This exercise investigates stream discharge and stream water level (stage), natural flood hazard frequencies and probabilities, and relationships among rainfall, total yearly stream discharge and the annual peak discharge.

For the first part of the exercise we will consider a section of a creek running out of nearby mountains into a moderate-sized city in Colorado. The creek is relatively small… it can be stepped across on stones during intervals of low flow (late summer/early fall).

The creek’s “stage” or water level height (in feet) above the creek bottom has been measured and compared with measured stream discharge (cubic feet per second) at a particular site near where the creek enters the city. If a hazardous flood occurs, the dwellings and businesses near this site will be damaged if the floodwaters rise too high above the creek’s normal height.

**1.** Plot the values in the table below to relate discharge to height. Later in the exercise you will extrapolate the height of a 100 and 500-year flood discharge, so plot data accordingly (choose appropriate axes). Determine the mathematical relationship of height as a function of discharge. This is called a “rating curve”. You should compare a linear trend-line fit vs. a power function and see which gives you an R² value closer to 1 (recall that higher r² values are indicative of better curve fits).

<table>
<thead>
<tr>
<th>Discharge (cubic feet/sec)</th>
<th>Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>2</td>
</tr>
<tr>
<td>1120</td>
<td>4</td>
</tr>
<tr>
<td>1390</td>
<td>6</td>
</tr>
<tr>
<td>1620</td>
<td>8</td>
</tr>
<tr>
<td>1760</td>
<td>10</td>
</tr>
<tr>
<td>1900</td>
<td>12</td>
</tr>
<tr>
<td>2100</td>
<td>14</td>
</tr>
</tbody>
</table>

Use the data in the Excel file on the class homepage (GEO209HW10DischargeData.xls) to answer the following:

**2.** First, evaluate how total annual rainfall (inches) and total yearly discharge (all the water passing this point on the creek in each year, in 10⁵ cubic feet) have varied over the 30-year period of record. This is called a “time-series” plot. Drier and wetter intervals are notable. When was the longest dry spell? Use the data to calculate the mean annual rainfall for this area over the 30 years of record given here.

**3.** Construct x-y plots of a) rainfall vs. total yearly discharge, and b) rainfall vs. peak discharge. Fit trend-lines to these plots and evaluate (in words) how strongly these parameters are related to each other. Which parameter is better associated with yearly rainfall? What is a possible reason that there is a steepening of the curve relating total discharge to rainfall at the higher rainfall values? Why might this occur?

**4.** Make a copy of the “Peak Discharge” data column and then use the DATA→Sort command in Excel to do a Descending Sort on that column. You now have the Peak Discharges sorted by magnitude. In the
next column, assign ranks to each of these values, beginning with rank of 1 for the largest value, and continuing through to smallest peak discharge value with rank of 30.

**Hint:** If you begin series (1, 2, 3, …) then drag fill handle down with mouse cursor Excel with put these numbers in for you.

In the next column to the right, calculate the **Recurrence Interval (RI)** of each peak discharge magnitude.

$$ RI = \frac{n + 1}{r} $$

where $n =$ number of years of peak discharge records and $r =$ rank of the peak discharge magnitude, as determined above. See your textbook on page 341 for more discussion of this calculation.

Make a plot of RI vs. Peak Discharge. What type of relationship is displayed by the data? Construct the graph so that the data fall on a straight line. Fit a trend-line to the data. Use the mathematical relationship to extrapolate your dataset out through a 500-year flood.

**5.** In the next column over from **Recurrence Interval (RI),** calculate the percent probability that flows of the given peak discharge magnitude will be exceeded in any given year. Recall that

$$ \text{Probability} = \frac{1}{RI} $$

Thus, percent probability is equal to

$$ 100 \times \frac{1}{RI} $$

(Again, see textbook pg. 341 for discussion.)

Plot percent probability vs. peak discharge magnitude. What is the percent probability that a peak discharge flow of 700 cfs will be exceeded in any given year? What about a flow of 1300 cfs?

**6.** Use the peak discharge values calculated for 50-yr flood (RI = 50 years), 100-yr flood and 500-yr flood from equation in #4, and plug those values into the equation you fit to the stage height vs. discharge data from question #1. What is the predicted stage height (water level elevation) for these three (50-, 100-, and 500-yr) flood events?

**7.** If you own a creek-side house near this location that sits at an elevation equal to the creek stage height of 20 feet, are you comfortable there? What if you want to leave this house for your great-grandchildren’s inheritance? Do you think it will be there for them?