

I. Objectives

1. Create daily and annual streamflow graphs for interpretation in a historical, regional and climatic context.

II. Introduction

Stream flow is one part of the hydrologic cycle that we can monitor fairly well, because of how the upstream contributing area, called the watershed, aggregates and integrates runoff from precipitation. A graph of streamflow at hourly or daily time step is called a hydrograph and can illustrate the dynamic response a watershed has to a given storm.

The US Geologic Survey (USGS) monitors our streams and makes this data available (sometimes in real-time) to the public in numeric and graphical formats. When a streamflow hydrograph is plotted for a full year, the resulting 'Daily Streamflow' graph provides a dramatic view of the high and low flow events for that year, many of which are diagnostic of the seasonal ebb and flow of a particular river.

Another useful product is the 'Annual Average Streamflow' for a series of years. A plot of annual average streamflow illustrates how climatic conditions might vary over time at a particular location. In this representation, the effect of any one storm or drought might be masked by the overall average, but it is easier to discern long-term trends and means.

III. Materials

This is a web based lab that requires access to water.usgs.gov and the use of a spreadsheet, such as Excel. We will provide step-by-step instructions using Excel on a computer using a Windows operating system. The general progression of tasks should be achievable on whatever software you are using.

IV. Theory and Calculations

The units of flow are volume per time and are commonly cubic feet per second (cfs) or cubic meters per second (cms). On an annual basis, it is often more useful to consider a larger unit, like millions of acre feet per year (Maf/yr). In general, if one knows the cross-sectional area of a stream (A) and the average stream velocity (v) at that point, one can calculate flow (Q):

$$Q = v \times A$$

To convert cfs to af/yr requires the following conversion factors:

$$1 \text{ af} = 43560 \text{ ft}^3 = 325,851 \text{ gal}$$

$$1 \text{ ft}^3/\text{sec} \times 3,600 \text{ sec/hr} \times 24 \text{ hr/day} \times 365 \text{ day/yr} \times 1 \text{ af}/43,560 \text{ ft}^3 = 724 \text{ af/yr}$$

V. Prelab Definitions

1. hydrograph
2. period of record
3. daily streamflow
4. average annual streamflow
5. base flow
6. trendline

VI. Lab Procedure

1. Work in groups of two. Each group will select and work on one major Arizona river listed on the attached sheet.
2. Access <http://nwis.waterdata.usgs.gov/nwis/si>
 - a. Click the blue Site Information link.
 - b. Check the Site Number box under **Site Identifier**.
 - c. Click on the Submit button.
 - d. Enter your Site Number.
 - e. Click on the Submit button at the bottom of the page.
 - f. Click on the hyperlinked **Site Number**.
 - g. You will see a page that includes a **Description** of the gauge site to be included in Table 1 and a table of **Available Data** that lists the various data sets available, the period of record, and the number of data points in this period, the count.
 - h. Bookmark this page. It is the starting point for Parts A & B.
3. Complete the table below, except for the average daily and average annual flow rates.

Table 1: Stream Gauge Characteristics					
State/River		Site number		Period of record	
Drainage area in mi ²	Average daily flow rate in cfs (from A)		Average annual flow rate in af/yr (from B)		Elevation (ft)

4. Complete part A, using either gage site, then complete part B individually. Each student must turn in his/her own worksheet and what is not finished in class must be completed for homework.

Part A. Daily Streamflow (to be completed as a team)

5. From the bookmarked starting point, click on the Daily Data hyperlink.
6. Define the period of record that you want to retrieve:
 - a. Select *Discharge* as the parameter of interest.
 - b. Select *Tab-separated* under *Output Format*.
 - c. Enter any valid one-year range beginning on October 1st (eg. 10/01) and ending September 30th (09/30), the method used to count Water Years.
 - d. Click the *Go* button.

7. Save and download your data selection to your computer:
 - a. Right-click on this page of data and either *Save Page As* or *Save Frame As* to save this data as a text (.txt) file.
 - b. Name the file something you will remember and save to the desktop (i.e. daily data, rio_grande1, name_daily).
8. Start EXCEL and import your data file:
 - a. Open your file using the *File* tab or *from text* using the *Data* tab making sure *All File Types* is set (default is .xls/.xlsx).
 - b. **Text Import Wizard** will open. Make sure *delimited* is selected, then click *Finish*.
9. Define the data you want to graph:
 - a. Scroll down the page. There are 5 columns of data. Data starts on row 27.
 - b. Select all the data for the date and stream flow data columns.
10. Graph the daily data:
 - a. Once you have highlighted all the data in these two columns for the one-year period, create an XY (scatter) graph.
 - b. Use *Insert>Charts* and select *Scatter plot*.
11. Label your graph so it is understandable:
 - a. Locate the *Layout* tab and note the options.
 - b. Include a title, for example, 'Daily Streamflow for Las Flores Creek near Oceanside, CA, Gage 11046100, Oct. 2000 – Sep. 2001'.
 - c. Label the x-axis (date).
 - d. Label the y-axis (Flow [cfs]).
12. Use *Insert > Textbox* to label and describe the seasonality of your hydrograph, using terms from the lecture such as base flow, storm flow, monsoon and snowmelt. Note the geographical location and expected precipitation patterns of your gage.
13. Use EXCEL to calculate the average daily flow rate and record in Table 1.
 - a. Highlight all streamflow values, click the Σ button, then select *Average*.
14. Print a PDF file with your half/full-page graph (**excluding the tables**). Use *Insert > Textbox* to label how the graph varies seasonally and turn in to the class website.

Part B. Annual Streamflow (to be done individually):

15. From the bookmarked starting point:
 - a. Click on *Annual Statistics*.
 - b. Select *Discharge* next to *Parameter Code*.
 - c. Select *Tab-separated* under *Output Format*.
 - d. The full period of record will automatically be selected.
 - e. Click *Submit* button scroll at the bottom of the page.

16. Save and download your data selection to your computer:
 - a. Right-click on this page of data and either *Save Page As* or *Save Frame As* to save this data as a text (.txt) file.
 - b. Name the file something you will remember and save to the desktop (i.e. annual data, rio_grande2, name_annual)

17. Start EXCEL and import your data file:
 - a. Open your file using the *File* tab or *from text* using the *Data* tab making sure *All File Types* is selected (the default is .xls/.xlsx).
 - b. **Text Import Wizard** will open. Make sure *delimited* is selected, then click *Finish*.

18. Define the data you want to graph:
 - a. Scroll down. There are 6 columns of data. Data starts on row 37.
 - b. Select all the data for the year column and for the next column to its right, the mean annual data.

19. Graph the annual data:
 - a. Once you have all the data in these two columns highlighted, make an XY (scatter) graph.
 - b. Use *Insert>Charts* and select *XY (scatter) plot*.
 - c. Change chart type to a vertical bar (column) graph.

20. Label your graph so it is clear:
 - a. Locate the *Layout* tab and note the listed options.
 - b. Include a title such as 'Annual Streamflow for Las Flores Creek near Oceanside, CA, Gage 11046100 from 1974-2005'.
 - c. Label your x-axis (years) and your y-axis (cfs).

21. Further enhance your graph by adding a trendline:
 - a. Right click a data-point on your graph and select *Add Trendline*.
 - b. Select '*Moving Average*' and change the period to 5 years.

22. Use EXCEL to calculate the average annual streamflow, **convert cfs to af/yr** (in box below) and place in Table 1. Show your conversion work.
 - a. Highlight all streamflow values.
 - b. Click the Σ button.
 - c. Select *Average*.
23. Print a PDF file with your half/full-page graph with labels and attach to this worksheet and turn in at the beginning of the next class. Do not include the tables. Include your name.

Calculation area for Average annual flow (cfs to af/yr). Note: 1cfs = 724 af/yr

VII. Lab Discussion

1. Describe two climate or historic events that are identifiable in your annual streamflow graph. You may need to research your river, site location, and climate history.
 - a.
 - b.
2. Why is it useful to add a 5-year moving average trendline to the annual stream flow graph, rather than simply considering each year's average flow?
3. Discuss any noticeable or strange trends in your graph and list potential causes of these anomalies. Include at least one specific example.

Lab courtesy of Dr. Jim Washburne