

G322 Geomorphology / Aerial Photography
Lab Exercise: Fluvial Hydrology of Luckiamute River (Fluvial Lab Part 2)

c:\wou\2005\fluvlab2.wpd

Part I. Field-based hydraulic calculations.

Recall that we spent an afternoon collecting basic field data on the Luckiamute River at Helmick State Park. Our field teams were working on various geomorphic aspects of the Luckiamute River. Attached are the following results:

Channel Profile Data from Active Channel Table 1; Figure 1

Valley Profile Data from Bridge Transect Table 2; Figure 2

Slope and Manning's Roughness Estimates Table 3

I have converted the profile depth measurements to elevation (m) and assembled the profiles as shown in Figure 1 and Figure 2. Refer back to the field trip lab hand-out for pertinent information, equations, etc.

- I-1. Referring to Figure 1 and Table 1, use the Continuity Equation to determine the discharge of the Luckiamute on the day of the field trip. Divide the channel flow into 5 sub-domains as shown on Fig. 1. Calculate the discharge for each domain and sum them to derive total discharge for the channel. **Give your answers in both m³/sec and ft³/sec.** The 10 x 10 transparency grid provided by the instructor can be used to determine the channel areas.
- I-1A. Using the data provided, calculate the total stream power and unit stream power for the Luckiamute on the day of the field trip. **Answer in watts and watts/m, respectively.**
- I-1B. Using an average depth and velocity, calculate the Froude Number for the Luckiamute on the day of the field trip. Based on the Froude No., was the flow "tranquil", "critical", or "supercritical"?
- I-2. Referring to Figure 2, Table 2 and Table 3, use the Manning's Equation and Continuity Equation to determine the hypothetical discharge of the Luckiamute when the valley is flooded to the level of the bridge deck. Use the grid provided on Figure 2 to determine channel areas. **Give your answers in both m³/sec and ft³/sec.**
- I-2A. Since we have estimated a range of roughness, we can bracket our velocity and discharge predictions. Calculate a "minimum" and "maximum" velocity and discharge, using the roughness range listed in Table 3.
- I-2B. Using the data provided, calculate the hypothetical total stream power and unit stream power for the Luckiamute when it floods to bridge level. **Answer in watts and watts/m respectively.**

Part II. Historical Discharge Analysis / Recurrence Intervals.

As discussed during the field trip, the Luckiamute at Helmick State Park is gaged by the U.S. Geological Survey. Discharge data has been collected at the site since the 1940's. Table 4 is a summary of annual peak discharge data from the Luckiamute / Helmick gaging station. This data is also on-line in an Excel format at www.wou.edu/taylor ... follow the links to G322 and Luckiamute Gage Data. Download the data and save it to your local hard-drive or floppy disk. Then use Excel as needed to complete the following exercises.

Recurrence Interval and Gumbel Plots

The recurrence interval of a given flood discharge is commonly calculated from a set of historical data. The annual peak discharges for the Luckiamute gaging station are listed in Table 4. The "annual peak discharge" represents the maximum discharge recorded at the station for a given water year. Recurrence interval of annual peak discharge represents an estimation, based on the historical record, of the probability of a given flood discharge occurring over a given time period. For example, the "100 yr flood" is a flood-discharge magnitude that has a probability of occurring once every 100 yrs. Generally, the lower the magnitude of event, the statistically more frequent the chance of occurring, and vice-versa. Once the recurrence intervals for given discharges are calculated, the relations may be visually plotted on a Gumbel-type graph. This is more-or-less a semi-log graph relation (see the attached Gumbel graph paper).

Methods of Calculation

1. Once you've downloaded the discharge data from the internet, open the data set with Excel.

2. The data from the USGS are listed in ft^3/sec , set up a new data column entitled "Discharge m^3/sec "

- A. Use Excel cell formula techniques to convert the discharge from ft^3/sec to m^3/sec ($1 \text{ cu. m} = 35.31 \text{ cu. ft}$) for each water year listed.

2. Sort and rank the data using Excel in order from highest to lowest discharge.

- a) highlight all of the data cells in Excel, but NOT the Column Titles (hint: highlight all column cells, otherwise you will mix the data).

- b) Use Data-Sort, to sort the data in descending order by discharge, from highest to lowest.

- c) Create a new data column, entitled "Rank - m", then numerically rank the discharges from highest to lowest; with highest being "1".

(hint: you can do this by hand, or tell Excel to enter a string of numbers from 1 to ... n, this is done with Edit-Fill-Series-Columns-Increment = 1)

3. Create two other new columns entitled "Recurrence Interval yrs" and "Probability". Then calculate RI and P for each flood discharge by using the following formulas:

$$R.I. = (n+1)/m \quad p = 1/(R.I.)$$

where
R.I. = Recurrence Interval of a Given Discharge of Rank m
m = Rank of Discharge
n = total number of observations
p = probability of occurrence
(1.0 = 100% chance of discharge occurring, 0.1 = 10% chance)

Try using Excel to calculate the R.I. and p for each discharge. Remember to set up cell equations, then copy and paste them to automatically calculate the numbers for each discharge. (hint: check your excel cell algebra with a calculator to make sure you did it properly)

PRINT OUT YOUR COMPLETED DATA SHEETS!

4. Using the attached graph paper, plot a Gumbel curve for the Luckiamute, with the recurrence interval on the log-interval x-axis, and discharge on the y-axis (choose an appropriate linear scale for the y-axis).

5. On the same graph, create a Gumbel plot for the Smith River Watershed of the McKenzie basin. The R.I. and discharge data are presented in Table 5.

Questions:

Based on your calculations of R.I., p, and the Gumbel Curve, answer the following:

II-A. Calculate a unit discharge for the highest and lowest peak discharge events observed in the record. The formula for unit discharge is:

$$\text{Unit Q} = Q_p/A$$

where Q_p = peak discharge, and A = drainage area above the gage station (see header on Table 4).

Make sure you get all units in the proper metric format... thus Unit Q = $m^3/\text{sec}/\text{km}^2$

II-B. What was the unit discharge on the day of our field trip to Helmick?(show your work)

II-C. Calculate the unit discharge for our hypothetical "flood-the-bridge" event.(show your work)

II-D. What is the recurrence interval of the spot discharge that we calculated on the day of the field trip. What is it's probability of occurrence? (hint: use Gumbel curve plot).

II-E. What is the recurrence interval of the hypothetical "flood-the-bridge" discharge that we calculated in Part 1? Use the conservative low-end discharge that we estimated. (hint: use the Gumbel plot to predict the R.I. ... if the hypothetical discharge is off the scale, project the curve to make an approximation of the R.I.).

According to our calculations, what is the probability of occurrence of our hypothetical "flood-the-bridge" discharge?

- II-F. Calculate the unit discharges for the 30 yr floods on the Luckiamute and Smith River. Which has a higher unit discharge? Compare and contrast the Gumbel plots for the Luckiamute and Smith drainages. What geologic / climatic / hydrologic variables account for the similarities and differences between the two (you will have to look at a basic geologic map of Oregon, locate the watersheds by long. and lat., then comment on the geologic environment, etc.).

Part III. Other Data Analysis / Intro to Regression Analysis

Table 6 is a different version of Luckiamute discharge data. Listed are the average daily discharge values for the months of January, February, and August, 1941-1984. For example, on any given day in January of 1941, the Luckiamute averaged a discharge of 1771.13 cu. ft / sec. Table 5 is also available for download from the G322 web site (www.wou.edu/taylor).

Your job is to determine whether there is a statistically significant difference between the average daily discharges in January, February and August. It is safe to assume that daily discharge is directly related to the amount of precipitation the Luckiamute watershed is receiving, i.e. low discharges correlate to low rainfall periods, and vice versa (dah!).

Methodology

- 1) Run a systematic t-test between Jan-Feb, Jan-Aug, and Feb.-Aug. and determine if there is a significant difference between average daily discharges (we've been here before! Use a 99% confidence interval this time; i.e. $\alpha = 0.01$). **Print out and attach your results.**

The next question is: "Is there a relation between January discharge levels and August discharge levels, during wet and dry years?"... that is, is there a correlation in any given year, between low/high discharges in January, and low/high discharges in August? To test this hypothesis, we will create a simple x-y scatter plot of January vs. August daily discharges. If there is a correlation between wet and dry years, we should see somewhat of a linear relation between the two. The other statistical test we will use is the regression analysis... this also tests for correlation between two phenomena.

Excel Techniques:

- 1) X-Y scatter plots: highlight the Jan and Aug. data columns, and click on the graph tool icon. Choose the "(X-Y) Scatter" graph type. **Create the plot (you know what to do), format your graph, and print.** Make sure you label the graph axes, and give it a title... don't forget to list the discharge units.
- 2) To run a regression analysis, select the Jan and Aug data columns, choose "tools-data analysis-regression", analogous to the t-test methodology.
 - input the Jan. cells in the "Input Y-Range"
 - input the Aug. cells in the "Input X-Range"
 - use a 95% confidence interval
 - click on the line-fit plots radio box
 - choose where you want the output located (new worksheet, etc.)
 - **run the analysis, print, and examine the results.**

3) The critical information that will relate the Jan and Aug discharge data is the "R-square" value. In a regression, the software will test how well the data relation to one another, and if there is a linear relation between the two. How to interpret the R-square value:

R-square = 1.0 a perfect fit / linear relation
R-Square = 0.7-0.9 a pretty good linear relation
R-square < 0.5 no relation between the two data sets.

Questions based on your t-test and regression analysis of average daily discharge data:

III-A. Is winter daily discharge in the Luckiamute significantly different that summer daily discharge? Provide supporting data to validate your conclusion.

III-B. In any given year, is a high discharge in January related to a high discharge in August? Do wet and dry years show up correspondingly in the Jan. and Aug. data? Or is the variation purely seasonal?