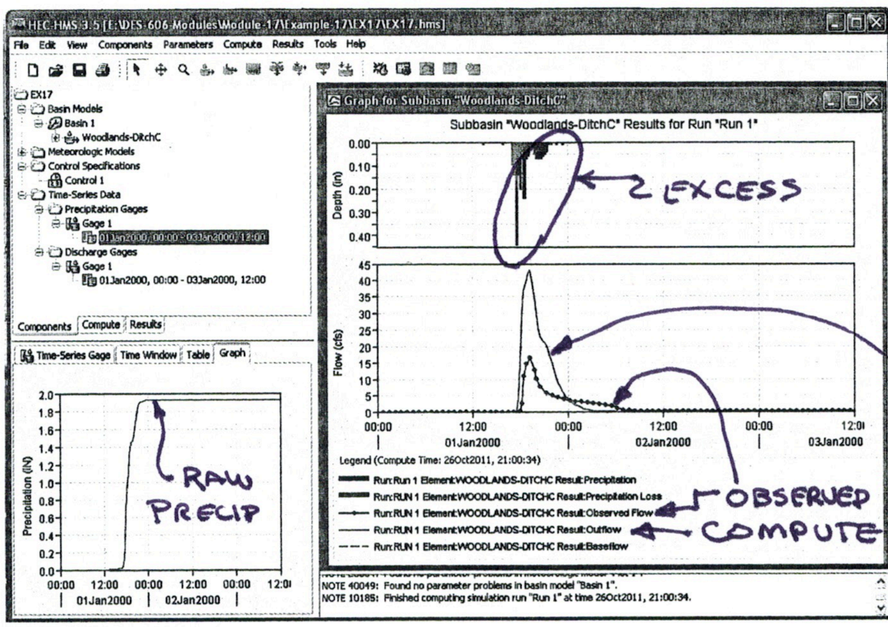

Figure 1: HEC-HMS Model Run for Woodlands-Ditch C sub-basin.

+2 a) What is the **COMPUTED** peak discharge for the Woodlands-DitchC sub-basin?

~ 44 CFS (NUMBER + UNIT)
(40–45 OK)

+2 b) What is the **OBSERVED** peak discharge for the Woodlands-DitchC sub-basin?

~ 19 CFS (NUMBER + UNIT)
(15 – 20 OK)

+2 c) What is the total **RAW** input precipitation for the Woodlands-DitchC sub-basin?

~ 1.9 INCHES (NUMBER + UNIT)
(1.8 – 2.0 OK)

+2 d) What is your estimate of the total **EXCESS** input precipitation for the Woodlands-DitchC sub-basin?

ABOUT 1/2 OF RAW

~ 0.95 INCHES (NUMBER + UNIT)
(0.9 – 1.3 OK)

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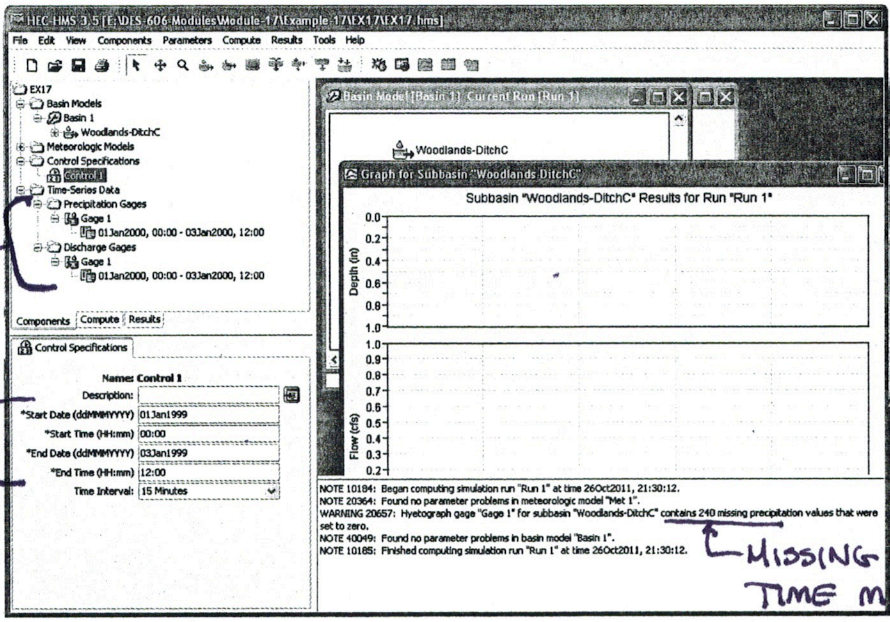
14. Figure 2 is a screen capture of a HEC-HMS model run. The model appears to have successfully run, but when the output graph is selected there in no hyetograph nor hydrograph displayed.



TIME MISMATCH

MISSING BECAUSE OF TIME MISMATCH.

Figure 2: HEC-HMS Model Run for Woodlands-Ditch C sub-basin.

What is a likely explanation for the unanticipated output?

THE PRECIP TIMES ARE DIFFERENT FROM SIMULATION WINDOW TIMES

+5 IF STATE TIME MISMATCH

+2 IF SAY PRECIP GAGE NO DATA

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+1

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15. Figure 3 is the unit hydrograph response for a watershed to a 1-hour long excess rainfall event of intensity equal to 1-inch/hour.

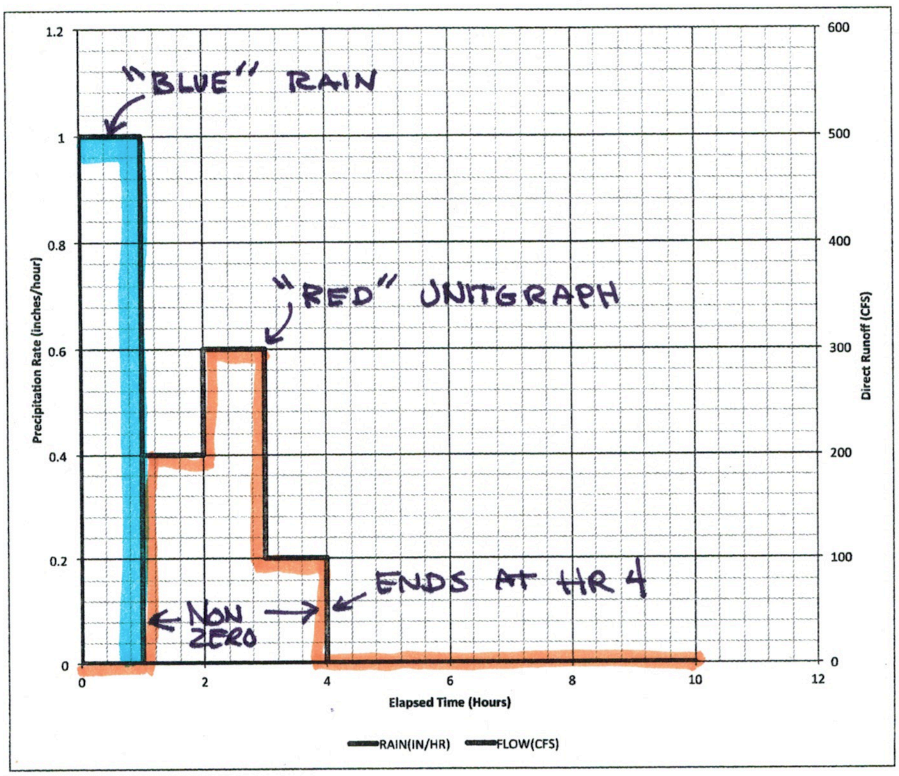

Figure 3: Unit hydrograph response (red) to a 1-inch per hour constant intensity precipitation (blue) input.

a) How long is there non-zero (starting from hour zero) direct runoff for the unit hydrograph?

+2

4 HOURS TO END UH. (OR 3 HRS OK FOR UH NON-ZERO)

b) What is the peak discharge in CFS indicated by the unit hydrograph? (NUMBER+UNIT)

+2

300 CFS (NUMBER+UNIT)

c) What is the total volume (in ft^3) of runoff indicated by the unit hydrograph?

+3

$$\left[\left(\frac{200 ft^3}{sec}\right)+\left(\frac{300 ft^3}{sec}\right)+\left(\frac{100 ft^3}{sec}\right)\right] 3600 sec = 2.16 \cdot 10^6 ft^3$$

(ARITHMETIC + NUMBER + UNIT)

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+4

d) What is the watershed area (in mi^2) of the watershed?

$i(1hr)\,Area = \forall_{RUNOFF}$

$\left(\frac{1in}{\cancel{1hr}}\right)(\cancel{1hr})\,Area = 2.16\cdot 10^6\,ft^3$

$Area = \frac{2.16\cdot 10^6\,ft^{\cancel{3}2}}{1\cancel{in}}\cdot\frac{12\cancel{in}}{1\cancel{ft}} = 2.592\cdot 10^7\,ft^2 \rightarrow 2.592\cdot 10^7\,ft^2\cdot\frac{1ac.}{43560ft^2}\cdot\frac{1mi^2}{640ac}$

$= 0.929\,mi^2$

$(0.93mi^2)$ (FORMULA + ARITHMETIC + NUMBER + UNIT)

+4

e) What is the total volume (in ft^3) of runoff anticipated for the storm depicted in Figure 4? $(\Sigma P_{in})(1hr)\left(\frac{\forall}{1in}\right) = \forall_{TOT}$

$\left[\left(\frac{0.1in}{hr}\right)+\left(\frac{2.0in}{hr}\right)+\left(\frac{0.5in}{hr}\right)\right][1hr]\cdot\frac{2.16\cdot 10^6\,ft^3}{1in_{EXCESS}} = 5.616\cdot 10^6\,ft^3$

(FORMULA + ARITHMETIC + NUMBER + UNIT)

+9

f) Plot the response to the 3 consecutive 1-hour events with the intensities indicated in Figure 4.

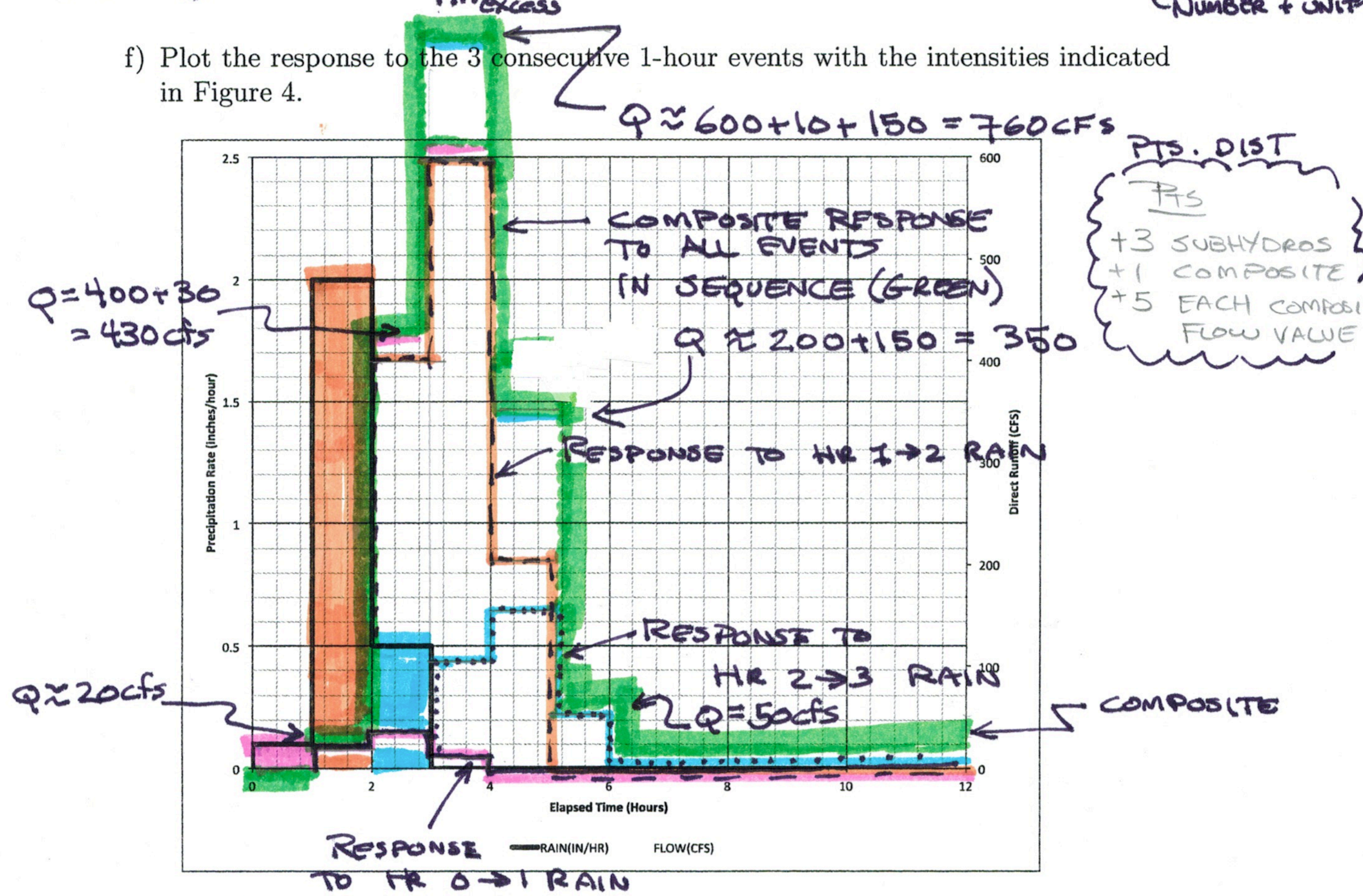

Figure 4: 3-hour event comprised of 3 consecutive 1-hour events.

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+1

16. Figure 5 is a schematic diagram of a creek that penetrates a 3-meter thick confined aquifer. During a long drought the flow in the creek **decreases** by 1.1 cubic meters per second between two gaging stations along the creek located 6 kilometers apart. On the west side of the creek the hydraulic head contours run parallel to the bank of the creek and the contour levels decrease as one moves **away** from the creek at a rate of 0.0007 m/m. The head contours on the east side of the creek are also parallel to the creek and the levels decrease as one moves **towards** the creek at a rate of 0.0003 m/m.

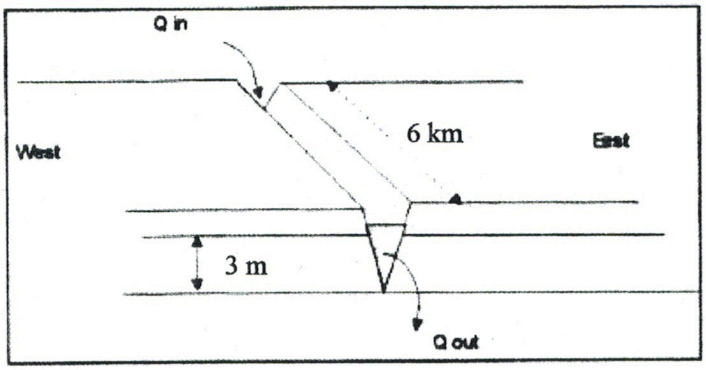

Figure 5: Dog Run Creek Schematic

a) Figure 6 is a representative sketch of a water balance where the term R_{in} represents the recharge from the stream into the aquifer.

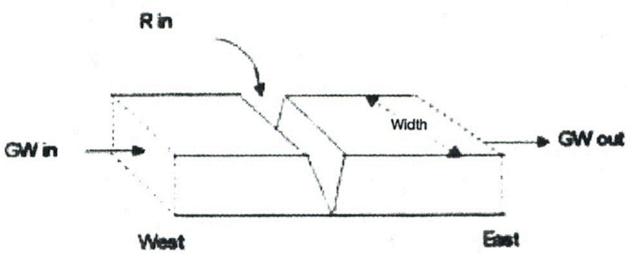

Figure 6: Dog Run Water Balance

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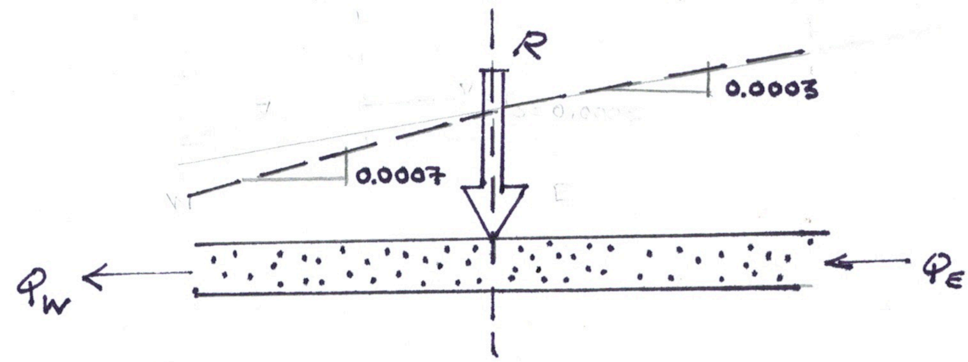
Write the water balance for the **aquifer** in the vicinity of the creek.



$$\dot{INFLOW} - \dot{OUTFLOW} = \frac{\Delta S}{\Delta t}$$

$$Q_E + R - Q_W = \frac{\Delta S}{\Delta t}$$

+2

IF STEADY FLOW THEN $\frac{\Delta S}{\Delta t} = 0$

$$Q_E + R = Q_W$$

$$Q_E = KA\frac{\Delta h}{\Delta x_E}$$

$$Q_W = KA\frac{\Delta h}{\Delta x_W}$$

b) Use Darcy's Law and the water balance to estimate the hydraulic conductivity of the aquifer.

$$R = Q_{IN} - Q_{OUT} \text{ (RIVER)}$$
$$= 1.1\, m^3/sec \text{ (GIVEN)}$$

+4

$$R = Q_W - Q_E$$
$$= KA\frac{\Delta h}{\Delta x_W} - KA\frac{\Delta h}{\Delta x_E} = KA\left(\frac{\Delta h}{\Delta x_W} - \frac{\Delta h}{\Delta x_E}\right)$$

$$1.1\, m^3/s = K\,(3m)(6000m)(0.0007 - 0.0003) \quad \Leftarrow \text{SOLVE FOR } K$$

$$K = \frac{1.1\, m^3/s}{(3m)(6000m)(0.0004)} = 0.153\, m/sec$$

FORMULA + ARITHMETIC + (NUMBER + UNITS)

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17. During a drought period the following declines in the water table were recorded in an unconfined aquifer.

Table 1: Water Table Declines

Area	Size (mi2)	Decline (ft)
A	14	2.75
B	7	3.56
C	28	5.42
D	33	7.78

The total volume of water removed from storage in this aquifer during the time period was 5.7385×10^4 acre-feet. Estimate the specific yield of this aquifer.

$\forall_{PUMP} = S_y \forall_{AQUIFER}$

AREA	$\forall_{AQUIFER}$
A	$14 mi^2 \times \frac{640 ac}{mi^2} \times 2.75 ft = 24{,}640$ ac-ft
B	$7 mi^2 \times \frac{640 ac}{mi^2} \times 3.56 ft = 15{,}948.8$ ac-ft
C	$28 mi^2 \times \frac{640 ac}{mi^2} \times 5.42 ft = 97{,}126.4$ ac-ft
D	$33 mi^2 \times \frac{640 ac}{mi^2} \times 7.78 ft = 164{,}313.6$ ac-ft

$\Sigma \quad 3.016528 \cdot 10^5$ Volume aquifer dewater

+6 EQUATION + FORMULA + ARITHMETIC + NUMBER $\forall$ + ARITHMETIC + NUMBER S_y +

$$S_y = \frac{\forall_{PUMPED}}{\forall_{AQUIFER}} = \frac{5.7385 \cdot 10^4}{3.0165 \cdot 10^5} = 0.19$$

$S_y \approx 19\%$

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18. Three wells monitor an aquifer as shown in Figure 7. The head in each well is listed in table 2 below. Determine the magnitude and direction of the hydraulic gradient in this aquifer.

Table 2: Moniotring Well Locations and Head

Well ID	X ft	Y ft	Head ft
#1	10	90	93.2
#2	20	5	88
#3	90	95	90

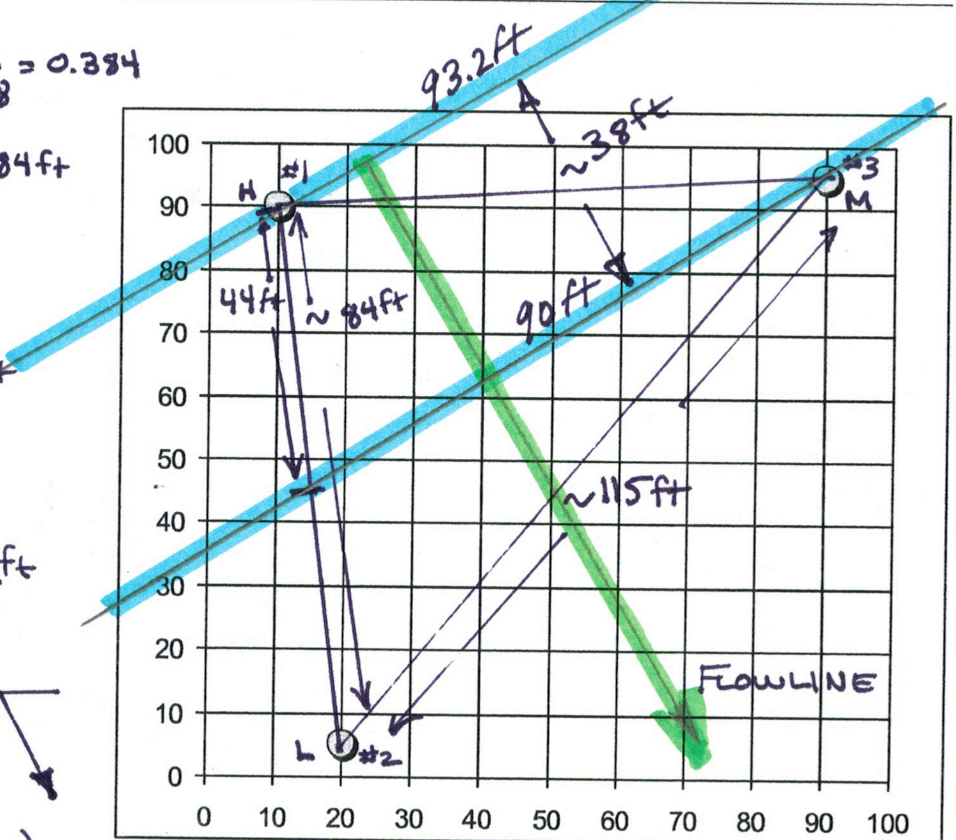
$\frac{M \to L}{H \to L} = \frac{90-88}{93.2-88} = 0.384$

DIST H→L ≈ 84ft

DIST M→L + MOV H→L = 0.384 · 115ft = 44.16ft

$\frac{\Delta h}{\Delta L} = \frac{93.2-90 \text{ ft}}{38 \text{ ft}} = 0.084$

(SAME AS FLOWLINE)



+1 LABEL WELLS

+1 DRAW △ +1

+1 COMPUTE $\frac{M \to L}{H \to L}$

+2 MEASURE H→L M→L

+1 COMPUTE: +H→L

+1 MEASURE ΔL

+1 COMPUTE $\frac{\Delta h}{\Delta L}$

+1 SHOW DIR

Figure 7: Map of well locations for Table 2

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This page is for calculations associated with the three-well problem.

ALL CALCS. PRIOR PG.

Pg 11 & 12 COMBINED

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