2.e. Concentration-Flow Relationships

Introduction

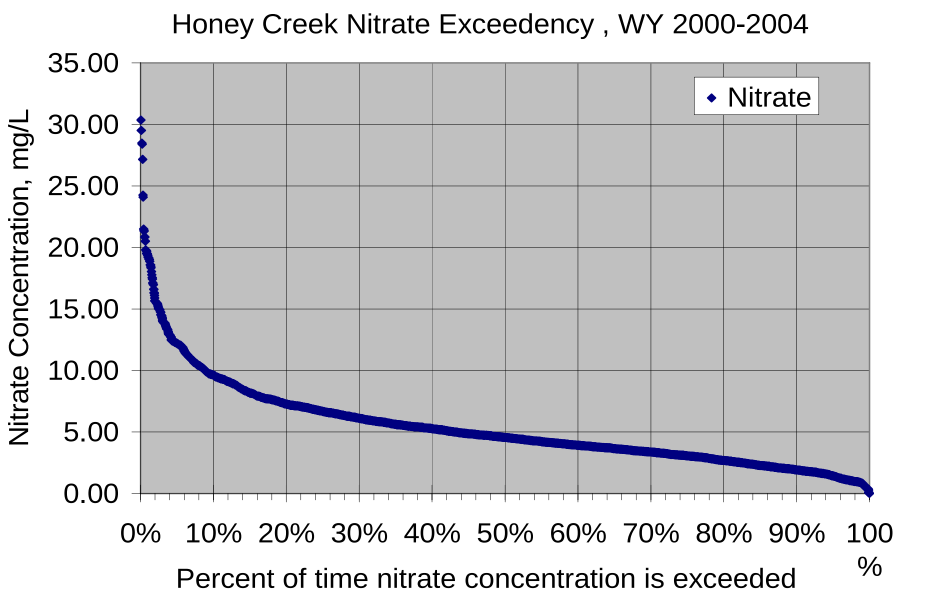
Concentration exceedency curves often indicate violations of water quality standards relative to certain water uses. As the adjacent graph shows, nitrate in Honey Creek exceeds the drinking water standard of 10 mg/L about 9% of the time. Honey Creek serves as a drinking water source for two public water supplies.

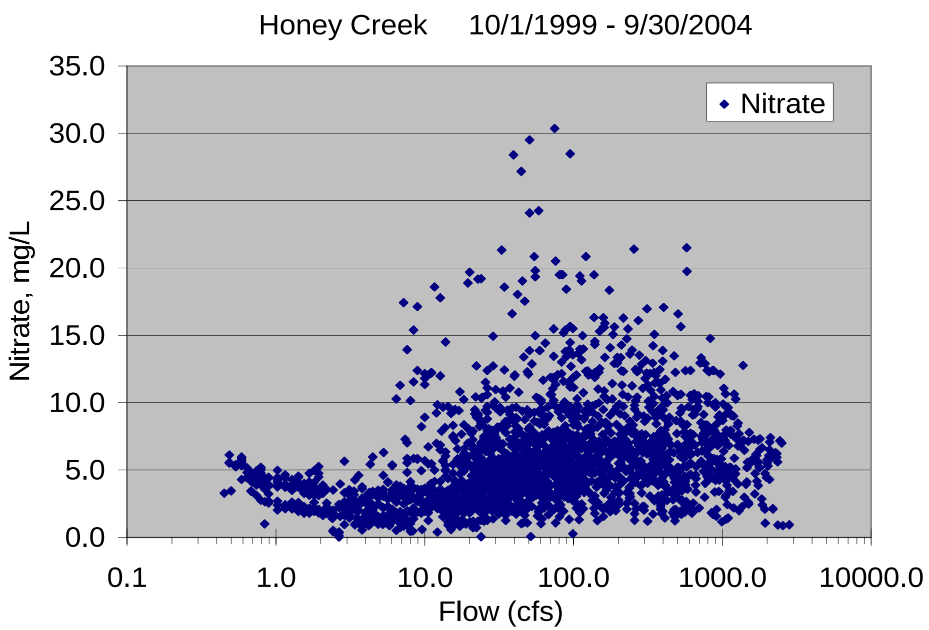
To determine appropriate measures to reduce nitrate concentrations, it is useful to know whether point sources, nonpoint sources or both contribute to the elevated nitrate concentrations. One way to determine the major source is to look at the relationship of nitrate concentrations to stream flow. In general, where pollutants are derived from nonpoint sources, their concentrations increase with increasing flow. The same rainfall runoff that increases stream flow also carries the pollutants from land surfaces and tile flow into streams.

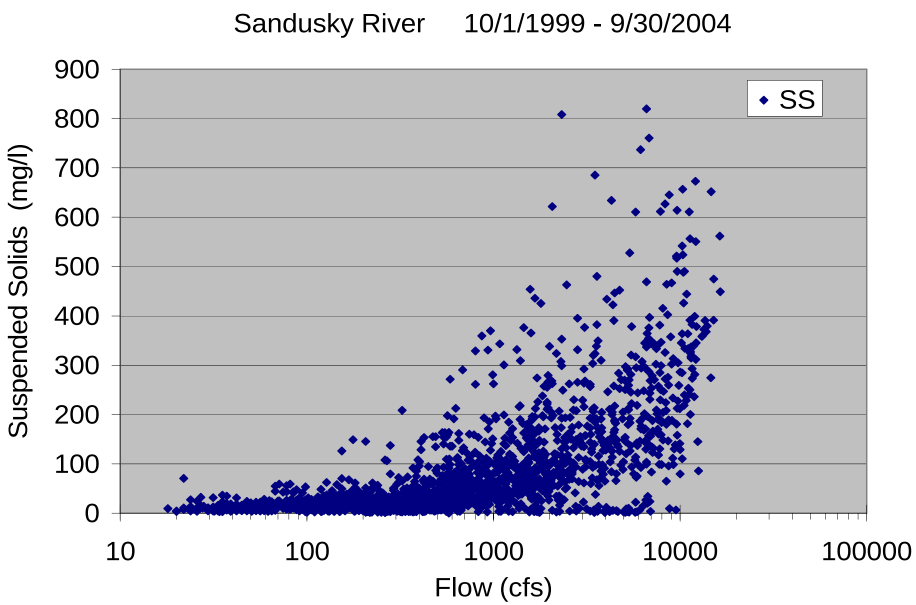
Where pollutants are derived from point sources, their concentrations increase as stream flow decreases. Generally, point sources, such as municipal sewage treatment plants discharge pollutant at relatively constant rates. As stream flow decreases, there is less stream water to dilute the pollutants so pollutant concentrations increase.

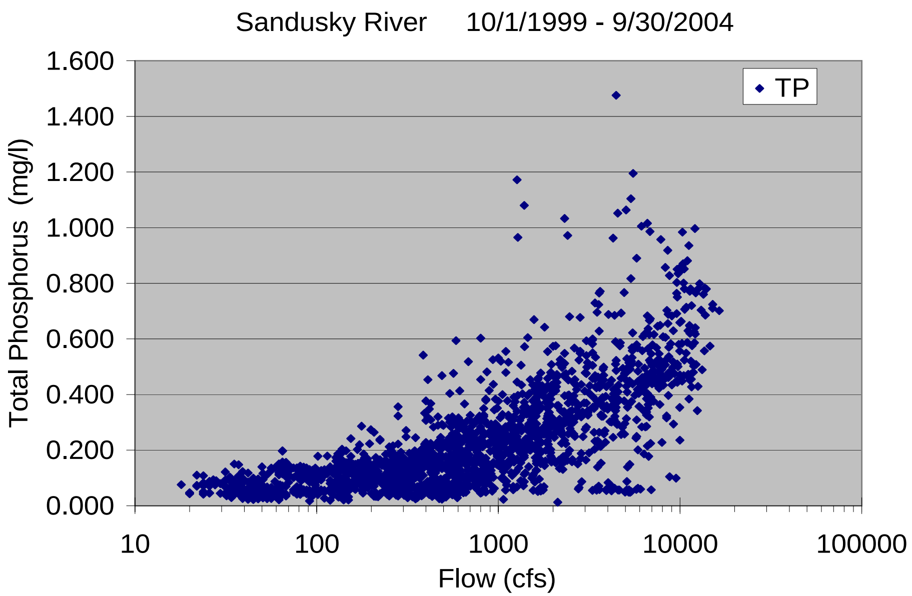
In the Honey Creek example to the right, it is evident that, for the higher concentrations, nitrate increases as stream flows increase. The violations of drinking water standards (10 mg/L) result from nonpoint sources.

It is also evident that nitrate concentrations increase within the low range of stream flows. This suggests that point sources also contribute nitrate to the stream. However, these concentrations do not exceed the drinking water standard at the monitoring station. (See section on nutrient processing within streams (under development).)







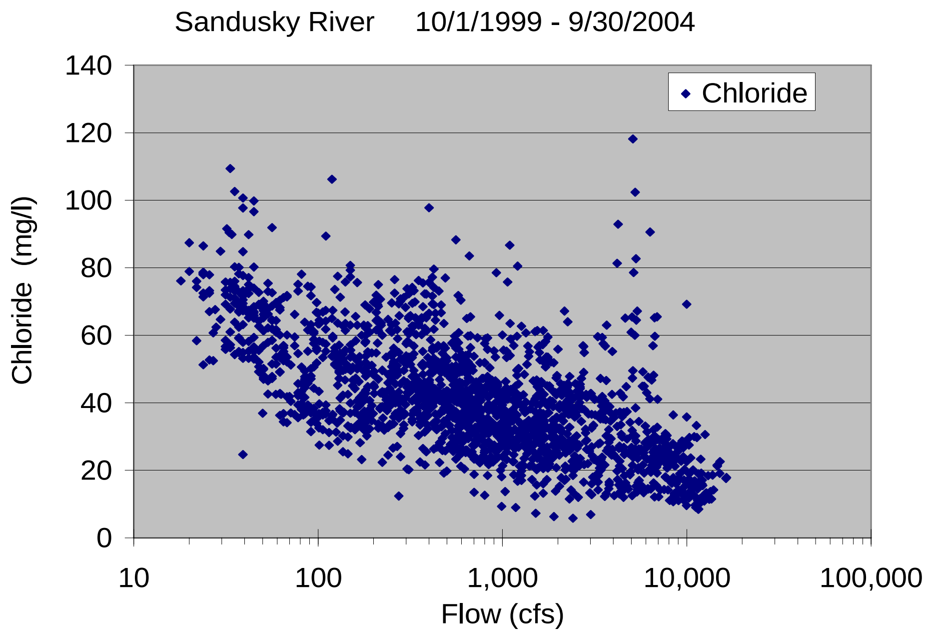


Some Examples of Concentration- Flow Curves

These graphs illustrate the concentration-flow relationships for three substances in the Sandusky River for a 5-year period. Suspended solids (above) are derived from nonpoint sources. All streams and rivers that we have studied have suspended solids/flow curves with the same general shape as shown above.

In the Sandusky River, total phosphorus concentration-flow graphs have the same general shape as suspended solids. As noted in Hydrographs, Sedigraphs and Chemographs most of the total phosphorus is particulate phosphorus that is attached to suspended solids particles.

In the Sandusky River, and in most rivers, chloride concentrations decrease with increasing flow. The chloride concentrations present in ground water and point sources is high relative to rainwater. Although rainwater does pick up chloride as it moves across land surfaces, generally its concentration is lower when it reaches streams, so it dilutes the baseflow water. Rainfall and snowmelt runoff following road salt application can result in high chloride concentrations at high flow. This is particularly evident in streams draining urban areas.

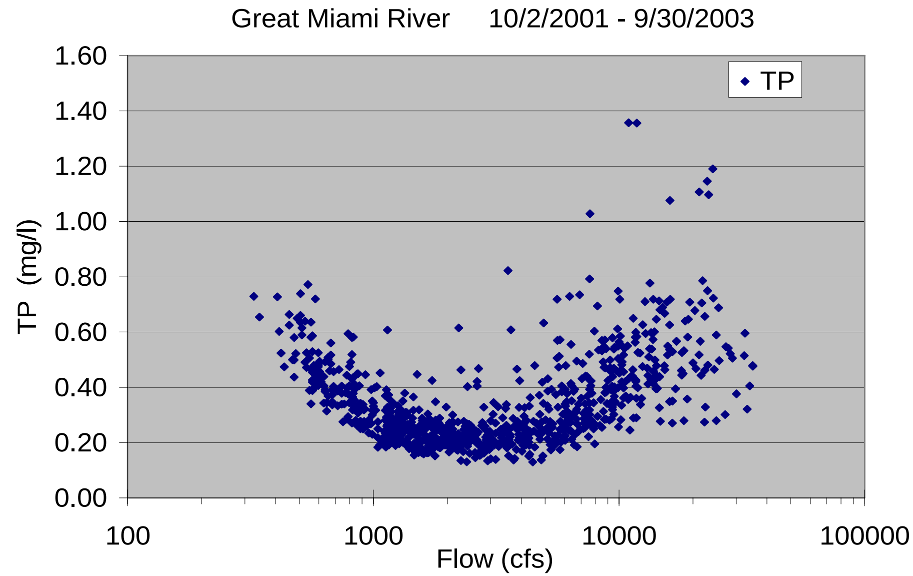


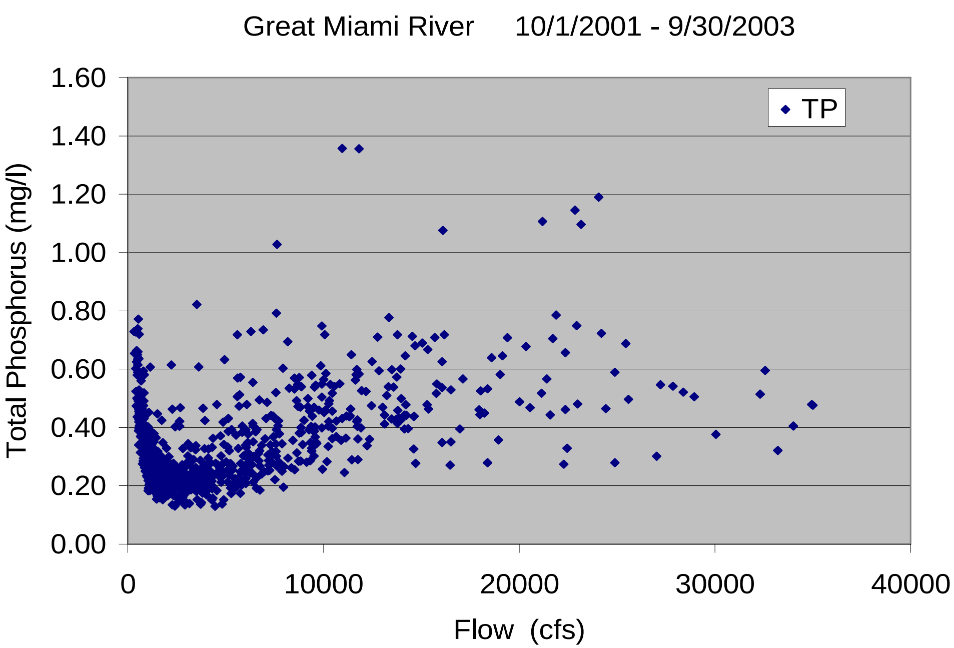
Some Examples of Concentration-Flow Curves, cont.

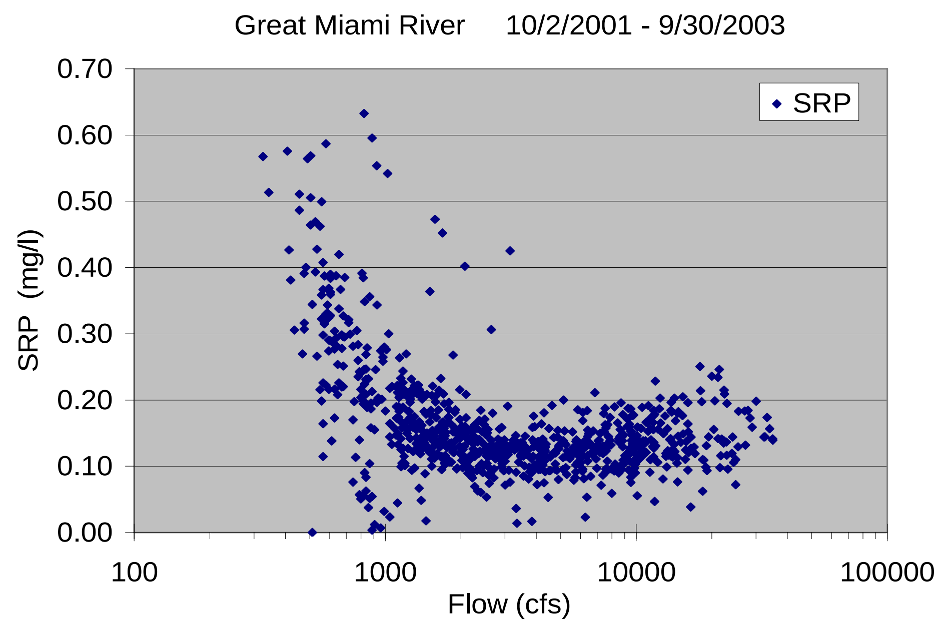
Where both point and non-point sources contribute to elevated concentrations of pollutants, the concentration-flow graphs are often U-shaped. This is the case for total phosphorus in the Great Miami River. Municipal sewage treatment plants and cropland erosion both contribute phosphorus in quantities that result in elevated phosphorus concentrations. However, they affect phosphorus concentrations under very different flow conditions.

That point sources are responsible for the increasing phosphorus concentrations under low flows is confirmed by examination of the soluble reactive phosphorus concentration-flow curve to the lower right. A high proportion of the total phosphorus from point sources is soluble reactive phosphorus. The increasing SRP concentrations with decreasing flow in the low flow range is a sure indicator of sewage effluent.

In these concentration-flow graphs, we use log scales for flow axis so that the low flow responses are more evident. The graph below shows the same TP data with a linear flow axis.



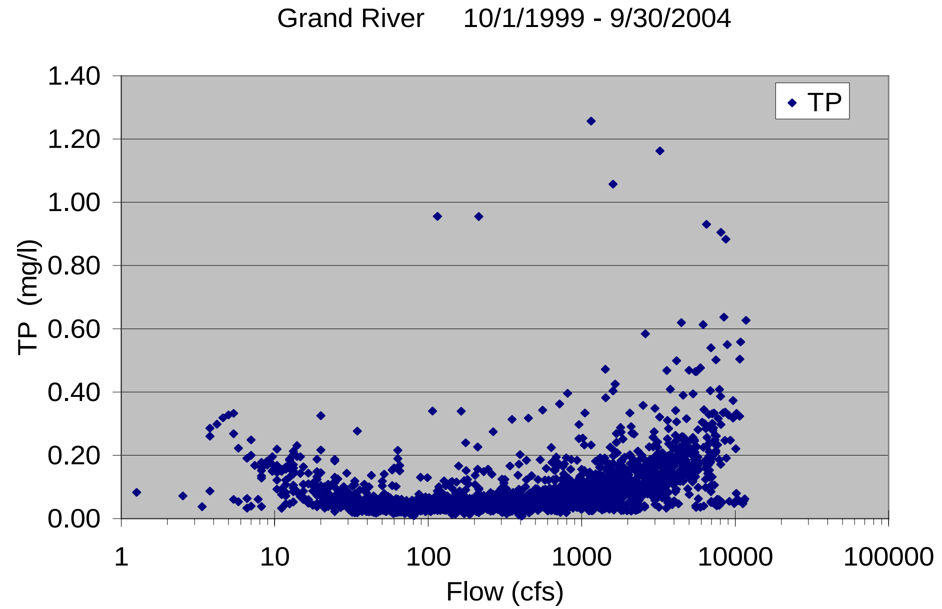


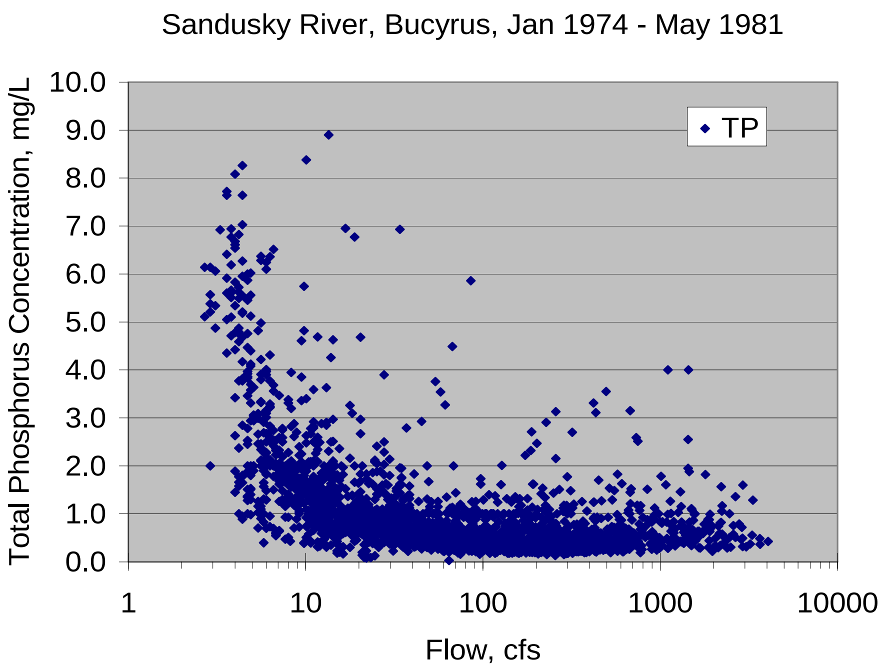


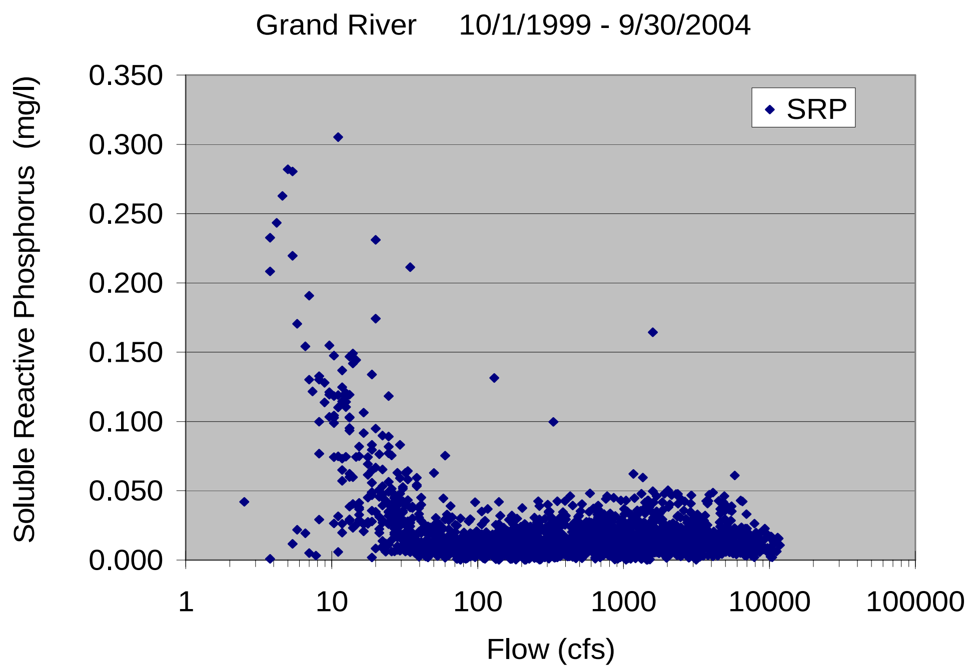
Some Examples of Concentration-Flow Curves, cont.

The Grand River provides another example of a stream where both point and nonpoint sources contribute to elevated phosphorus concentrations. Note that much of the total phosphorus under low flows is comprised of soluble reactive phosphorus (lower right graph). This pattern of increasing SRP concentrations under low flow suggests point source impacts low flow conditions. Under high flow conditions, the soluble reactive phosphorus remains low.

Prior to the onset of phosphorus removal at sewage treatment plants in the Lake Erie Basin the pattern of total phosphorus-flow graphs showed much higher low flow concentrations. This is illustrated for the Sandusky River below Bucyrus from earlier WQL data sets. Note the differences in the Y-axis scales for the Grand River and for the earlier data from the Sandusky River below Bucyrus.







Plotting Concentration-Flow Relationship Graphs

Plots of pollutant concentration versus flow are easy to make, requiring simply the pollutant concentrations and their associated flows for the samples collected within the period of interest. This information may be copied from the RiverData files into new Excel Worksheets prior to using the Excel Chart Wizard for making the plots.

Alternatively, you may use the Concentration versus Flow Plots worksheet of the AnalysisTemplatev3 program to select the river, parameter and inclusive dates. It will make the graph and create a data sheet with the selected data. It will also transfer the graph and data to a new Excel workbook for your subsequent use.

Caution in interpretation of concentration-flow graphs:
The points on these plots represent individual samples. Some samples represent one full day (primarily low flow samples), while other samples represent one third of a day (primarily high flow samples). Thus the distribution of points on the graph does not reflect the frequency of occurrence of conditions in the stream.