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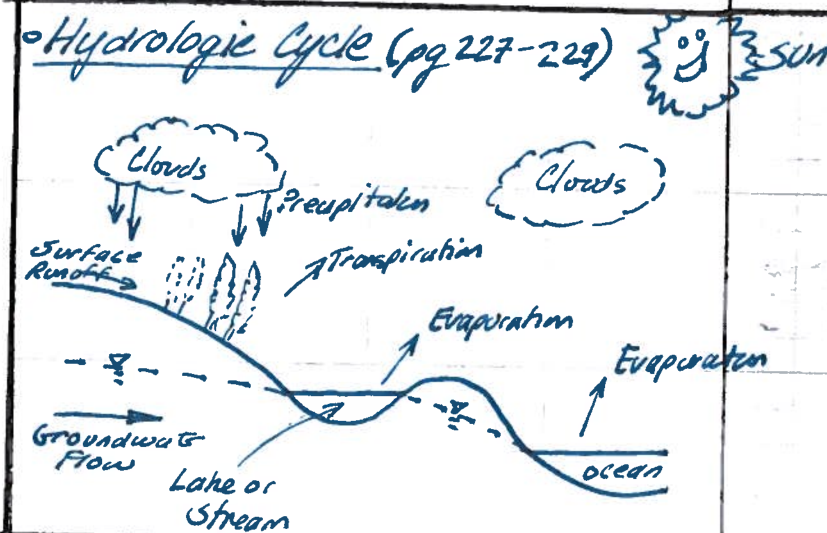
TEXAS TECH UNIVERSITY
J.H. MURDOUGH
ASCE STUDENT CHAPTER

NAME Cleveland DATE 4 sep 14
COURSE CE3354 SHEET 1 OF 5

- Hydrologic Cycle (pg 227-229)



- Global system that circulates water on the Earth.
    - sun supplies energy
    - water evaporates & transpires into atmosphere
    - Vapor condenses in clouds
    - condensation gains weight and drops (rain) ice (snow) falls as precipitation

- precipitation hits surface and either run into ground as <u>infiltration</u> or overland as surface <u>runoff</u>

Consider fig 7.1.1, pg 228
7.1.1 shows relative "fluxes" in different compartments
Roughly • 61% precipitation returns as evapo-transpiration
- 38% is surface runoff
- 1% is groundwater

At different <u>locations</u> the relative proportions can be quite different.

Usually talk in terms of watershed inches (or millimeters)

Precipitation (pg 237-238)

- Water vapor in atmosphere condenses into drops
- Drops "fall" as precipitation (rainfall)

- Processes

  Orographic rain
  - Air mass lifted by topographic feature

  Cyclonic rain (frontal)
  - Air mass lifted by invading cooler mass (front)

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NAME [illegible] DATE 4Sep14
COURSE CE3354 SHEET 4 OF 5

Convective rain

- Air heated at surface and lifted by density gradient

Rainfall Measurements

- Point precipitation
  - Total gage (manually read)
  - Tipping bucket gage (automated)
- Radar DPA
  (Digital Precipitation Array)

Rainfall Variability

- Spatial variability
  - Rains different amounts at different locations
  - Use averaging techniques to determine EUD

EUD = Equivalent uniform depth.

- Use DPA when trying to consider spatial variability
- Problem & scale dependent

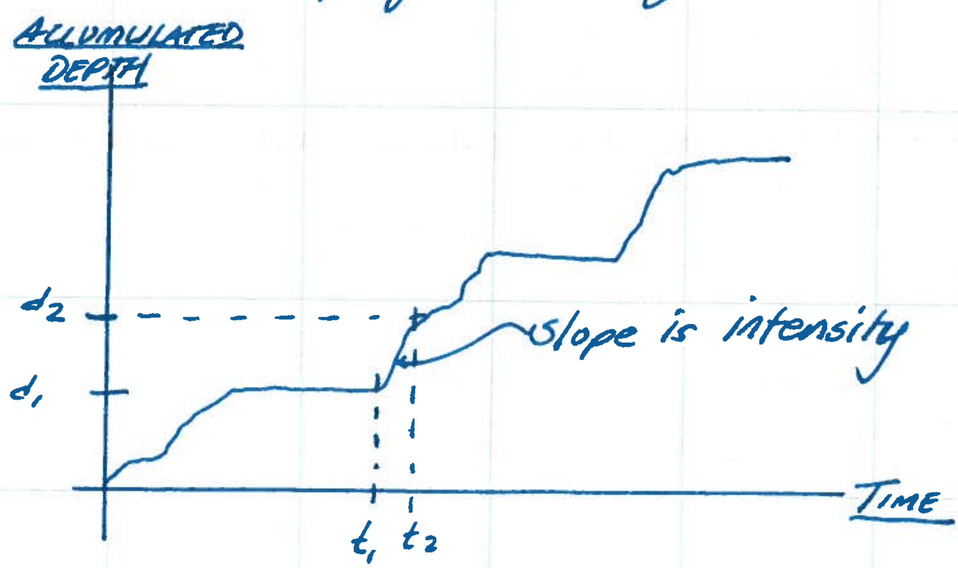
Precipitation

Four variables of interest

1) Space : average (equivalent) rainfall over area
2) Intensity: how hard it rains
3) Duration: how long at a given intensity
4) Frequency: how often at a given intensity & duration

Point precipitation analysis

- Data from a single gage is often useful for small project design



$$\text{Intensity} = \frac{d_2 - d_1}{t_2 - t_1}$$ } Slope of cumulative catch

$$= \frac{\Delta d}{\Delta t}$$

Δt is called the duration

Δt is a critical design value.

Consider that a 15-minute rainfall event produces:

one 15-minute duration event

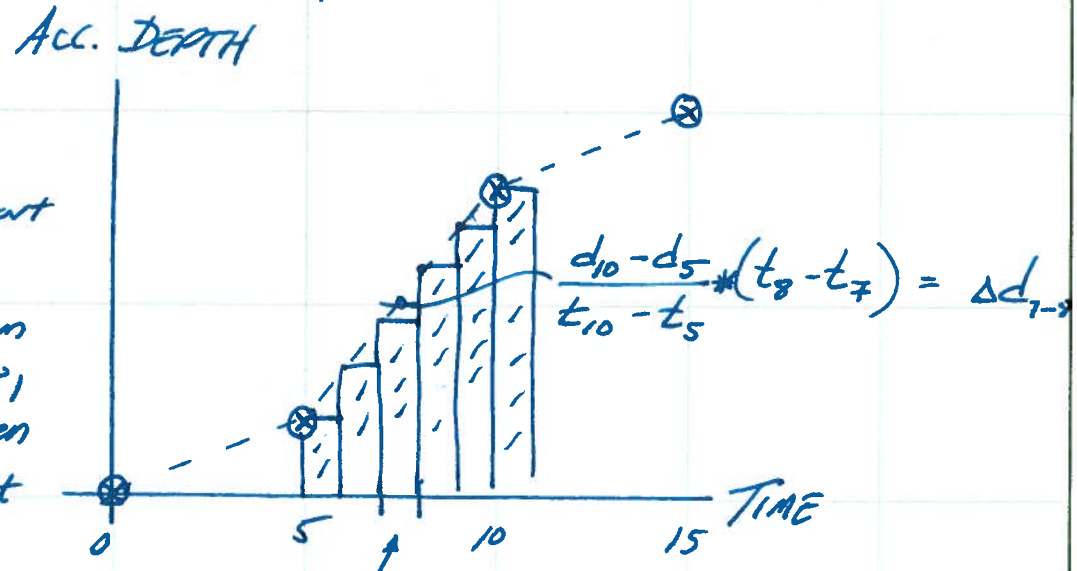
six 10-minute duration "events"

11 5-minute duration "events" (3 5-minute in sequence)

15 1-minute duration "events"

Typically - 15-minute is the smallest time interval usually available; sometimes 5-minute.
Any shorter is by differencing the signal

*Raingages report "tips" - if data are uniform space in time, they have been "processed" at least once!



if interested in this minute, have to difference 5 & 10 http://www1.ncdc.noaa.gov/pub/orders/cdo/390512.csv

Texas Tech U...lty & Staff U.S. Citizens... Case Status The Ec

http://www1.ncdc.noaa.gov/pub/...

YEAR — Date — CATCH, HUNDREDTH-INCH — MISSING DATA CODE

```
STATION,STATION_NAME,DATE,QGAG,QPCP
COOP:415410,LUBBOCK 9 N TX US,20130101 00:00,23,-9999
COOP:415410,LUBBOCK 9 N TX US,20130101 00:15,0,0
COOP:415410,LUBBOCK 9 N TX US,20130102 16:30,24,-9999
COOP:415410,LUBBOCK 9 N TX US,20130109 17:15,25,10
COOP:415410,LUBBOCK 9 N TX US,20130109 18:30,26,10
COOP:415410,LUBBOCK 9 N TX US,20130109 19:30,27,10
COOP:415410,LUBBOCK 9 N TX US,20130109 20:00,28,10
COOP:415410,LUBBOCK 9 N TX US,20130109 20:30,29,10
COOP:415410,LUBBOCK 9 N TX US,20130109 20:45,30,10
COOP:415410,LUBBOCK 9 N TX US,20130109 21:15,31,10
COOP:415410,LUBBOCK 9 N TX US,20130110 04:45,32,10
COOP:415410,LUBBOCK 9 N TX US,20130131 23:45,32,-9999
COOP:415410,LUBBOCK 9 N TX US,20130201 00:00,32,-9999
COOP:415410,LUBBOCK 9 N TX US,20130201 00:15,0,0
COOP:415410,LUBBOCK 9 N TX US,20130212 04:00,34,-9999
COOP:415410,LUBBOCK 9 N TX US,20130212 04:30,35,10
COOP:415410,LUBBOCK 9 N TX US,20130212 05:00,36,10
```

Time

January 9th storm.

↑ TYPICAL HISTORICAL DATA FROM NWS.

I CHOOSE LUBBOCK, 15-MINUTE PRECIP.

2-SERIES QGAG & QPCP

QGAG means 1/4 hour Fischer-Porten gage values are used

QPCP is 1/4 hour gage values

In above screen capture units are in 1/100th inches.

New Open Save Print Import Copy Paste Format Undo

	A	B	C	D
1	TIME-MIN	DEPTH-IN		
2	0	0		
3	15	0		
4	30	0		
5	45	0		
6	60	0		
7	75	0		
8	90	0		
9	105	0		
10	120	0		
11	135	0		
12	150	0		
13	165	0		
14	180	0		
15	195	0		
16	210	0		
17	225	0		
18	240	0		
19	255	0		
67	975	0		
68	990	0		
69	1005	0		
70	1020	0		
71	1035	0.25		
72	1050	0.25		
73	1065	0.25		
74	1080	0.25		
75	1095	0.25		
76	1110	0.51		
77	1125	0.51		
78	1140	0.51		
79	1155	0.51		
80	1170	0.78		
81	1185	0.78		
82	1200	1.06		
83	1215	1.06		
84	1230	1.35		
85	1245	1.65		
86	1260	1.65		
87	1275	1.96		
88	1290	1.96		
89	1305	1.96		
90	1320	1.96		
91	1335	1.96		
92	1350	1.96		
93	1365	1.96		
94	1380	1.96		
95	1395	1.96		
96	1410	1.96		
97	1425	1.96		
98	1440	1.96		
99				

24 hours of precipitation

lots of zeros

Consider the 97 rows of a time-depth series for the 9 JAN 2013 storm.

A tool to "automatically" analyze the data and find the maximum intensity.

The next sheet shows a script that reads the two columns and then plots the data, then searches and finds the maximum intensity.

Suppose we want to "analyze" the January 9th storm.

First extract the data –
Put into a time series –
Convert incrementals into cumulative –
Analyze as needed –

Suppose wanted to find the largest intensity over any 15-minute interval for the January 9th storm?

Fairly easy by just looking –
largest increment is 0.31 inches at hour 21:15

$$\therefore \text{intensity} = \frac{0.31 \text{ inches}}{0.25 \text{ hrs}} = 1.24 \text{ inches/hour.}$$

However, sometimes the time series are too long to easily read – then we want a tool to search for the value.

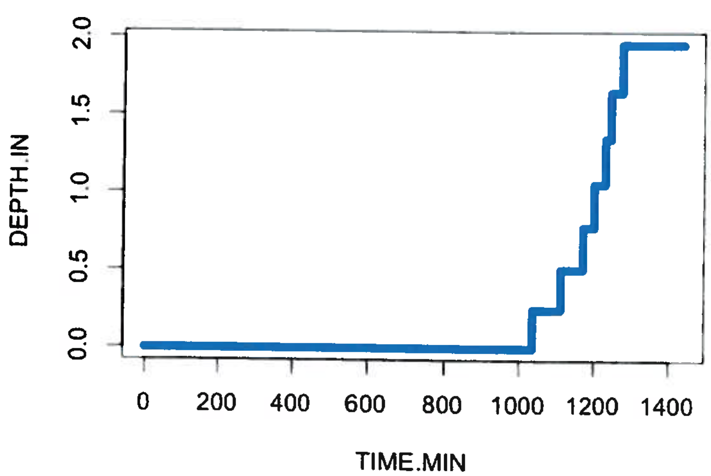
For example, suppose the entire 24 hrs (in 15 minute intervals is supplied)

R Console

~/Desktop

```
> source("/Users/cleveland/Sites/module1/LubbockStorm.R")
[1] 0.31
Maximum Intensity for 15-minutes is 1.24 inches per hour
>
```

Quartz 2 [*]



LubbockStorm

<functions> Help search

```
# analysis lubbock 9 Jan 2013 rainfall
dummy<-read.csv("LubbockStorm.csv",header=T) #read the data
# check that read is good
summary(dummy)
# attach column names
attach(dummy)
# plot the time series
plot(TIME.MIN,DEPTH.IN,type="s",lwd=5,col="blue")
# find the largest 15-minute incremental change
biggestchange <-0  # set biggest to zero to start
for (index in 2:length(DEPTH.IN)){
   test <- DEPTH.IN[index]-DEPTH.IN[index-1];
   if(test > biggestchange) biggestchange <- test;
   }
print(biggestchange) # print result
# now convert into an intensity
intensity <- biggestchange/0.25
message("Maximum Intensity for 15-minutes is ",intensity," inches per hour")
```

message(..., domain = NULL, appendLF = TRUE)

The script above is typical — often software can make the conversions. HEC-HMS has ability to do the conversions.

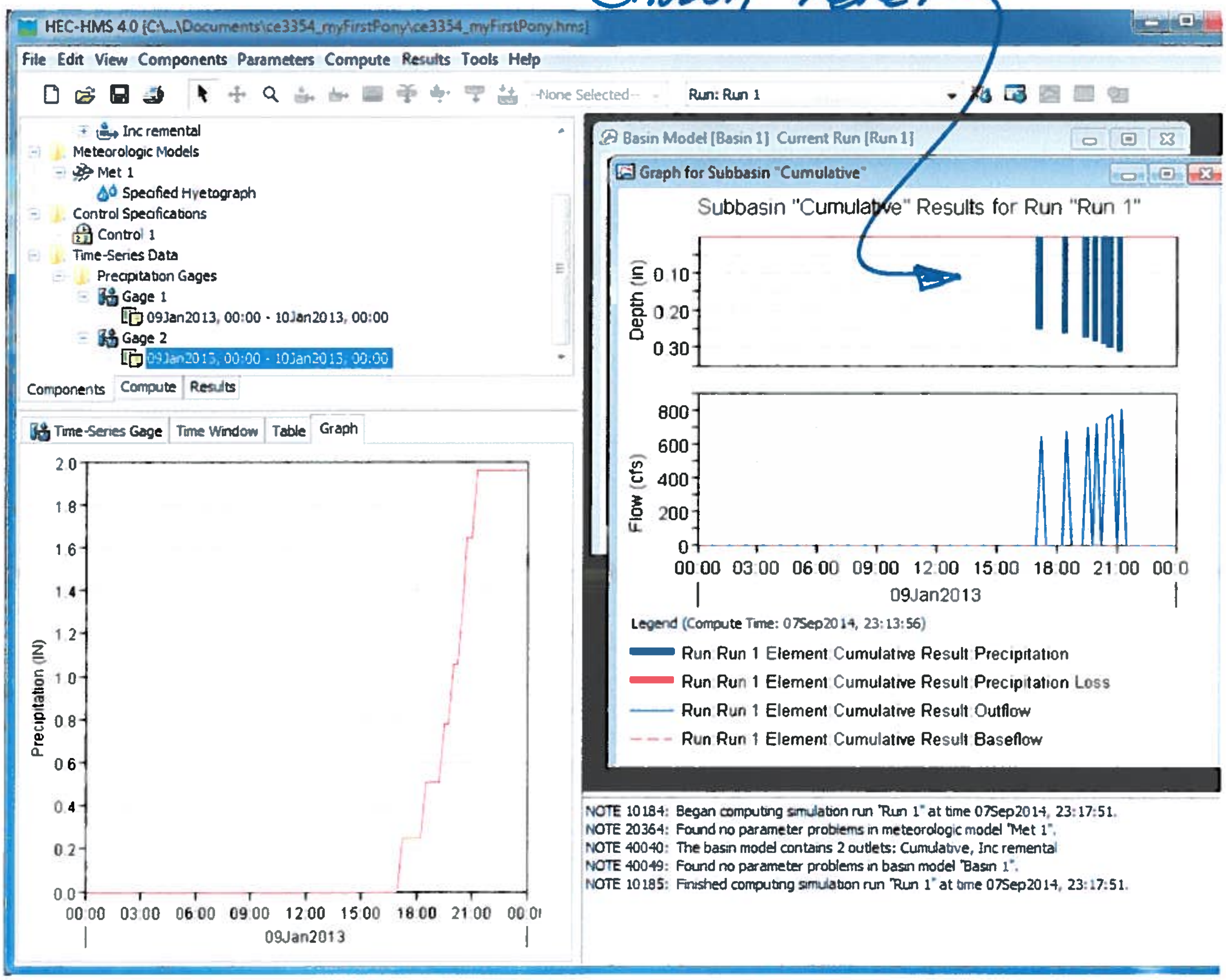
Cleveland
CE 3354

Fall 14
7/7

Here is same data entered into HEC-HMS.

Notice that the cumulative plots look the same (they should)

The incremental plot is shown here



HMS does not directly compute peak intensity (but it can be tricked - using a basin area of $1/640$ mi^2, the peak discharge in CFS will be peak intensity in in/hr)

- In this case 1.25 in/hr which is pretty close to 1.24 in/hr.