

**STREAM DISCHARGE**

# Learning objectives:

* You will understand how to download, organize and analyze streamflow data.
* You will learn about major climate impacts in their region.
* You will analyze streamflow data to detect and quantify climate change impacts on water quantity in their region.
* You will learn about flood events and how to predict the likelihood of big flood events.

Why this matters:Fresh water is a fundamental resource for our society. Discharge measures the volume of fresh water passing by a point on a riverbank per unit time. Discharge is also a way to measure the quantity of water that is available. For example, water rights are often measured in units of discharge. Fish might require a certain discharge in a reach of stream in order to thrive or move through the reach. Conversely, the highest discharges result in floods that may harm people and structures. Discharge is fundamentally connected to our hydrologic cycle. Streams are fed by water that originally fell as rain and snow. Changes in the quantity of rain and snow, their distribution, and their timing, can be expected to cause changes in stream discharge. Clearly, it is important to be able to understand the way discharge varies. How can we measure these changes?

We must start with data. In this activity we will use data from the United States Geologic Survey (or USGS) network of stream gaging stations. The USGS is a governmental organization established in 1879, as part of the Department of the Interior. Originally tasked with the classification and mapping of United States public lands (and assessment of their mineral resources), the USGS has since expanded their role as a provider of impartial information on the status of ecosystems in the United States. (See <http://www.usgs.gov> for more details.) The USGS intensively monitors a network of 37 streams in relatively undisturbed watersheds around the US. These monitoring sites are collectively called the Hydrologic Benchmark Network.

Outline:

1. Activity A: Variability in stream flow
2. Activity B: Changes in discharge over time

This module was initially developed by Bader, N.E., T. Meixner, C.A. Gibson, C.M. O’Reilly, and D.N. Castendyk. 26 June 2015. Project EDDIE: Stream Discharge. Project EDDIE Module 5, Version 2. <http://cemast.illinoisstate.edu/data-for-students/modules/stream-discharge.shtml>. Module development was supported by NSF DEB 1245707.

# **Activity A**: Variability in real stream data

## A.1: Viewing and accessing data

1. Navigate to the Hydrologic Benchmark Data website, at <http://ny.cf.er.usgs.gov/hbn/index.cfm> LINK BROKEN!!!!

1. Click on “Site list” to see a map showing the locations of the gaging stations in the network. These stations have data on both streamflow and chemistry. Today we will concentrate on the streamflow data.
2. Select the Neversink River in New York to see a photo of the river and the types of data available.
3. Click on the Site Description link. You can see that the water draining past this point has been collected from a drainage area of 66.6 square miles (172.5 square km).
4. Click on Current/Historical observations and scroll down to see how discharge and temperature have changed over the past week.

**A.2 Questions for Discussion** (take notes but will not be collected)

1. Look at the temperature data. How variable was temperature over the past week (the maximum minus the minimum)? A good way to think about variability is to think about percent change. Estimate the mean value of the data. Approximately how much higher (as a percent) are the highest temperatures?
2. Based on the temperature graph, what probably drives temperature changes in the Neversink River? Do you think there is any relationship between temperature and discharge? If so, what do you think it might be?
3. When discharge is high enough, flooding occurs. Is the discharge you observe here unusually high? Unusually low? Typical for the region? Can we answer these questions with only a week’s worth of data?

## A.3: Seasonal variation in streamflow

We might expect flow in a stream to change seasonally. After all, most (or all) of the streamflow that you observe originated as rain and snow falling in the watershed, and precipitation in most places is seasonally variable. Let’s take a look at how streamflow changes over an entire year to see what happens.

* Go back to the summary of all available data for the Neversink River, and choose Daily Data. Type in a start date of January 1 of last year, and an end date of December 31 the same year. Make sure the output format is Graph and click Go.
1. **Question**: Temperature is high in summer and low in winter, as you might expect. What about discharge? Is it the same all year? What months have the highest discharge? The lowest?

# **Activity B:** Changes in discharge over time

##

## B.1: Change through time on the Neversink River

Let’s go back to an important question we had at the beginning of this activity. Is stream discharge changing through time? How might we answer this question, given the seasonal variability of the data?

One solution is to reduce the variability in our data by considering summer and winter data separately. In order to do this, we will need to manipulate the data ourselves using Excel.

1. First, export the data. Go to Monthly Statistics for the Neversink River. Select discharge, and leave the date range blank to get the entire date range. Choose tab-separated data in YYYY-MM-DD format, and save to file. Once you click Submit, a text file called “monthly” will be saved to your computer.
2. Now import the data into Excel. Open Excel, and select File > Import > Text file. Navigate to your “monthly” file and open it. (If it is grayed out, you may need to change “Text Files” to “All files” in the drop-down menu under the dialog box.) The text file is delimited by tabs, so check the appropriate boxes to tell this to Excel, accepting the remaining defaults.
3. You only need three columns: year, month, and mean discharge. Take a close look at your columns to see if you can figure out which is which. When you are confident, type “Year”, “Month”, and “Discharge” in the cells above the appropriate columns. Now you can delete the remaining columns, and the rows above your labels.
4. Now is a good time to save your Excel spreadsheet. Call it something sensible such as “Neversink monthly discharge” and save it in a folder where you can find it again. You should periodically re-save your spreadsheet so that you don’t lose your work.

### Plotting discharge by month

1. Currently your data is organized by year, and within each year it is organized by month. In order to make a plot of a particular month, you should arrange your data by month instead.
* Click one of the cells in the month column and use Sort Ascending in Excel to sort by month - you will see all of the January data first, followed by February, etc.
* Select all of the data cells from February. (Hint: you can click once to select the top left cell, then scroll down and shift-click on the bottom right cell to select the data you want.)
* Graph the data with a scatter plot. You should see a cloud of points with discharge on the Y axis and year on the X axis.
* Excel will also plot all of the integers representing the month in another series on the plot. You can click on a point in the series to select it, then delete the series to get it out of the way.
1. Take a look at the plot you made. This shows the mean monthly discharge for February, over the entire period of record. How variable is it? In which year was the highest mean discharge? What was it?
2. Now let’s compare this data to mean discharges from a summer month. Let’s use August.
* Right-click on the chart and Choose Select Data from the drop down menu.
* In the “Name” box, rename your series “February data.”
* Add a new series, and name it “August data.”
* Click on the small button next to the “X values” field. You can scroll down using the bar on the right and select the corresponding years next to the August data. (Alternatively, you can note the cell names at the top and bottom of the range, and type them into the field.)
* Do the same thing with the “Y values” field, selecting the August discharge data.
1. Examine the plot you made. How is August mean discharge different?

### Change in time

1. Can you see any change in time? It may be difficult to see, against such a variable background. We can use a regression line to visualize and measure this change through time.
* Right-click on a point from one of your data series, and select “Add trendline.”
* In the dialog box that pops up, make sure that you have selected a linear trendline and that you show the equation and R-squared on the screen.
* NOTE: The “**R-squared**” is the fraction of the variance in the Y-axis that can be explained by the X variable. For example, in your plot of Neversink discharge against time, an R-squared of 0.20 means that 20% of the variance in discharge can be explained by the trend. The other 80% of the variance in discharge would be due to other factors.
1. Is there a trend? Are August and February the same, or are they different?

## B.2: Try the analysis on a new watershed

1. This analysis tells us something about the drainage basin in Neversink, New York. Now let’s try this again in another location. Select another watershed in the Hydrologic Benchmark Network and repeat the analysis. When you are finished, convene with the rest of your class to share your results.
2. It is very likely that the watersheds that you analyzed are not the same. These watershed are from a variety of geographic regions, with different patterns of precipitation, different precipitation regimes (e.g., rain vs. snow), and different topography and soils. Why do you think the discharge pattern in your area is different from other places? Come up with a hypothesis to explain some of the differences that you observe. *How would you test this hypothesis - what additional data would you need?*