Geomorphology Laboratory Exercise

The concepts of
Effective Discharge and Effective Floods

Streams do not act like conveyor belts such that all flows contribute equally to transporting sediment downstream. Streams and rivers have highly variable water discharge and each discharge moves a different sediment flux. Higher discharges move greater sediment flux, but lower discharges occur more frequently. This exercise is designed to illustrate that an intermediate flow, the effective discharge, is large enough and occurs sufficiently frequently to move much of the sediment in a river over a long period (Leopold, 1994). We focus here on bedload rather than suspended sediment, although the results should apply to both.
76 pts total.

Reports will be typed (font 11 pt and larger) and each answer will follow the numbering system of the questions and be in consecutive order. Graphs need to be adequately labeled including axis labels with units. All features in a graph or drawing must be identified. Neatness counts and all pages need to be stapled.

Effective Discharge

On the attached sheet data is included for, measured discharge and bedload, and frequency of discharges for a 10-year period. From these data please complete the following instructions.

1. *(5 pts)* Plot the bedload as a function of discharge using the data in Table 1. Remember to label the axis with units. Plot just points.

Table 1 Mean daily river discharge and bedload.

Discharge (m^3 s^{-1})	Bedload (kg day^{-1})
150	1000
300	3000
500	8000
700	20000
1000	90000
3000	1000000
5000	2000000

2. *(15 pts)* The plot in question (1) suggests an exponential relation between bedload and discharge. Construct a rating curve for bedload using the relation,

$$Q_s = aQ^b$$

where Q_s is sediment discharge in kg/day, Q is mean daily discharge in m^3/s, and a and b are constants to be determined. Although ways now exist to solve this equation directly as is, please transform the exponential equation into a linear equation, where more mathematical tools exist for solutions. To transform the equation, take the natural log, $\log_e$, of both sides. This will create a linear equation of the form y = mx + c where y and x are variables and m and c are constants.

a. SHOW YOUR WORK TO TRANSFORM THE EQUATION.

From the transformed equation figure out the constants of a and b. This can be done using either a spreadsheet linear regression program or you can do it by hand. In either case, show your work.

Although we are relying on high school math here, this application may be unfamiliar and a simple oversight will throw your answer way off. LIST THE CONSTANTS AND THEIR MAGNITUDES.

b. Plot the data and resulting line on a log - log curve showing the straight line (calculated) and the data points (measured).

c. Plot the original data and line again but this time transformed back into normal units. This second plot should look like the plot made in question (1) but will include the calculated line. Use the same scale for the second plot as you did in question (1).

> *In science, it is the common practice to plot the model results as a line and the measurements as points.*

3. *(5pts)* Using the rating curve of sediment and water discharge calculated previously, determine the total mass of sediment transported by each flow-magnitude class during the 10 years of record (Table 2). Neatly tabulate your results in the following order of column headings, discharge class, bedload, number of days, and total bedload for that class. After the last row of data, include the total number of days and total bedload in the appropriate columns. Include the appropriate label for that row. Don't forget the label and units for each column heading.

4. *(5pts)* Plot the bedload/10 years as a function of water discharge. Use the mean value of water discharge in each discharge class. On the same plot include the number of days /10 years for each discharge class. Use the right hand vertical axis of the graph to plot this. If this is unclear, ask me. For both data sets plot them as points connected by lines. Do not smooth any lines. As usual, label all axis and include units.

5. *(5pts)* Which discharge class is responsible for transporting the most sediment? What is the fraction of total bedload transported? This is the effective discharge.

6. *(5pts)* How frequently does the effective discharge occur (time period of effective

discharge/total time period)?

7. *(5pts* What fraction of the total bedload for all classes for all years is moved by the effective discharge class?

8. *(5pts)* Briefly discuss these results

Table 2. Flow frequency for 10 years of record..

Discharge Class ($m^3\ s^{-1}$)	Number Of Days
0-500	2086
500-1000	786
1000-1500	254
1500-2000	161
2000-2500	103
2500-3000	74
3000-3500	53
3500-4000	39
4000-4500	27
4500-5000	19
5000-5500	14
5500-6000	9
6000-6500	7
6500-7000	5
7000-7500	4
7500-8000	3
8000-8500	2
8500-9000	2
9000-9500	1
9500-10000	1

Geomorphically Effective Floods

The same concept of geomorphically effective discharge applies to floods. Small floods occur frequently and the big ones occur only occasionally. So which size flood is the most geomorphically effective? Read, Costa, J.E. and O'Connor, J.E., 1995. Geomorphically Effective Floods. in Natural and Anthropogenic Influences in Fluvial Geomorphology. American Geophysical Union, Monograph 89, 45-56.

Answer the following questions:

9. *(5 pts)* In the *Introduction*, the processes of geomorphic change are discussed. The authors are basically restating what we learned in chapter 1 of Ritter and what we discussed in class. Relate this discussion to geomorphic thresholds. I suspect that they do not use the term "threshold" to avoid arguments regarding whether it is a true geomorphic threshold.

10. *(2pts)* What is the purpose of the paper?

11. (*3 pts*) Why was there little landscape change resulting from the floods resulting from the two dam failures?

12. *(5 pts)* In Table 2 examine the columns for Peak Stream Power and Geomorphic Impact. Is there a great correlation between the two? Briefly discuss the result.

13. *(5 pts)* What does the geomorphically effective flood require?

14. *(2 pts)* Why can't figure 11 be more specific about the required magnitudes of power and time?

15. *(2 pts)* What is the value of the conceptual model presented in figure 11?

16. *(2pts)* The second to last sentence of the conclusions restates one theme in our geomorphology class and is the challenge of geosciences itself. What is that theme?