

GEOL 1102
GEOLOGIC HAZARDS PART 3 - FLOODS

PART 1 – FLOODING DUE TO IMPERMEABLE SOILS

A new housing development is going to be built in an area that has 3 different types of soil: a sandy soil, a clay rich soil, and an organic rich “loam” type soil. A construction company is paying you to determine which area would be best to build the new houses. You begin your study by testing different samples of soil to determine the soil properties under both dry and saturated conditions. Soils that are permeable have many interconnecting pores (open spaces between sediment grains) that allow water to pass through. Soils that are less permeable, or even impermeable, have smaller pore spaces between sediment grains and few connected open spaces. It is more difficult for water to pass through these types of soils.

Materials:

- three soil samples: sandy, clay rich, and organic rich
- water
- three cups or beakers to collect the water
- measuring cup for water
- 3 funnels or coffee filters

Procedures:

- 1) Place equal amounts of each soil type in its dry state within a coffee filter (or funnel) that has been placed above a beaker.
- 2) Pour 50 ml of water over each soil and record the amount of water of that passes through each type of soil into the cup after a period of about 4 minutes.
- 3) After measuring the amount of water that has passed through each soil type, repeat the test again, using all three soils in their **saturated** states and measure the amount of **additional water that is able to pass through**. You may have to pour more water on the soil sample to make sure it is wet enough to be saturated.

SOIL TYPE	Amount of water that passed through dry soil (ml) after 4 minutes	Additional amount of water that passed through saturated soil (ml)
sandy		
clay rich		
organic rich		

Questions:

- 1) Which soil type would be MOST likely to retain so much water that flooding would occur if there were short periods of heavy rain?
- 2) Which soil type has the best drainage?
- 3) Why do you think there is such a difference in the permeability of the different soils?
- 4) Would food crops be able to grow in soil that had very high permeability? Explain.

PART 2 – FLOOD PLAINS

Another housing development is proposed in the Greenwood, Mississippi area. Using the Greenwood Mississippi topographic map, study the 3 possible locations for the housing development:

Cleveland, Mississippi; Monticello, Arkansas; or McGehee, Arkansas

Your first job in determining which town is the best site, is to map the **floodplain** for the area. Floodplains are the very flat areas near rivers. As you go out of the floodplain, the topography becomes steeper - that is the contours indicating elevation will be much closer together.

4) How wide is the floodplain (in miles) in the middle of the map?

Which of the 3 towns are in the floodplain?

5) Are any of the 3 towns surrounded by the many streams that could potentially flood? Which, if any, of the 3 towns have streams that go through the town center?

6) Elevations are given in small black numbers near the towns and airports (small bird symbol). Determine the elevation of Cleveland and the elevation of the small town of Rosedale, Mississippi, next to the river. Which town has the highest elevation?

Determine the elevation of McGehee and the elevation of Lake Village airport, next to the river. Which town has the highest elevation?

What is the elevation of Monticello?

What do you think these differences in elevation mean about the flooding potential for Monticello, Cleveland, and McGehee?

7) In the eastern part of the map, the Tallahatchie River and the Yazoo River flow parallel to the Mississippi. In the western part of the map, the Bartholomew Bayou also flows parallel to the Mississippi River. Why don't these tributaries flow directly into the Mississippi River?

8) Which town is your best choice for the housing development?

Desert regions are very prone to flash floods caused by short-lived, intense storms. These flash floods can quickly cause **urban flooding**, such as we see in El Paso. The mountains in desert areas are very prone to **debris flows**, since the waters from flash floods can easily pick up sediment.

9) Why is the sediment so easily eroded in desert areas?

Look at the El Paso topographic map. Elevations will be the small black numbers next to named areas or as brown numbers on the contour lines.

10) Determine the elevation near the "spaghetti bowl", the intersection of I-10 and Highway 54. The closest elevation given is near the Concordia cemetery.

What is the elevation near Piedras Street and I-10?

What is the elevation farther to the west along I-10, near where the (now demolished) City Hall is located?

Where is urban flooding likely to occur on this map? Why?

11) Look at the Promontory Butte, AZ map. A thunderstorm occurred at Nappa Spring along headwaters of Christopher Creek, causing a rapidly moving debris flow that went all the way to the R bar C Ranch. Which area do you think suffered the most damage - Christopher Creek Campground or the cabins (shown by small black squares) along the highway 260 (sections 20 and 30)? Why?

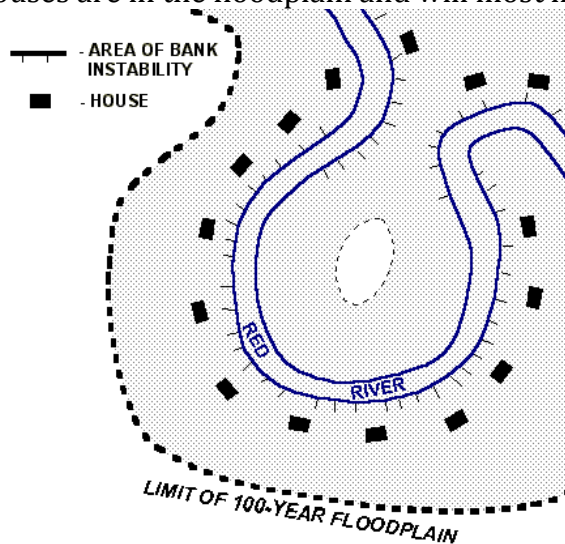
12) Another storm caused a debris flow that began in the north part of the map, where Tonto Creek and Dick Williams Creek meet. This debris flow continued for 3.5 miles, past Horton Creek Campground, Tonto Creek Campground, and the vacation area at Kohls Ranch. Which of these areas do you think suffered the most damage? Why?

What does this mean about how the National Forest Service plans the locations for its campground sites compared to how private homeowners decide on the locations of their cabins?

13) Along a mature river such as the Mississippi, there are many meanders. Your instructor will give you another topo map showing a meandering stream. On the topo map provided, indicate the letter where will erosion occur:

where will deposition occur?

14) One of the worst flooding rivers in the U.S. is the Red River that runs through Fargo, North Dakota. The Red River will flood almost every year in the spring when the snow melts. Below is a sketch map of houses in Fargo that have been built along the Red River. Draw a red circle around the houses that are likely to undergo damage from normal stream erosion. (Of course, all of the houses are in the floodplain and will most likely have problems with flooding.....)

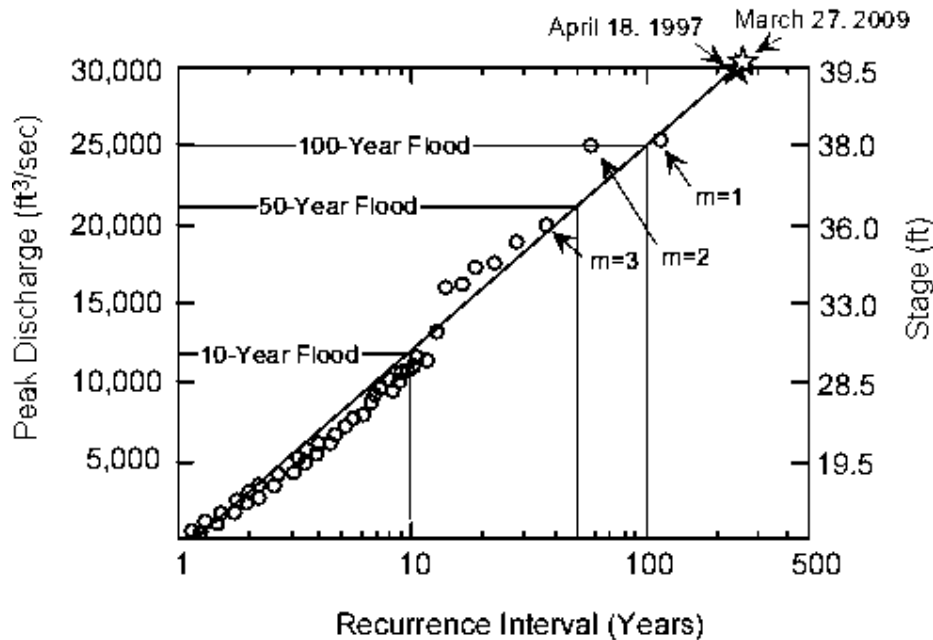


PART 3 - FLOOD RECURRENCE INTERVALS

The amount of water that is flowing in a stream is the **discharge** of a stream. The discharge is determined as the volume of water that passes a certain point per second. Common units of discharge are cubic feet per second (ft^3/sec) and cubic meters per second (m^3/sec). During flooding, the discharge will be much greater than normal.

Flooding is a normal part of a stream's life cycle. Smaller floods (with smaller discharges) can occur every year or every few years. Extreme flooding events with very large discharges will occur less often. If we measure the **largest annual discharge** of a stream for at least 10 years, we can use *statistical analysis* to create a graph showing the **recurrence interval** of a flooding event. *The recurrence interval is equal to the amount of time in which a flood with a specific discharge is likely to occur.* Knowing the recurrence interval of flooding events is very helpful when planning for the less frequent, but possibly very damaging, large floods.

Red River of the North at Fargo, North Dakota 1882-1994



In the recurrence interval graph above, a "10 year" flood will have a discharge of about 12,000 cubic feet per second, and a "100 year" flood will have a discharge of about 25,000 cubic feet per second. Note that the graph is semi logarithmic - the discharge is on a linear scale and recurrence interval in years is a logarithmic scale. This method allows us to extrapolate our data and determine recurrence intervals of 100 year floods, 200 year floods, etc., even when there is not data going back 200 years. By extrapolating and continuing the "best fit" line between data points, we can estimate "250 year" floods have discharges of about 30,000 cubic feet per second. *NOTICE THAT "250 year" floods occurred in 1997 and again in 2009!*

To calculate the recurrence interval of any stream, we obtain data on its maximum discharge per year, for at least 10 years. (For large rivers we use average peak annual discharges that are measured from several recording stations,) Then we calculate the recurrence interval (R) as:

$$R \text{ (years)} = (N+1)/m$$

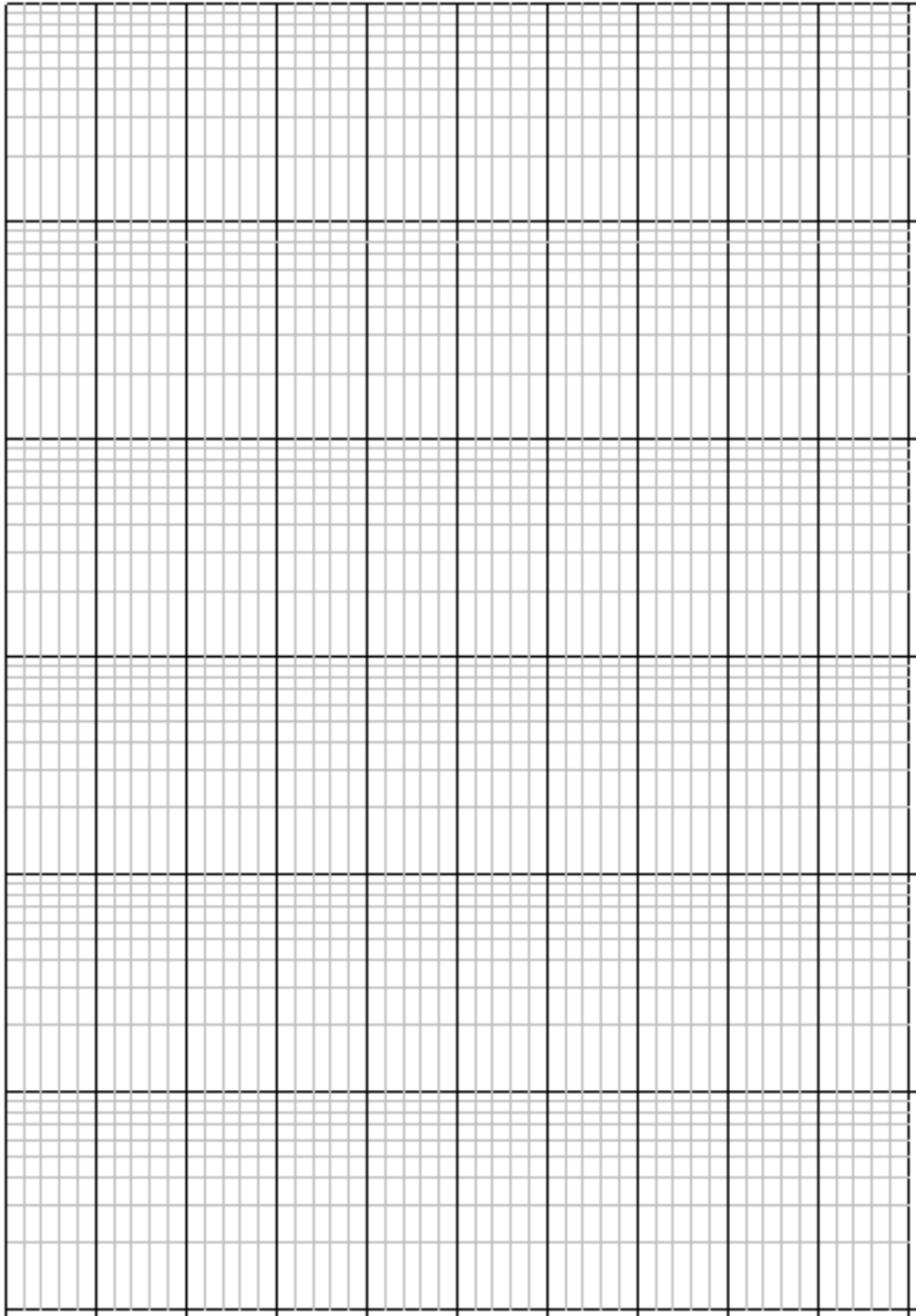
N = number of years that have been measured,
m = rank of the annual peak discharge.

To obtain a value for m, we take the **largest discharge recorded as 1**, the highest rank, the next largest as 2, etc. For records going back 20 years, the smallest m = 20. Then we simply calculate the recurrence interval (R) from the formula above.

The data below is from the Trinity River in central Texas, near Crockett, a small town about halfway between Houston and Dallas. For this exercise we will use the annual peak discharges from 1987 to 2013, a record of 27 years. You will work in groups to complete the chart determining the recurrence interval. Several of the flooding events have already been calculated for you. Then, you plot the data points on the recurrence interval graph, showing discharge and recurrence interval.

YEAR	DISCHARGE (in cubic feet per second)	RANK (m)	RECURRENCE INTERVAL (in years)
1987	6,847		
1988	2,290		
1989	8,653		
1990	13,430	3	
1991	6,047		
1992	16,810	1	28
1993	8,944		
1994	7,798		
1995	14,100	2	
1996	1,521	27	1.04
1997	10,420		
1998	7,494		
1999	7,131		
2000	2,664		
2001	10,200		
2002	6,231		
2003	4,512		
2004	5,487		
2005	5,747		
2006	1,758		
2007	11,310		
2008	5,216		
2009	3,146		
2010	11,920		
2011	1,644	26	
2012	4,043		
2013	1,771		

1. What is the discharge of a 10 year flood? _____
2. What is the discharge of a 20 year flood? _____
3. What is the discharge of a 100 year flood? _____
4. What is the recurrence interval to a flood with a discharge of 10,000 ft³/sec?
5. What is the recurrence interval for a flood with a discharge of 3,000 ft³/sec?



6. The probability of a 10 year flood happening in a given year would be 1 in 10, or $(1 \div 10)100$ which is 10%. What is the probability of a 100 year flood happening in any given year?

7. What does the term "recurrence interval" mean about a flood?

8. The flooding we discussed in class that occurred near Boulder and Estes Park, Colorado in 2013 had a probability of 0.1% happening in a given year. What would be the recurrence interval in years of a flood like this?

PART 4 - DETERMINING THE PROBABILITY OF A FLOODING EVENT

The probability of a flooding event happening in any given year is called the **annual exceedence probability, P_e** , and is the number most government agencies use when they analyze flooding risk.

Each year, the annual exceedence probability of a 10 year flood is 10%. So, it is possible to have a 10 year flood 2 or 3 years in a row, or, NOT to have a 10 year flood for 20 - 30 years. The term "100 year flood" therefore will give uninformed people a false sense of security in thinking that if one occurred the previous year, they are safe for the next 99 years!

This also means that the probability of a 100 year flood happening in a period of 100 years is NOT 100%!! Just like you calculated the probability of a 100 year flood happening in any given year in question 6, we can calculate the probability of a 100 year flood happening in 100 years, or 20 years, etc., using the formula:

$$P_t = 1 - (1 - P_e)^n$$

where n = the time period ; P_t = the probability of occurrence over the entire time period n ; and P_e is the probability of occurrence in any given year (the annual exceedence probability)

For example: what is the probability of a 10 year flood happening in the next 5 years?

$n=5$, $P_e=0.1$; so $P_t = 1 - (1-0.1)^5$

$$P_t = 1 - (0.9)^5$$

$$P_t = 1 - 0.59 = 0.41; \text{ or } 41\%$$

The probability of a 100 year flood happening within 50 years would be:

$n = 50$, $P_e=0.01$; so $P_t = 1 - (1-0.01)^{50}$

$$P_t = 1 - (0.99)^{50}$$

$$P_t = 1 - 0.605 = 0.395; \text{ or } 39.5\%$$

10. With a scientific calculator (either your own or free on the internet) use the formula above to calculate the probability of a 100 year flood happening within 100 years:

11. What is the probability of a 100 year flood happening within 200 years?

12. In 2006, El Paso had a "100 year flood". What is the percent probability of this large a flood happening in a particular year?

Is it possible for a flood this large to happen again before the year 2106? Explain.