Emily Lloyd
Commissioner

Paul V. Rush, P.E.
Deputy Commissioner
Bureau of Water Supply
prush@dep.nyc.gov

465 Columbus Avenue
Valhalla, NY 10595
T: (845) 340-7800
F: (845) 334-7175

June 5, 2015

Pamela Young, Ph.D.
New York State Department of Health
Bureau of Public Water Supply Protection
Empire State Plaza – Corning Tower 11th Floor
Albany, NY 12237

Phil Sweeney
United States Environmental Protection Agency - Region II
290 Broadway - 24th Floor
New York, NY 10007-1866

Dear Dr. Young and Mr. Sweeney:

Enclosed is the DEP Response to NYSDOH/EPA Comments on FAD Deliverables submitted March 31, 2015, in accordance with the Revised 2007 Filtration Avoidance Determination (FAD).

As always, if you have any questions about these comments or other aspects of the City's watershed protection efforts, please do not hesitate to contact me.

Sincerely,

David S. Warne
Assistant Commissioner

DEP Response to NYSDOH/EPA Comments on the FAD Deliverable Reports
Submitted March 31, 2015
Response Date June 5, 2015

4.2 Land Acquisition

The Revised 2007 FAD required DEP to execute a contract with the Watershed Agricultural Council (WAC), to pay for stewardship and enforcement costs associated with WAC's current and future portfolio of conservation easements acquired with funds from DEP. NYSDOH/USEPA acknowledge that this contract has been successfully negotiated.

DEP Response:

Comment noted.

5.2 Multi-Tiered Water Quality Modeling Program

The annual report was submitted as required by the Revised 2007 FAD. NYSDOH/USEPA offer the following questions/comments on this report:

Section 3.2 discusses Water Research Foundation Project 4262. A final report from this project was published in 2014. Overall, this work suggests that DEP may not be able to meet water quantity and quality goals in the future, particularly at the highest demand estimates. This does not seem to fit with past modeling results. For example, the 2010 annual report (pages 53-54) states, "the NYC reservoir system will most likely continue to show high resilience, high annual reliability, and relatively low vulnerability."

DEP Response:

DEP is committed to meeting its water quantity and quality goals in the future and takes a lead role among utilities in addressing the issues associated with climate change. For example, DEP is a member of Water Utility Climate Alliance (WUCA), which according to its mission statement, "provides leadership in assessing and adapting to the potential effects of climate change through collaborative action."

Toward that goal, WUCA just released the final report (http://www.wucaonline.org/assets/pdf/pubs_puma_white_paper_2015_04_27.pdf) on the Piloting Utility Modeling Applications (PUMA) project in which DEP was one of four water utilities "working in collaboration with local climate science consortiums to hand-pick or develop locally appropriate tools, projections and approaches to understand the impact of climate change on drinking water supplies."

As for the difference between the conclusions in the Water Research Foundation Project 4262 report and previous DEP reports, it should be noted that the reports did not use the same targets and/or assumptions, so a direct comparison of results is not possible. Also, the examples presented in the WRF project report for DEP and Colorado Springs Utilities were pilot studies for using the RDM guidelines and the results were considered preliminary. For example, on page 38 of the report, it is stated that "The inability of current climate science to adequately characterize the

uncertainty in future climate with respect to extreme event frequency and intensity, underscores the preliminary nature of the analysis and its conclusions because of the importance of extreme events to the reliability and quality of water supplied from the NYC system." The report goes on to say that "… the methodological framework is robust and could be re-applied when climate science provides better estimates of future climate to obtain more precise conclusions."

Also, the current work suggests non-climate factors, such as higher future demands and required community releases, drive modeled reliability and turbidity concerns. The Robust Decision Making (RDM) framework is an interesting approach and seems to work well here. Other than reducing computing needs, are there any other advantages of RDM over a more traditional Monte Carlo approach and other methods used in the past?

DEP Response:

As noted in the report, a Monte-Carlo approach samples according to a specified likelihood distribution that must be agreed upon prior to analysis. In RDM the samples are used iteratively without making any judgments on whether one future is more likely than another. The report states that "RDM seeks to evaluate the performance of water management strategies under a broad range of plausible futures, without an initial focus on the likelihood of the different futures." The report cites literature indicating that using "…a broad-range of assumptions about the future is increasingly considered best practice in climate change planning and decision support" instead of making a priori decisions about the shape of the distribution.

RDM is different in its planning approach, but the process does seem promising in that it seems to provide an opportunity to continually improve planning and preparation for the future. In the WUCA whitepaper, *Embracing Uncertainty: A Case Study Examination of How Climate Change is Shifting Water Utility Planning* (http://www.wucaonline.org/assets/pdf/pubs_uncertainty.pdf), RDM was used in the Colorado River Basin Water Supply and Demand Study. They found one of the most useful features of the methodology was in evaluating "…how alternative water management strategies would perform across a wide-range of plausible future conditions and identify those strategies most robust to these futures." It was viewed as an advantage that future conditions did not need to be assigned a probability. They did note that RDM requires sophisticated computer simulation and analysis.

In the 2014 final report, Figure 2.3 (page 8) shows that an RDM approach samples unlikely predicted futures at the same rate as more likely futures. Is this why the current work emphasizes future problems more than past efforts?

DEP Response:

As noted above, this report utilized different targets than past efforts by DEP, and the results should be considered preliminary, so a comparison between this report and past DEP reports is not valid. It should also be noted that Figure 2.3 is an illustrative case to show how sampling may occur based on a statistical distribution that was selected prior to analysis. The distribution selected does not represent the likely future for the NYC watershed.

Extreme weather projections are still difficult at this time. Could a stochastic weather generator and/or historical records from past extreme events be systematically evaluated using OST or other tools in the meantime to evaluate and plan for these events?

DEP Response:

One of the projects being carried out under the RF-CUNY contract will examine statistical downscaling methods using a "bottom-up" approach that is expected to incorporate the effects of extreme events better than the change factor methods that have been used previously. This will include the use of stochastic weather generators, which are often employed in bottom-up risk assessments to simulate potential shifts in both long-term (decadal) precipitation means and persistence as well as in extreme daily precipitation amounts. Also the RF-CUNY support scientist on this project is collaborating with doctoral students from the University of Massachusetts at Amherst and Universite du Quebec on a comparison of different types of weather generators. The initial plan is to compare the UMASS-developed Weather Generator (WG), which is semi-parametric, with some parametric weather generators developed by Universite du Quebec, and also compare their application to a single-site versus multiple sites.

In Section 4.1 (OST Development), please expand on the first bullet, which relates to deriving real-time input data by using relationships to local airport stations. It was the understanding of NYSDOH/USEPA and implied by Table 6-2, that most, if not all, reservoirs were equipped to collect meteorological data onsite. Please explain the advantages and disadvantages of using input data from reservoir locations versus local airports.

DEP Response:

There is a terrestrial station at each reservoir and meteorological instruments on buoys in most reservoirs. However, at times when local data are not available we use empirical relationships to off-site stations to produce local estimates. In order to clarify this, the bullet was expanded to state:

- Extending the meteorology input time series data through 2012 using, as a primary source, meteorological data collected on buoys deployed at each reservoir. During periods of instrument malfunction or where data gaps occurred for other reasons, these were filled using empirical relationships to local airport meteorological stations, including Binghamton (for Delaware system reservoirs), Albany (for Catskill system reservoirs), and White Plains (for EOH reservoirs). For example, wind stress is an important driving force for hydrodynamic and transport calculations. Therefore, localized on-site wind inputs are desirable, though not always available. The empirical models between on-site and off-site wind data seek to obtain representative on-site wind conditions. Although not ideal, empirical equations to local airports have shown to provide relatively good estimates for local meteorology, given both the model error and W2 model sensitivity to each meteorological variable (Gannett Fleming & Hazen and Sawyer, 2009). One disadvantage of using empirical relationships is their dependency on data characteristics inherent to the historical period used to develop the relationship. Also, problems may occur when either the on-site or off-site station is moved from its original location. As more data for common

periods becomes available, and as necessary, empirical relationships will be adjusted to account for current and a broader range of historical hydrologic regimes.

Gannett Fleming & Hazen and Sawyer (2009). Catskill turbidity control studies: Phase II Implementation Plan - Updates and Supporting Analyses. Prepared for New York City Department of Environmental Protection, Bureau of Engineering Design and Construction.

In Section 5.4 (Statistical Training for Data Analysis), NYSDOH/USEPA note the continued educational opportunities that DEP seeks out, such that the large amount and types of data that are generated in the watershed can be accurately interpreted using the most appropriate statistical techniques.

DEP Response:

Comment noted.

Figures 6.1 and 6.2 contain blurry, illegible text on the map and portions of legend. This happens frequently in DEP submissions. Please resend these two figures.

DEP Response:

The figures are attached.

Section 6.3 states, regarding time series data, "Lag times between the current date and the dataset end dates are the result of QA/QC processes at the data source and/or procurement timelines driving the acquisition of any purchased data." This information is useful in understanding the date span of data used by DEP in their modeling, such as in Table 6-2, which shows DEP meteorology data covering the period 1994-2010.

DEP Response:

Comment noted.

The abstract for papers and presentations show numerous works of interest. NYSDOH/USEPA would like to request copies of the presentations from Janus et al. (pg. 38) and Moore and Mayfield (pg. 39).

DEP Response:

The presentations are attached

8.1 Waterborne Disease Risk Assessment Program

The annual report was submitted as required by the Revised 2007 FAD. In general, the report was well written and informative. NYSDOH is interested in receiving a copy of the questionnaire used to gather information on potential exposures to *Cryptosporidium*. This would help us gain additional insight into the approach used by the program to obtain the reported data.

DEP Response:

The questionnaire is attached.

11. Reporting

The FAD Annual Report was submitted as required by the Revised 2007 FAD. Comments will be sent separately.

DEP Response:

Comment noted.

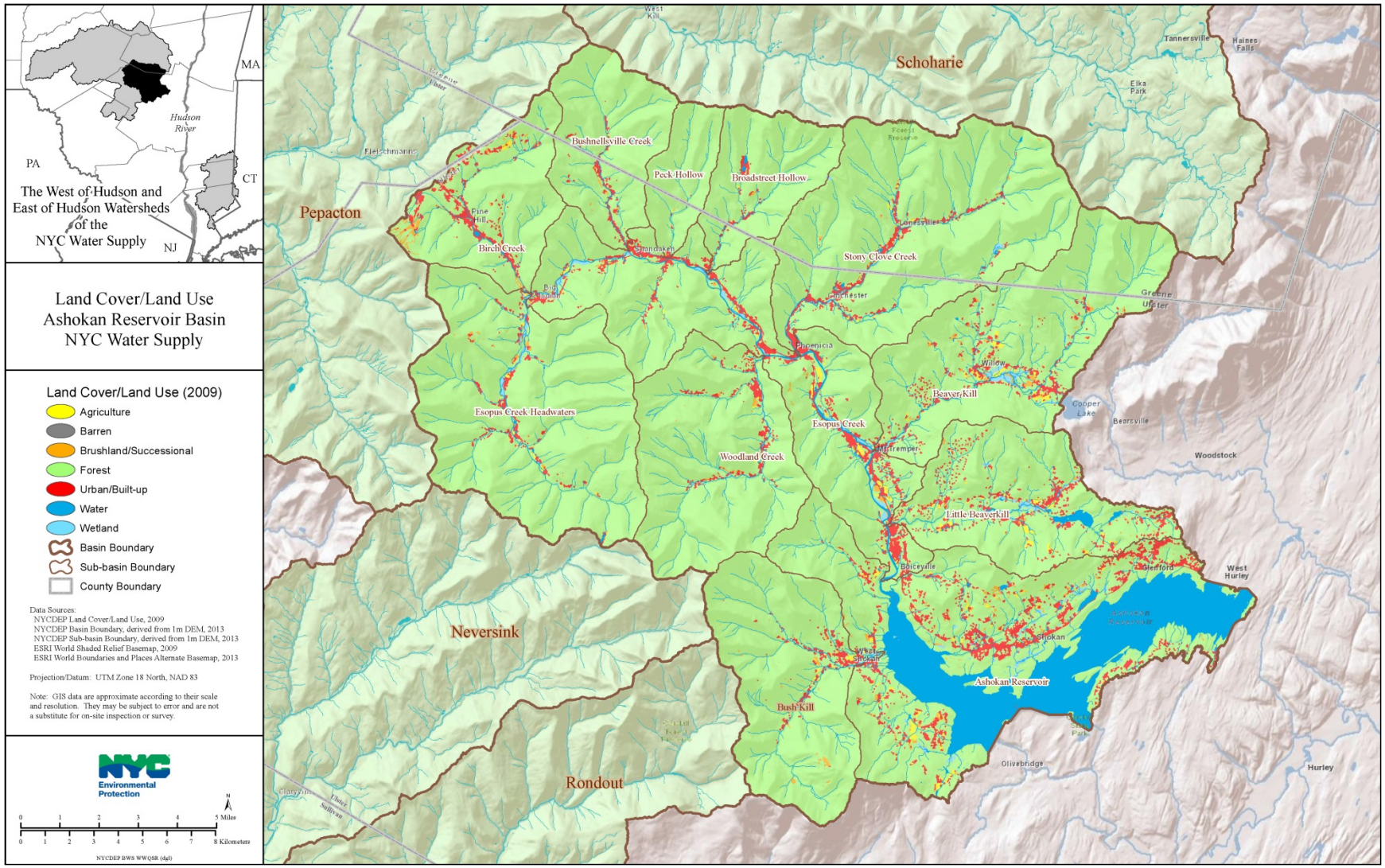


Figure 6-1 (revised) Ashokan Basin land cover.

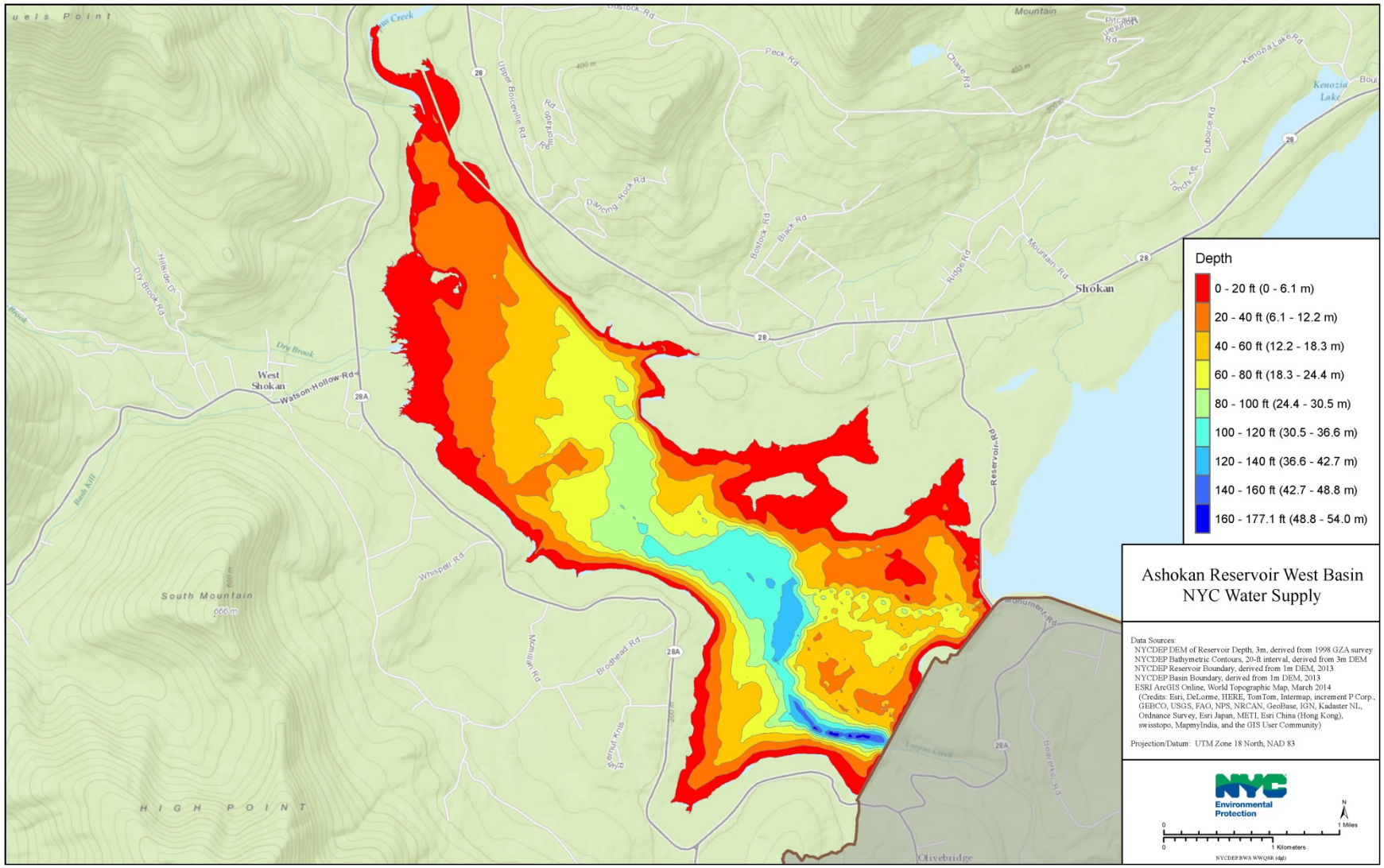


Figure 6-2 (revised) Ashokan Reservoir West Basin bathymetry.

Trophic Response of Catskill and Delaware Reservoirs compared to OECD Regressions

L. Janus, J. Mayfield, D. Pierson, R. Van Dreason

WSTC, West Point, NY, Sept 10, 2014

Outline

1. Why conduct this comparative analysis?
2. Organization for Economic Cooperation and Development (OECD) Eutrophication Program and objectives
3. DEP reservoirs relative to OECD Standards
4. Conclusions on behavior of 4 DEP reservoirs
5. Future directions

1. Why conduct this comparative analysis?

Application to NYC reservoirs will put our data in context and reveal important differences in reservoir responses that will be useful in water quality management.

- How do NYC reservoirs respond compared to other waterbodies?
- What physical, chemical and biological driving factors are important in determining WQ in reservoirs?
- How do extreme events such as floods and droughts affect algal biomass?
- What are the implications for WQ if extreme events increase?
- How have the NYC reservoirs changed over the past 23 years with many watershed protection programs in place?
- What are the expectations for WQ improvement?

- This project will contribute to the next **Summary and Assessment** (FAD due March 2016)

2. OECD program and objectives

- OECD Program was initiated to solve eutrophication (1960s – 70s) problem in Europe, which had a large impact on tourism & economy

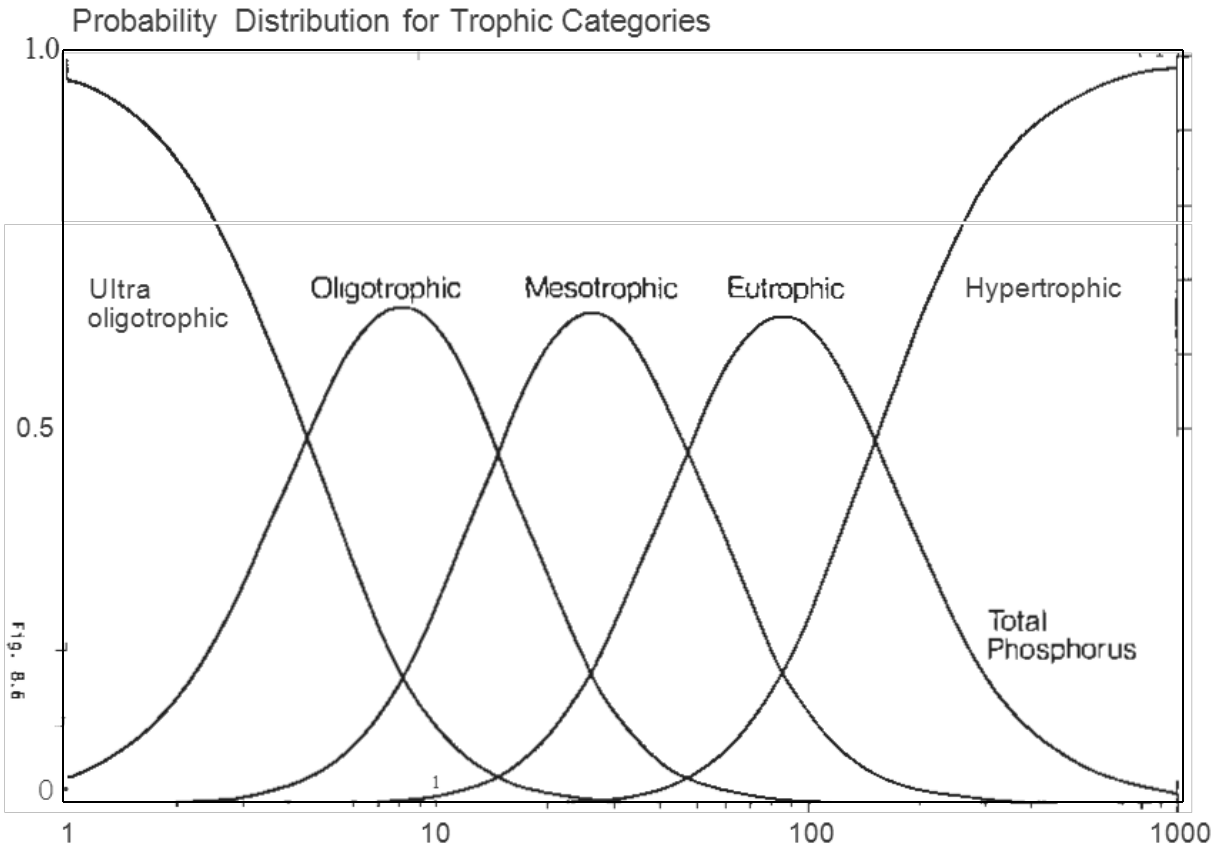
- Development s over the past 60 years:
  - OECD Cooperative Program on Eutrophication – 4 regions included: Alpine, Nordic, Shallow Lakes and Reservoir, North American Project
  - development of OECD Standard Regression Lines from over 100 northern temperate zone lakes
  - Canadian Contribution test case (1980s); included 7 lake regions across Canada
  - DEP reservoirs represent a second test case with 23 years of data

- The major OECD objective was to provide simple guidelines for WQ management

- The OECD lines provide context for reservoir data – a frame of reference; (similar to bearings in navigation).

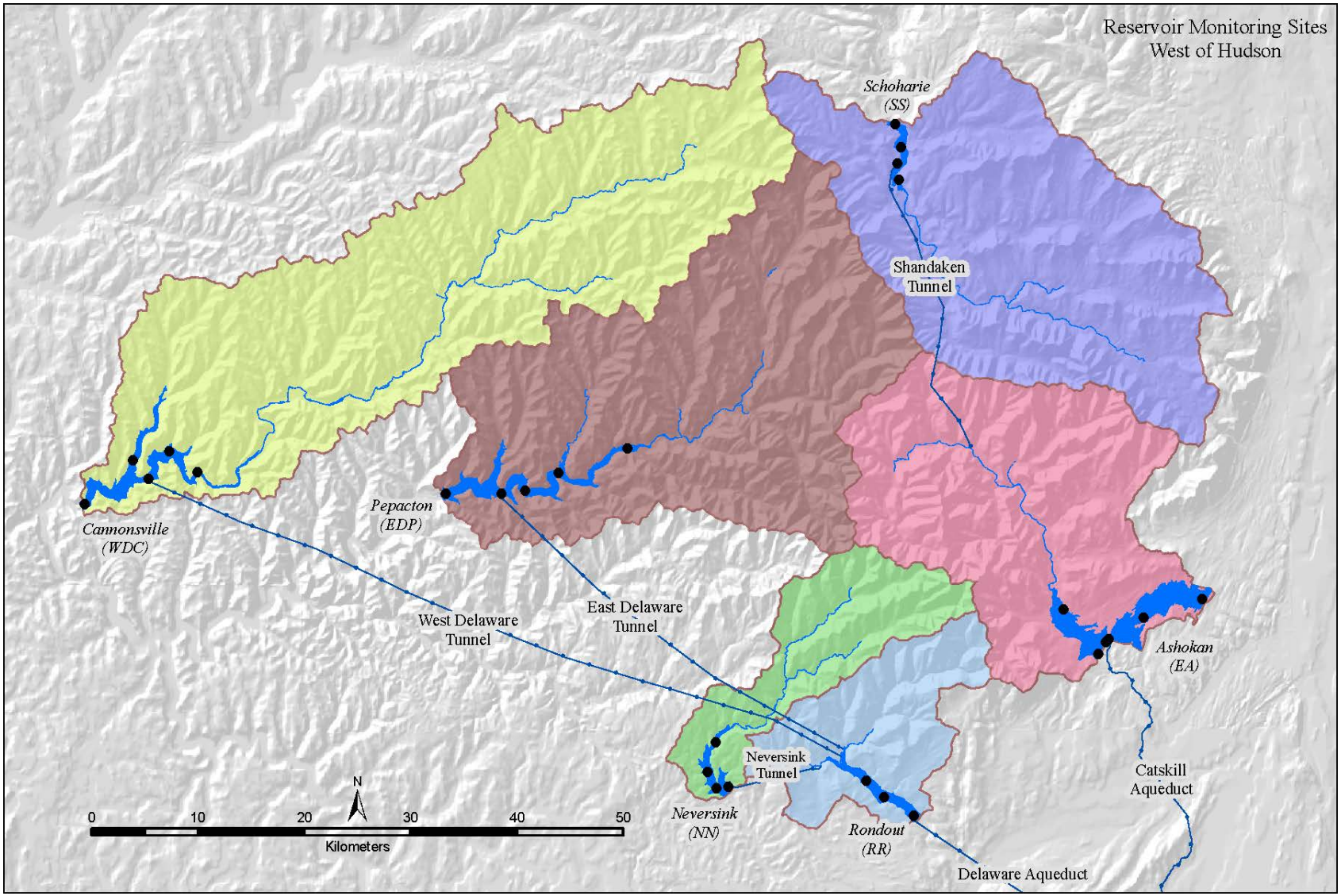
Probabilities of trophic states

At a given nutrient (TP) level, the probability of each trophic category varies due to factors affecting productivity; WQ responses vary widely.



Four headwater reservoirs examined

Neversink, Pepacton, Cannonsville , Schoharie



Objectively defined trophic categories with OECD observed means

Var. (mg m^{-3})	OLIGO -	MESO -	EU -	HYPER -
TP *(OECD lakes) Neversink Pepacton Cannonsville Schoharie	**8** 3.4 - 10 9.2 – 14.4	**27** 14.2 – 29.9 9.9 - 31	**84**	**>750**
TN* Neversink Pepacton Cannonsville Schoharie	**661** 164 – 458 184 – 593 270 – 782 201 - 496	**753** up to 782	**1875**	
CHL A* Neversink Pepacton Cannonsville Schoharie	**1.7** 1.7 2.4 0.8	**4.7** up to 4.1 6.2 4.4 6.2	**14.3** up to 13.6	**>100**
SECCHI* Neversink Pepacton Cannonsville Schoharie	**9.9** 6	**4.2** 4.9 4.0	**2.5** 2.4 2.4 1.4 2.8	**< 0.4** 0.7

Neversink 4/4 = oligotrophic

Pepacton 3/4 oligotrophic

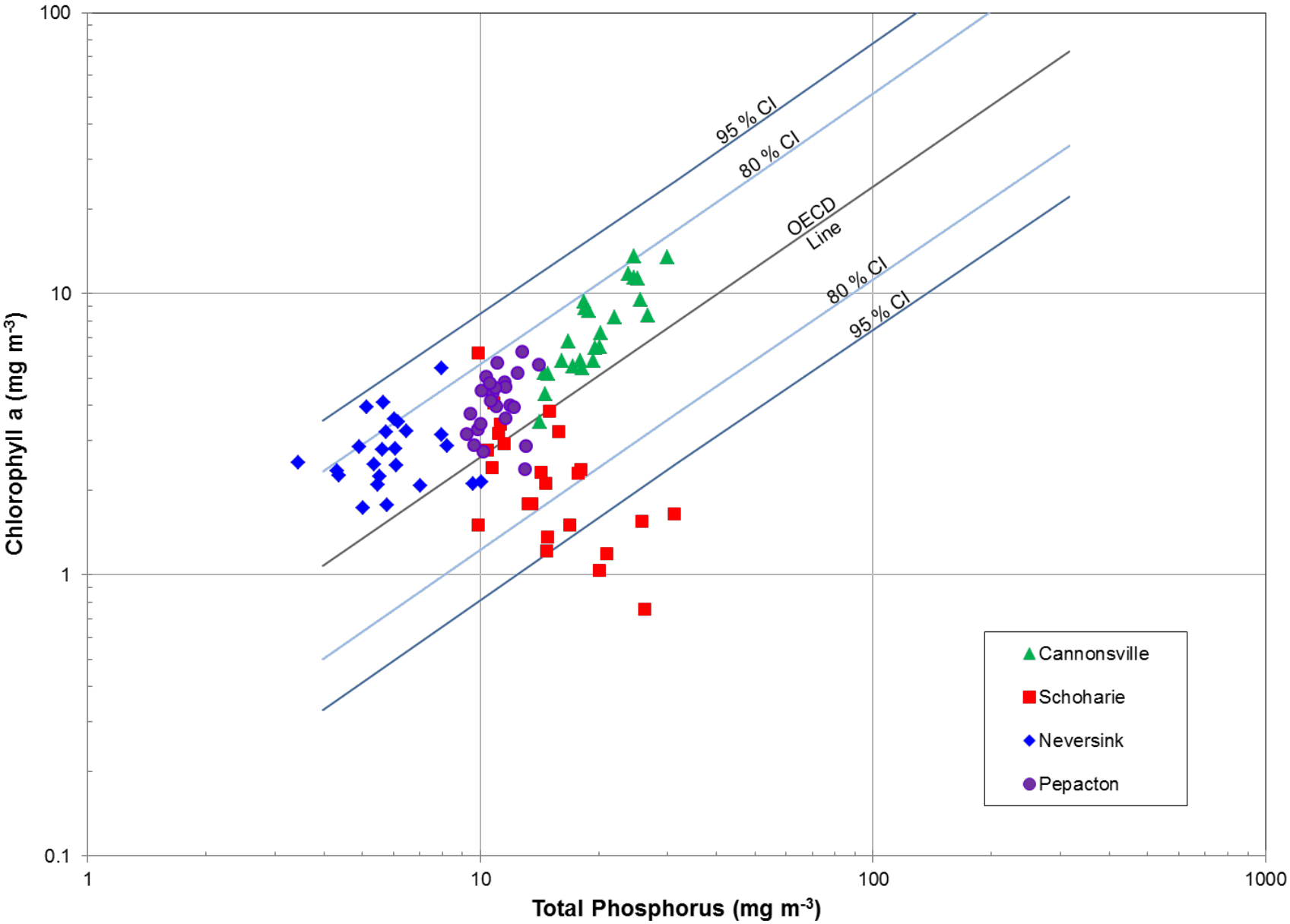
Cannonsville 2/4 = meso- to eutrophic

Schoharie 2/3 = oligo-mesotrophic

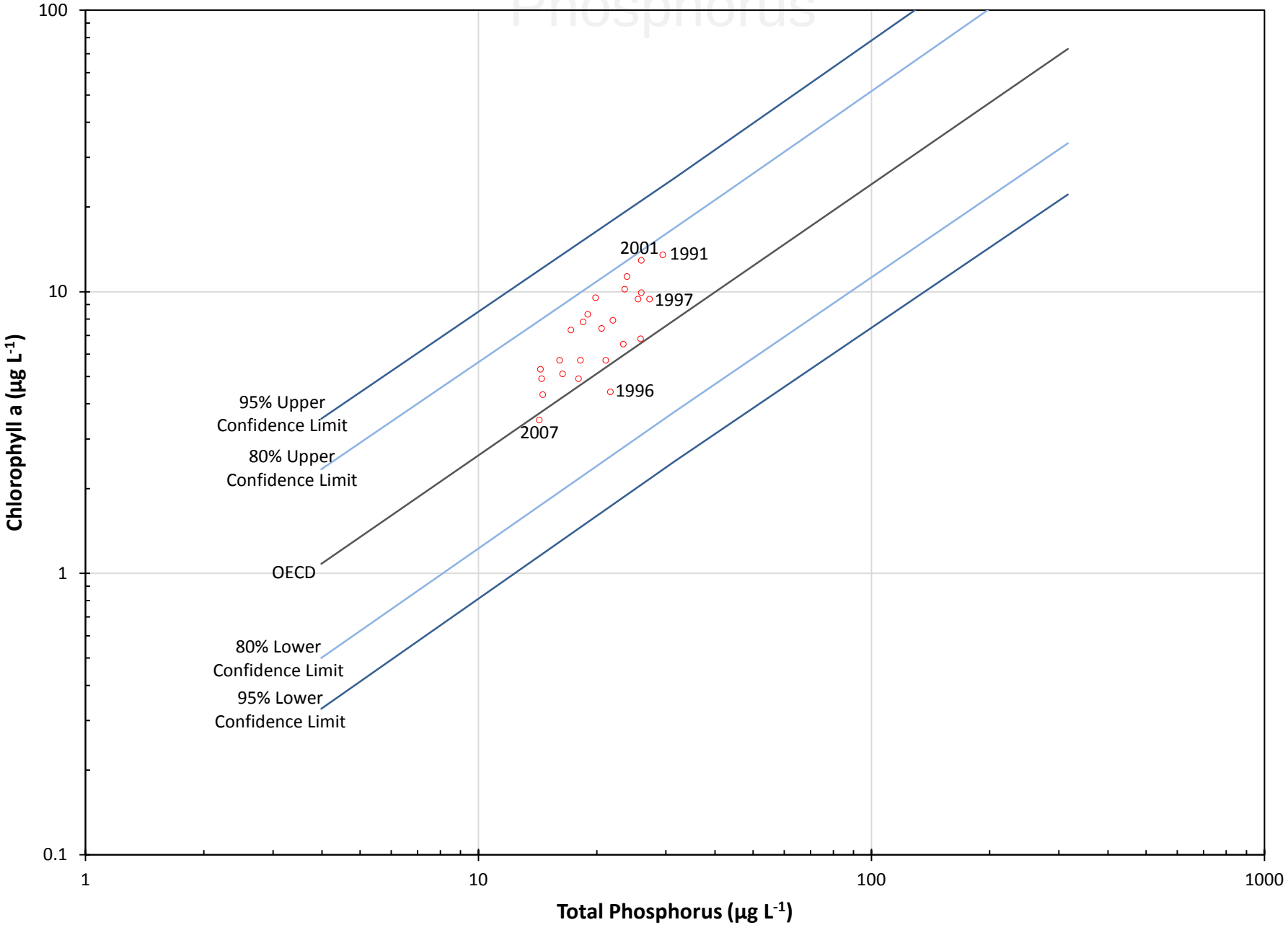
3. DEP reservoirs relative to OECD Standards

- Four OECD Standard regressions examined:
  1. Chl = f(TP); biomass response to nutrient level
  2. Maximum Chl = f(TP); maximum biomass response to nutrient level
  3. SD = f(Chl); light penetration dependence on algae and other particulates
  4. SD = f(TP); light penetration relationship to nutrients

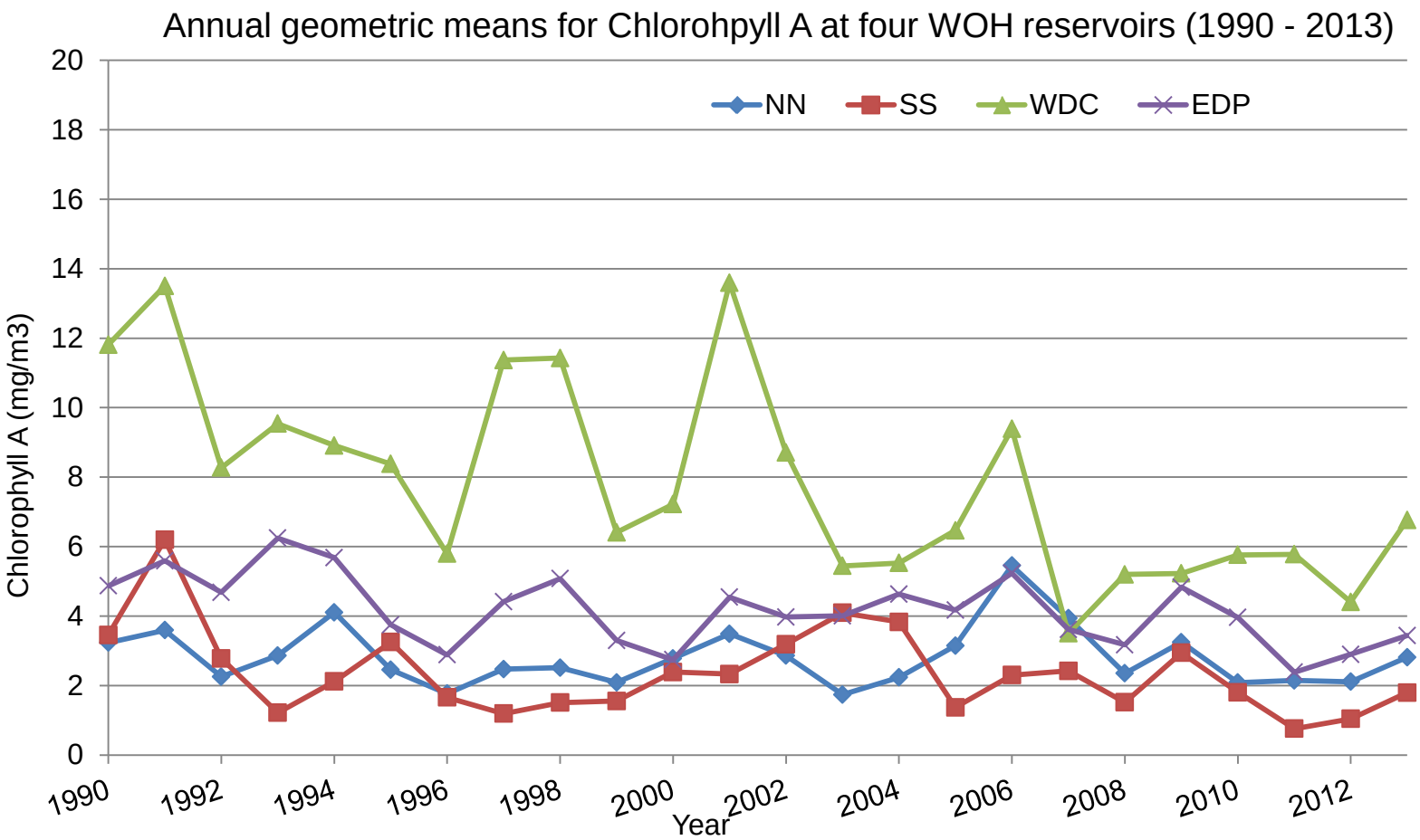
Chl a vs total phosphorus



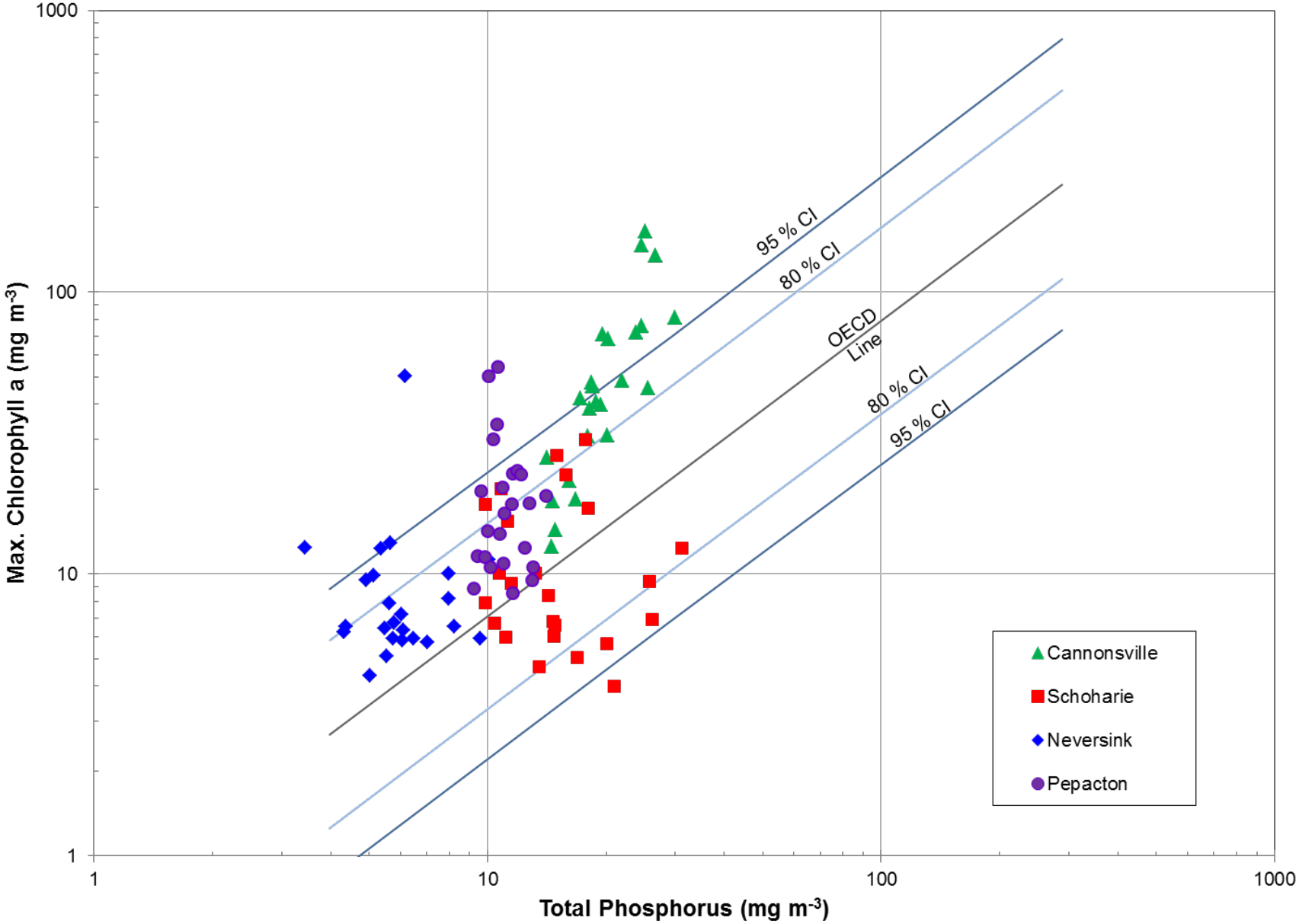
Cannonsville: Chlorophyll a *vs.* Total P



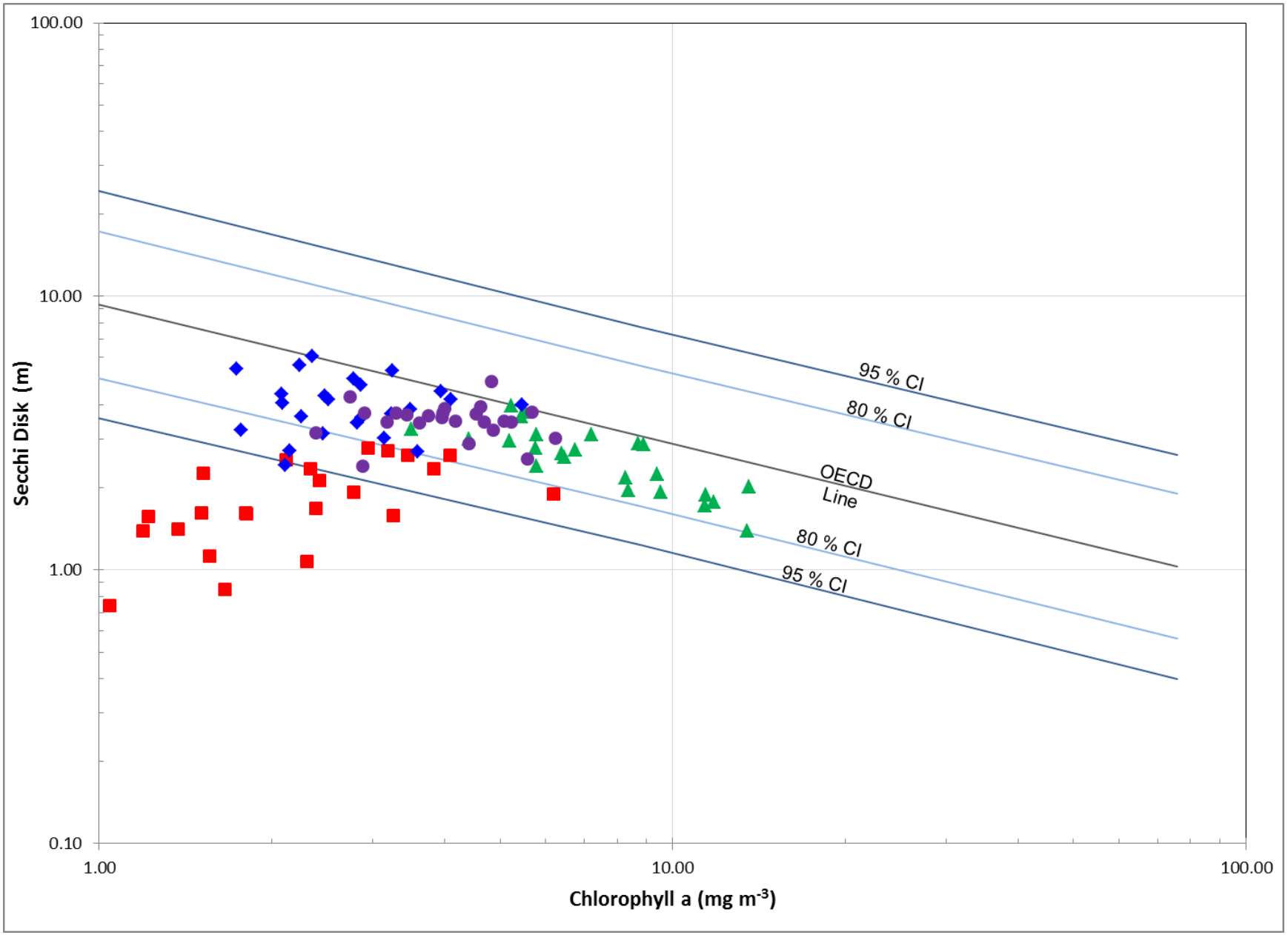
Chl a (geometric means) 1990 - 2013



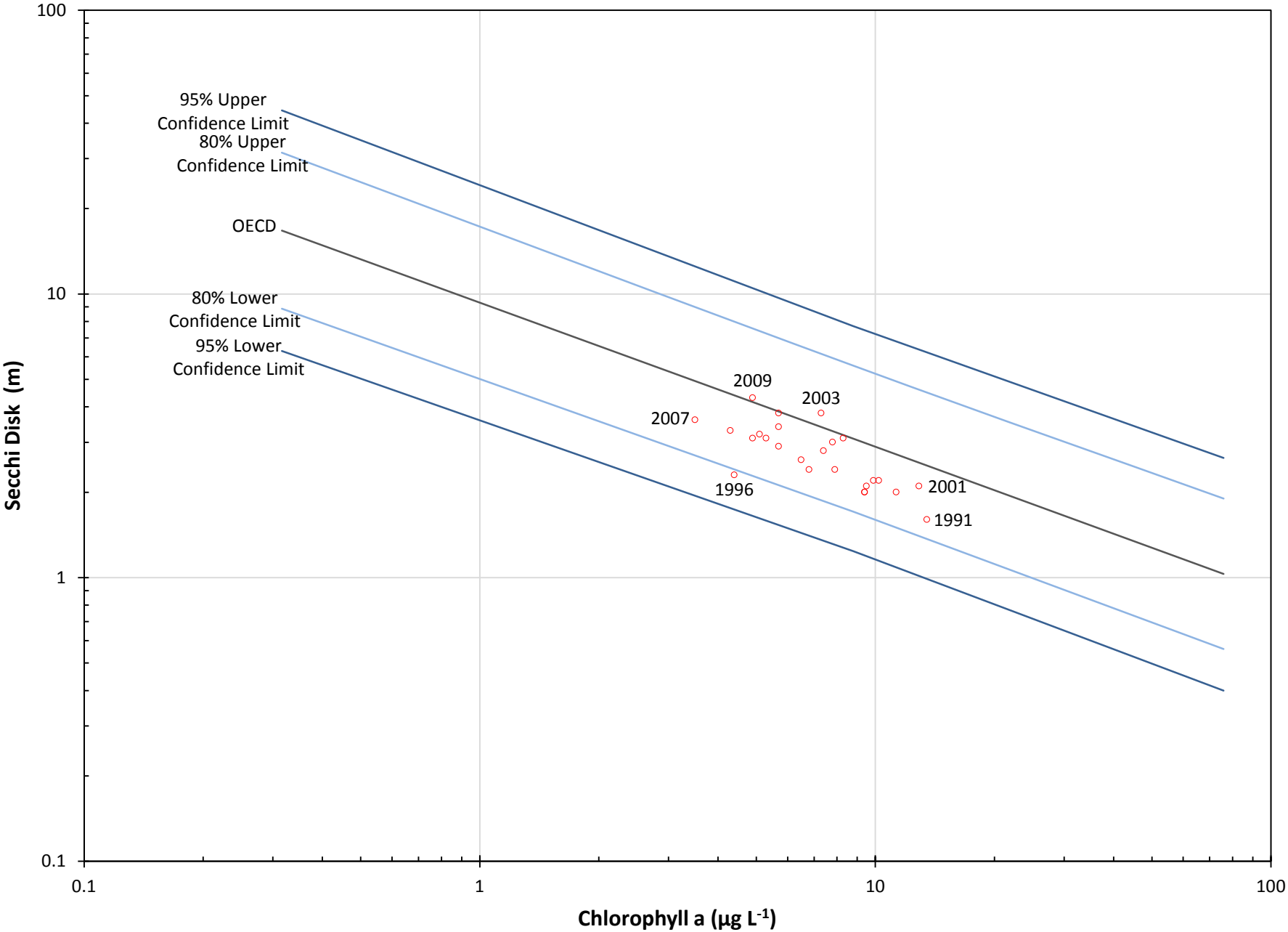
Maximum Chl a vs total phosphorus



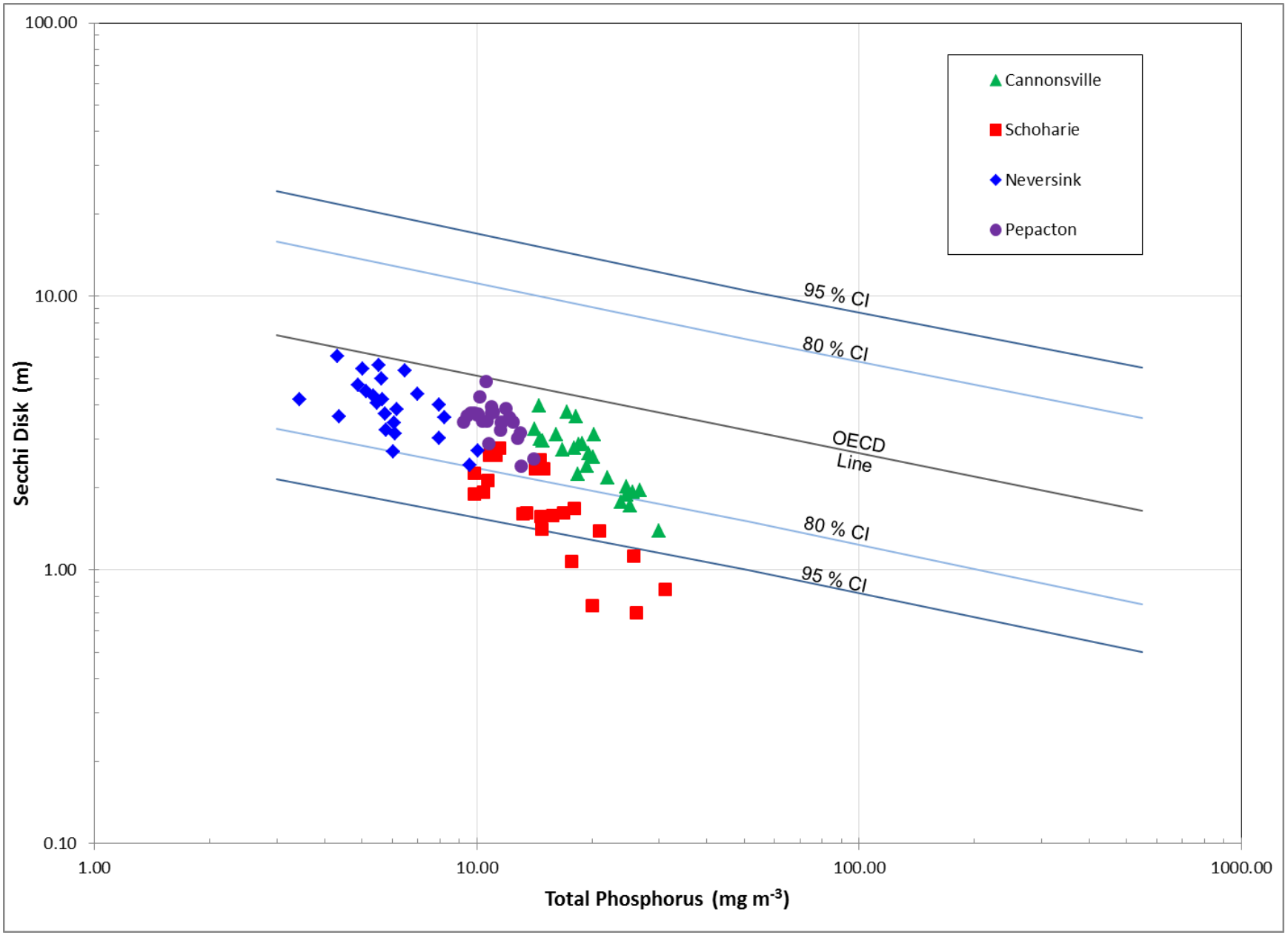
Secchi depth vs Chl a



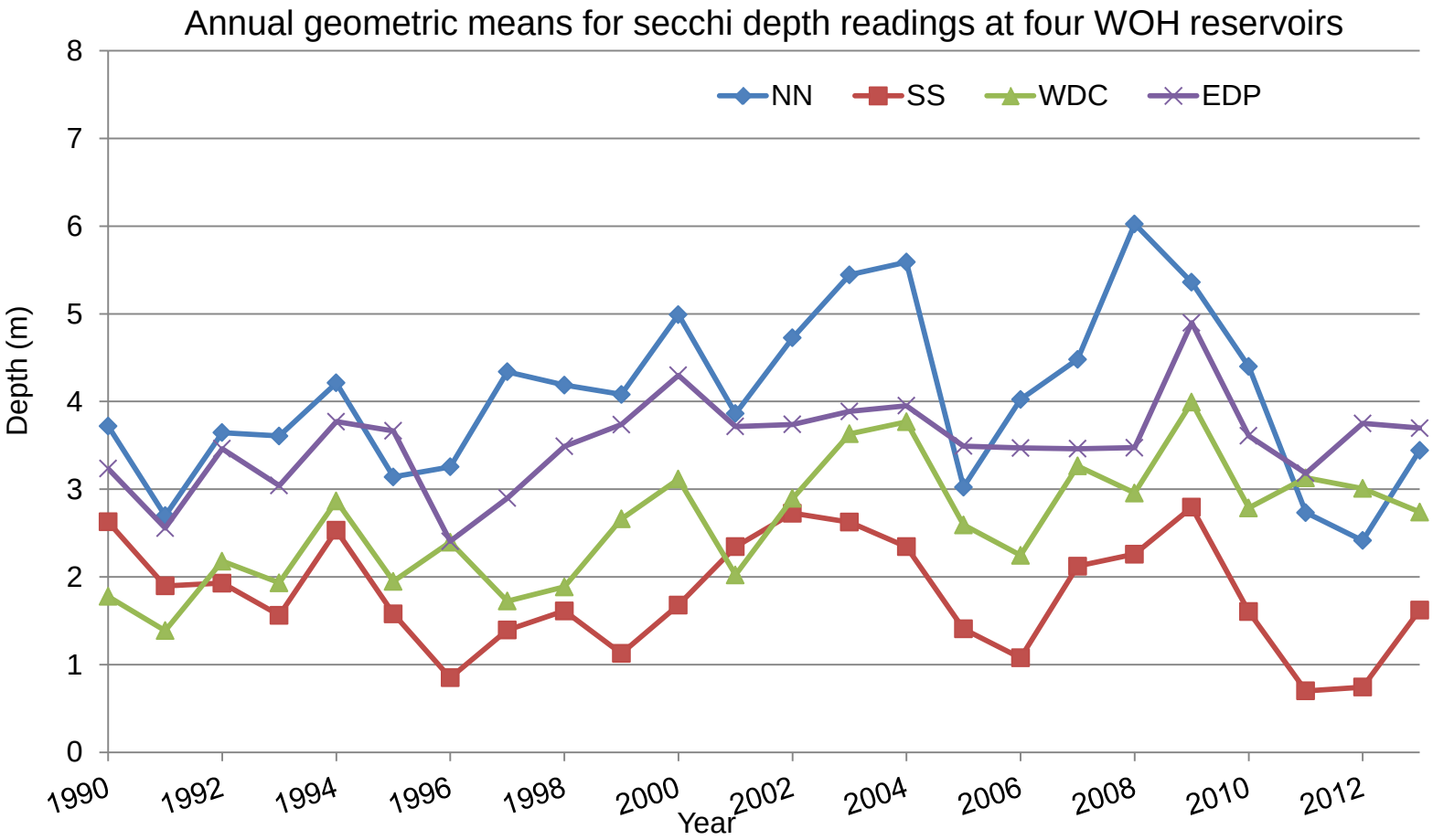
Cannonsville: Secchi depth *vs* Chlorophyll a



Secchi depth vs total phosphorus in 4 reservoirs



Secchi depths in 4 reservoirs, 1990 - 2013



5. Conclusions: reservoirs relative to OECD lines

- All 3 Delaware headwater reservoirs reflect their trophic conditions relative to the basic parameters examined here.
- Schoharie behaves quite differently reflecting the influence of turbidity, which limits light penetration (SD) and depresses algal biomass (Chl), regardless of high TP.
- TP increases with flood events and low light penetration indicating it is bound to particulates (clay) that cause high turbidity.
- Chl levels tend to be high relative to total phosphorus levels:
  - Growing season only values and low zooplankton grazing (due to predatory fish) may contribute
  - Chl is high in drought years and low in flood years
- Secchi depths in all reservoirs are systematically more shallow than expected on the basis of Chl levels. It is possible that the reservoirs are influenced by particulates from the landscape to a greater degree than other waterbodies, but further evidence is needed to test this idea.

6. Future directions

- This analysis is only the beginning, starting with a broad overview of annual tendencies.
- Analysis of DEP data using all reservoirs and the full suite of OECD standards has yet to be done.
- Identification of individual years and specific influential events will be identified to show how they influence water quality.
- Future analyses will examine progressively shorter time frames to ‘zoom in’ on factors important in determining metabolic balances and water quality.
- Diagnostic use of the OECD lines (analysis of residuals) can be used to highlight factors that need to be considered to improve predictive models.
- Further analysis of this type will lead to understanding of how nutrients, hydrology, and climate influence the metabolic responses of reservoirs to provide future expectations.
- High frequency monitoring is under rapid development at DEP and around the world (e.g., GLEON and Netlake). This data will contribute to explaining the mechanisms (relative rates) behind general water quality observations (state variables) leading to improved predictions and WQ management.

Questions?

Acknowledgements:

Thanks are due to the following people for their support:

- Ms. Emily Lloyd, Commissioner, NYCEP
- Mr. Paul Rush, Deputy Commissioner, BWS
- Mr. Steven Schindler, Director, WQD
- Ms. Lori Emery and the WWQO field and lab staff
- Co-authors: Mr. James Mayfield, Dr. D. Pierson, Mr. Rich VanDreason
- Mr. Chris Pace, WQD for assistance with plotting
- Mr. David Lounsbury for map
- Dr. Richard Vollenweider, OECD Chairman and Canadian Contribution co-author

Adventures in Data:

Revisiting Historical Water Quality and Streamflow Data in the Catskills

Karen Moore & James Mayfield

Catskill Environmental Research & Monitoring Conference

October 23-24, 2014

Overview

Focus: A new approach to looking at water quality and stream flow data.

Purpose: Extract new insights from old data.

<u>In this talk, I will discuss</u>:

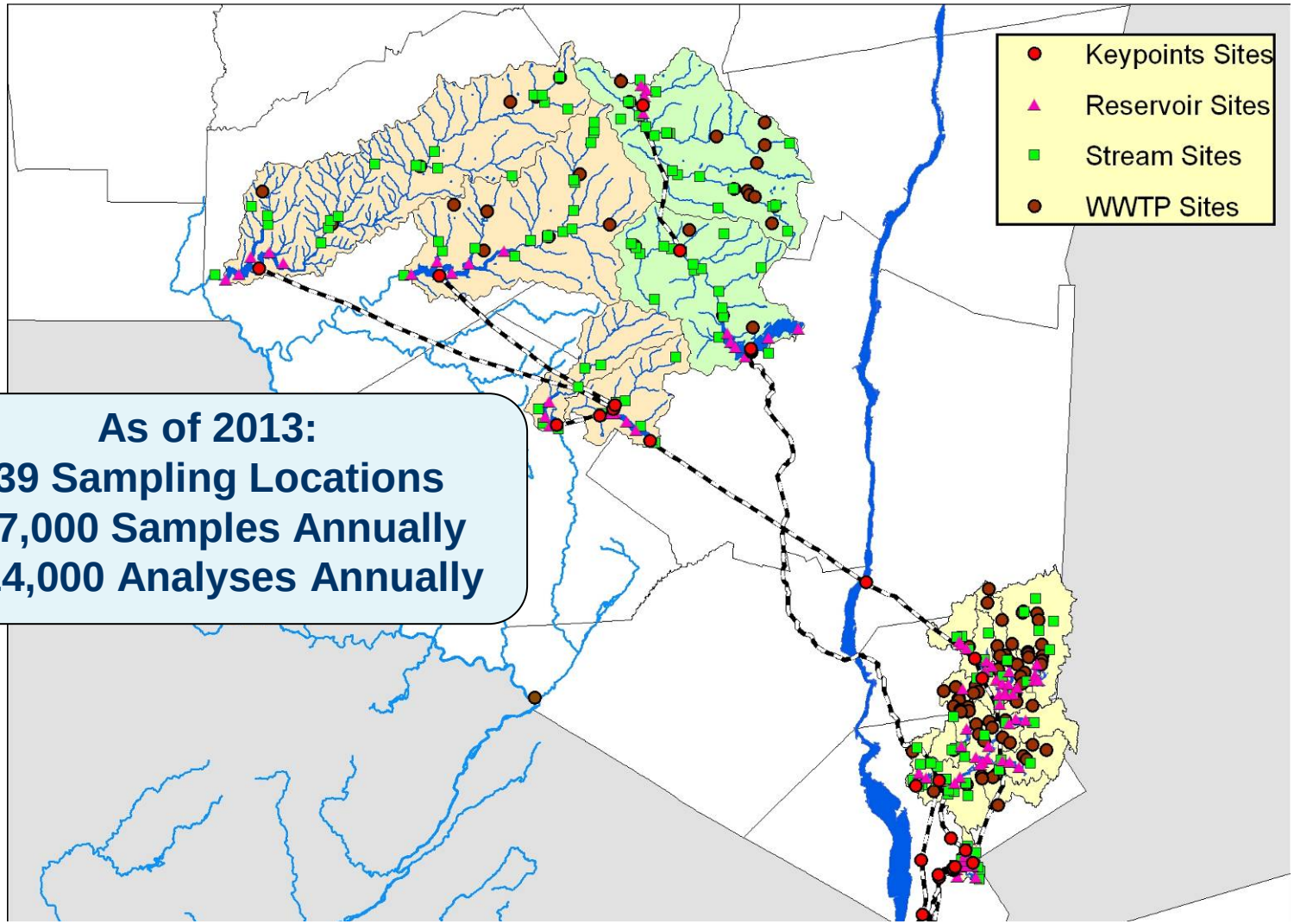
- Methods & tools developed by U.S. Geological Survey (USGS) scientists
- Examples from application of these tools to Catskill rivers

Underlying philosophy:
There is value to re-visiting the data to learn from it.

Source: http://relu.data-archive.ac.uk/media/36645/relubrief16.pdf

Watershed Water Quality Monitoring

DEP has a long-term investment in water quality monitoring throughout the watershed with 27 years of data for major river inflows to West of Hudson reservoirs.



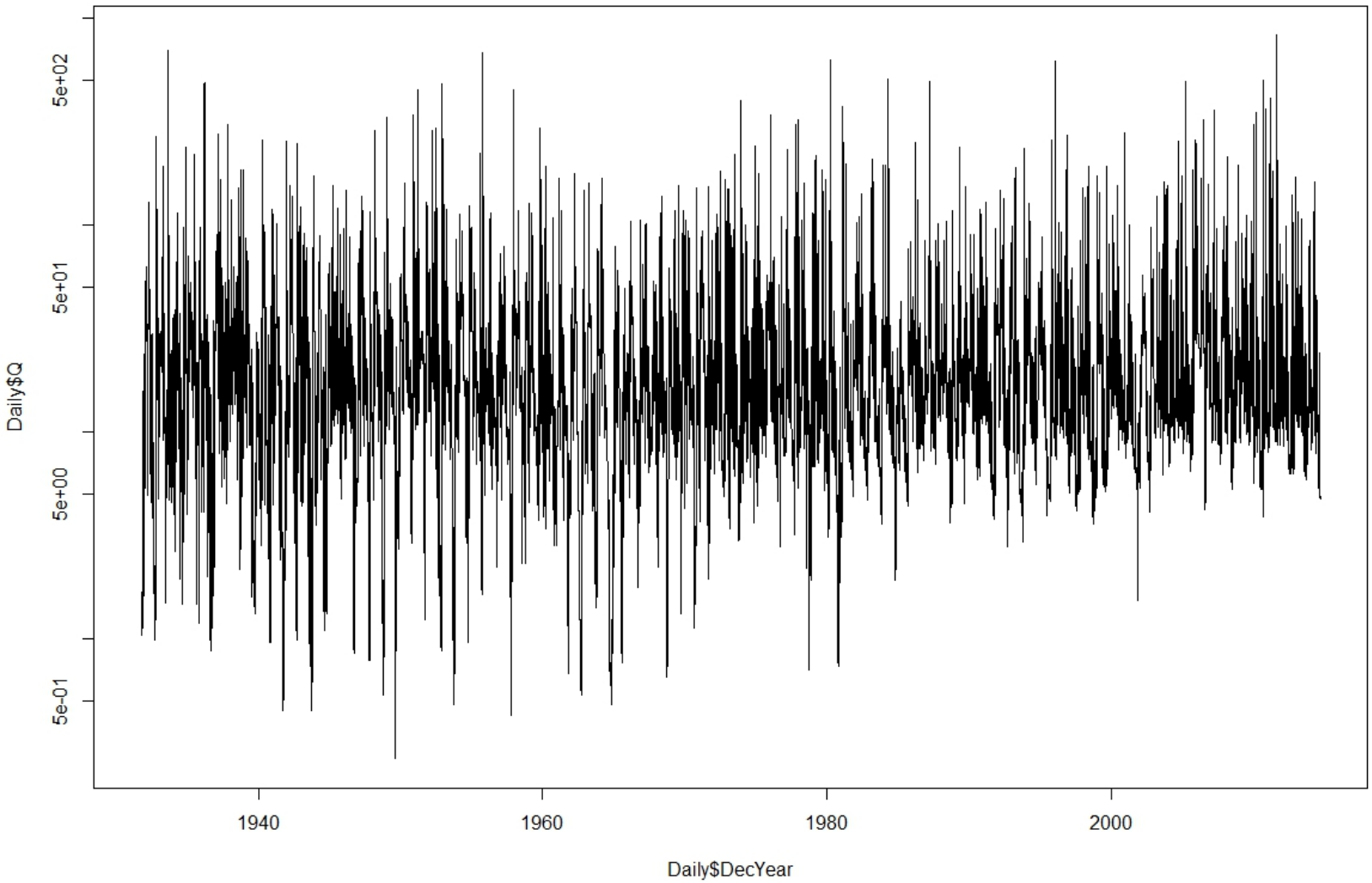
As of 2013:
439 Sampling Locations
>17,000 Samples Annually
>214,000 Analyses Annually

New Tools Developed by USGS

- R (free, “open source” software) packages courtesy of the U.S. Geological Survey:
- **dataRetrieval:** An R package that facilitates rapid acquisition of USGS daily streamflow data, water quality data, and meta data from USGS Web-repositories or from user-supplied files.
- **EGRET** (**E**xploration and **G**raphics for **R**iv**E**r **T**rends): An R package that generates graphics and summary statistics to aid in understanding the hydrologic system in a changing world.
- A tool-within-a tool: WRTDS (Weighted Regression for Time, Discharge, and Season) for river water quality analysis is part of the EGRET package.
- Value added to historical data as these tools help with the evaluation of changes from natural and unnatural causes, as well as viewing management strategies from a big-picture perspective.

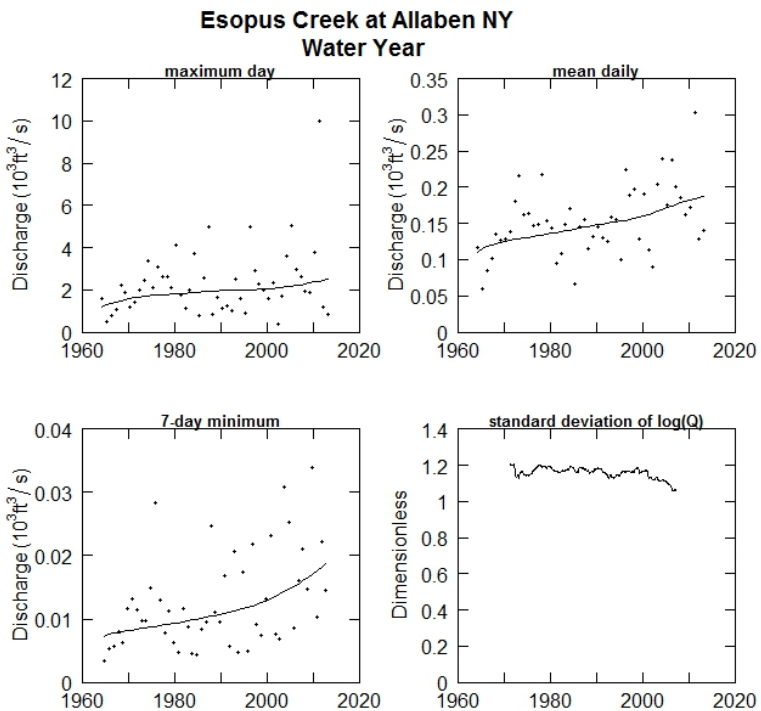
Links to some relevant papers and the program in R:
https://github.com/USGS-R/EGRET
Or type into your search engine: USGS EGRET

Esopus Creek at Coldbrook (flow in cfs)

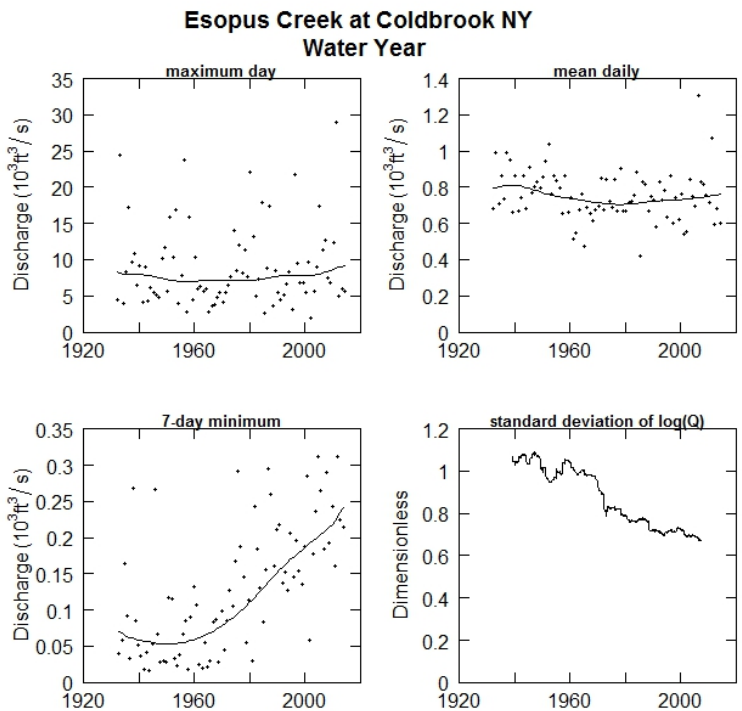


Raw output from EGRET showing mean daily flow (flow in cubic feet/sec, cfs)

Flow History Requirements for WRTDS

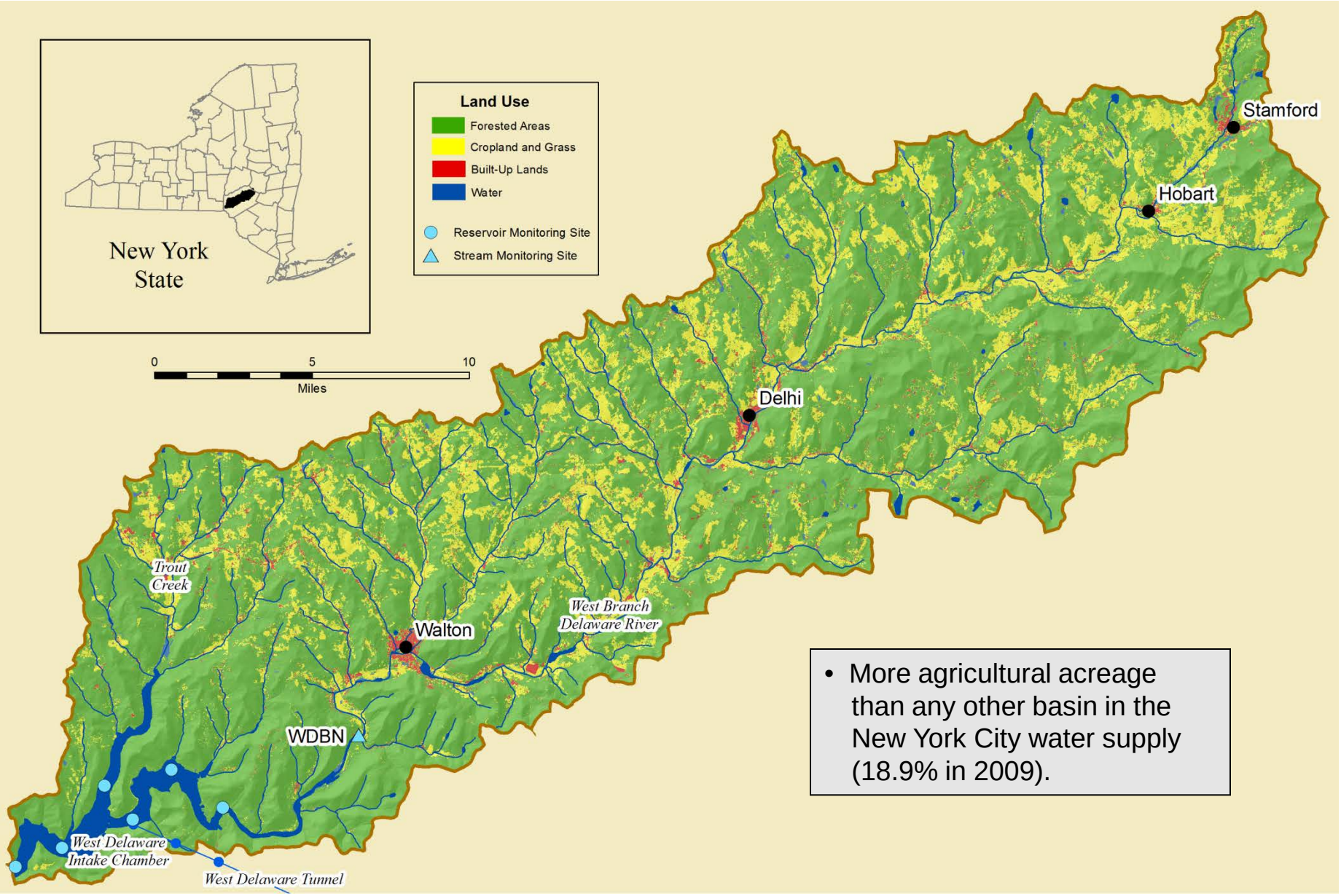


Upstream, unregulated site on Esopus Creek above Shandaken Portal. Note standard deviation plot shows stationarity, a requirement for WRTDS estimation of concentration and load (flux).



Site on Esopus Creek below Shandaken Portal. Note standard deviation plot shows non-stationarity and disqualifies it from use of WRTDS model.

Example analysis from Cannonsville



- More agricultural acreage than any other basin in the New York City water supply (18.9% in 2009).

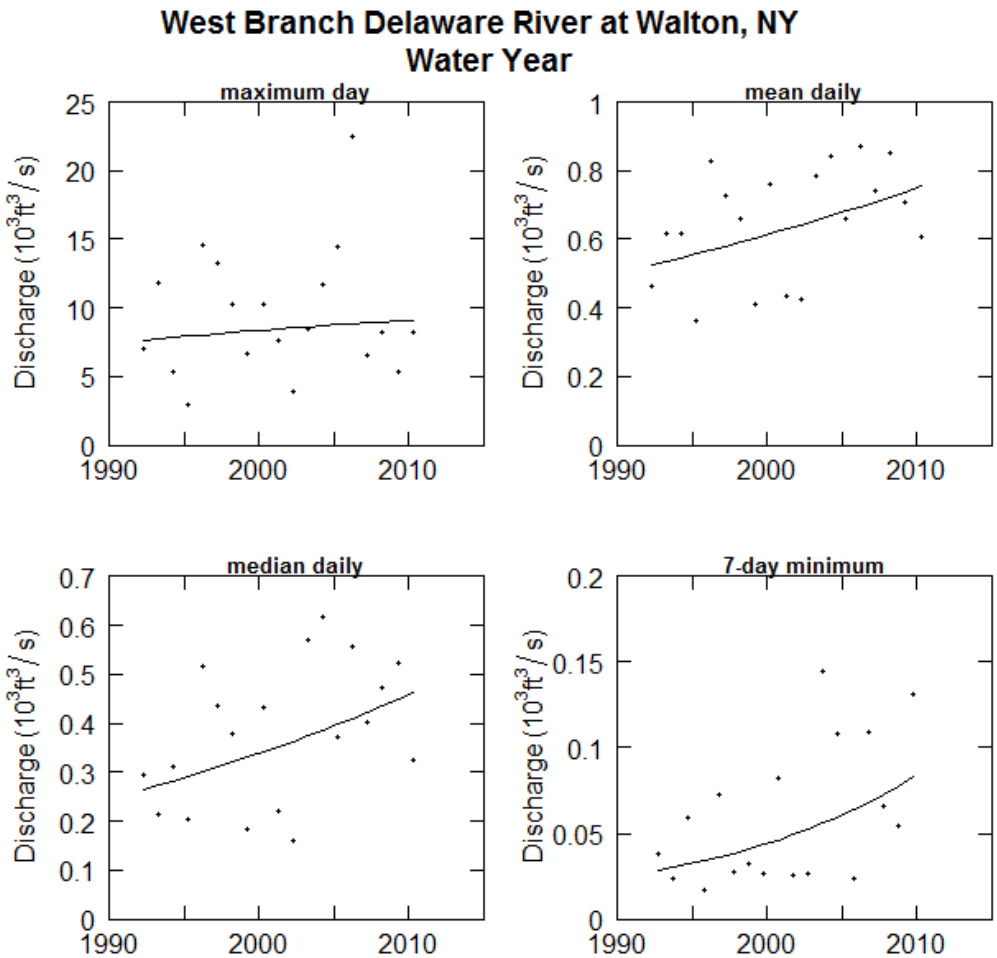
Watershed Partnership Programs

DEP manages and funds a broad spectrum of Cannonsville watershed initiatives including but not limited to:

Program	2005	2010 (Δ from 2005)
Farms with Whole Farm Plans		
Large farms	157	123 (-34)
Small farms	22	52 (+30)
Agricultural structural BMP's		
Large farms	1617	2066 (+449)
Small farms	172	365 (+193)
WWTP upgrades	5	5 (0)
Sand/Salt storage	10	10 (0)
Stream management projects (linear ft)	1200	4900
Acquired land + easements	12, 429 acres	27,165 acres (+14,736 acres)

Phosphorus reduction programs began in 1993; analyses show by 2002 Cannonsville was no longer considered a phosphorus-restricted basin.

Flow History Statistics from EGRET



- Curves show a LOWESS smooth (locally weighted scatterplot smooth), which indicates an upward trend at all levels of flow summary.
- All statistics are based on water year (Oct. 1 – Sep. 30) <u>except</u> the 7-day minimum, which is based on "climate year" (Apr.1 – Mar. 31) to minimize the probability that a droughts will be represented across multiple water years. Data source: USGS (NWIS).

Weighted Regression (WRTDS)

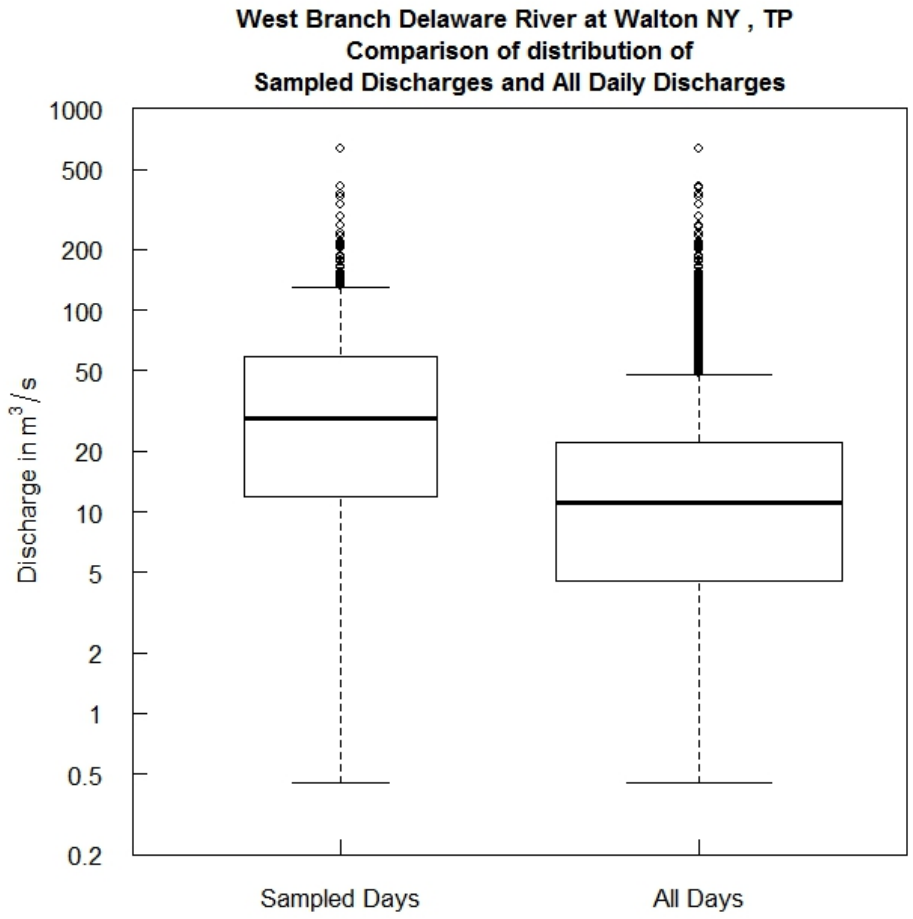
- Original paper describing approach: Hirsch et al. (2010) with more recent applications to Chesapeake Bay, Lake Champlain, and Mississippi R. watersheds.

- Requires long-term (20 yrs+ mean daily river discharge data and minimum of 200 water quality samples. Gaps in water quality should not exceed 2 yrs.

- Conceptual view: WRTDS is a locally-weighted regression where weights are based on <u>time</u>, <u>discharge</u>, and <u>season</u>.

- Basic idea: the weighted regression model can give a picture of the system for any given day. In addition to simple flux (load) and concentration estimates, the model calculates a “flow-normalized” flux and concentration.

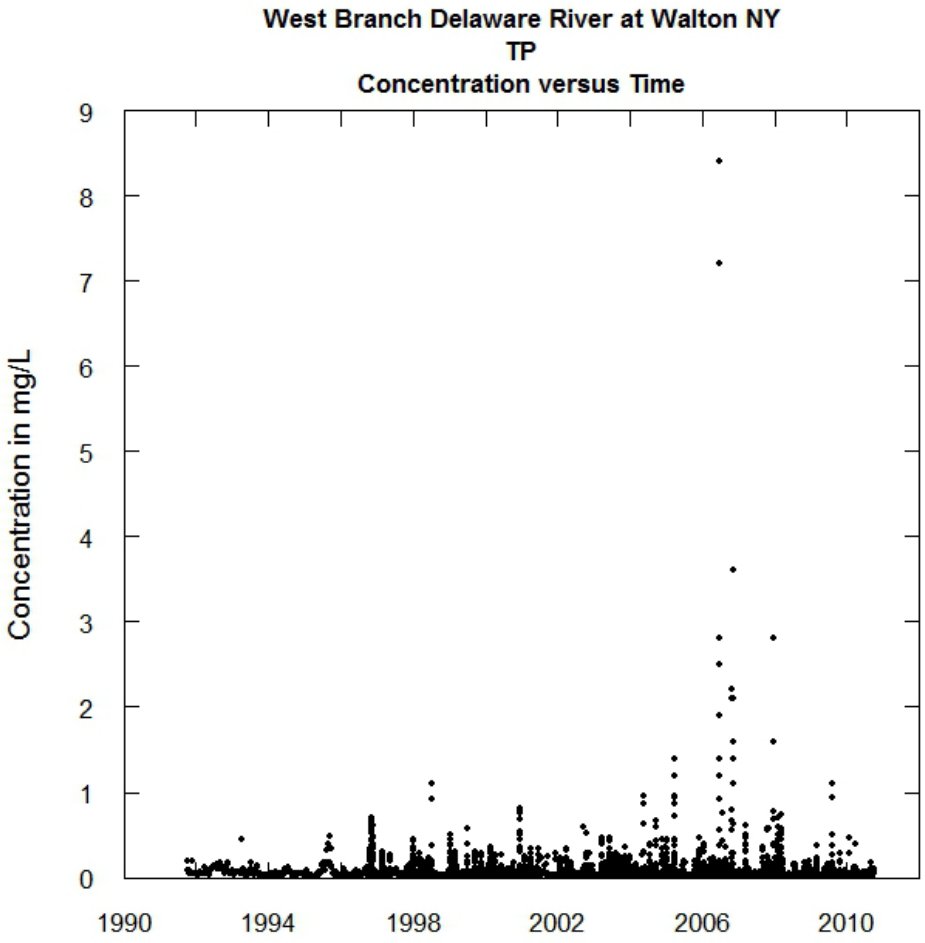
Sampling considerations



- Collecting representative samples across the range of flows is important. For this data set, high-flow events were sampled intensively and this is reflected in the distribution of discharge for sampled days (NYSDEC samples, 1991-2010).

- To obtain accurate estimates of flux (load), the best sampling strategy is to collect more samples at high discharge.

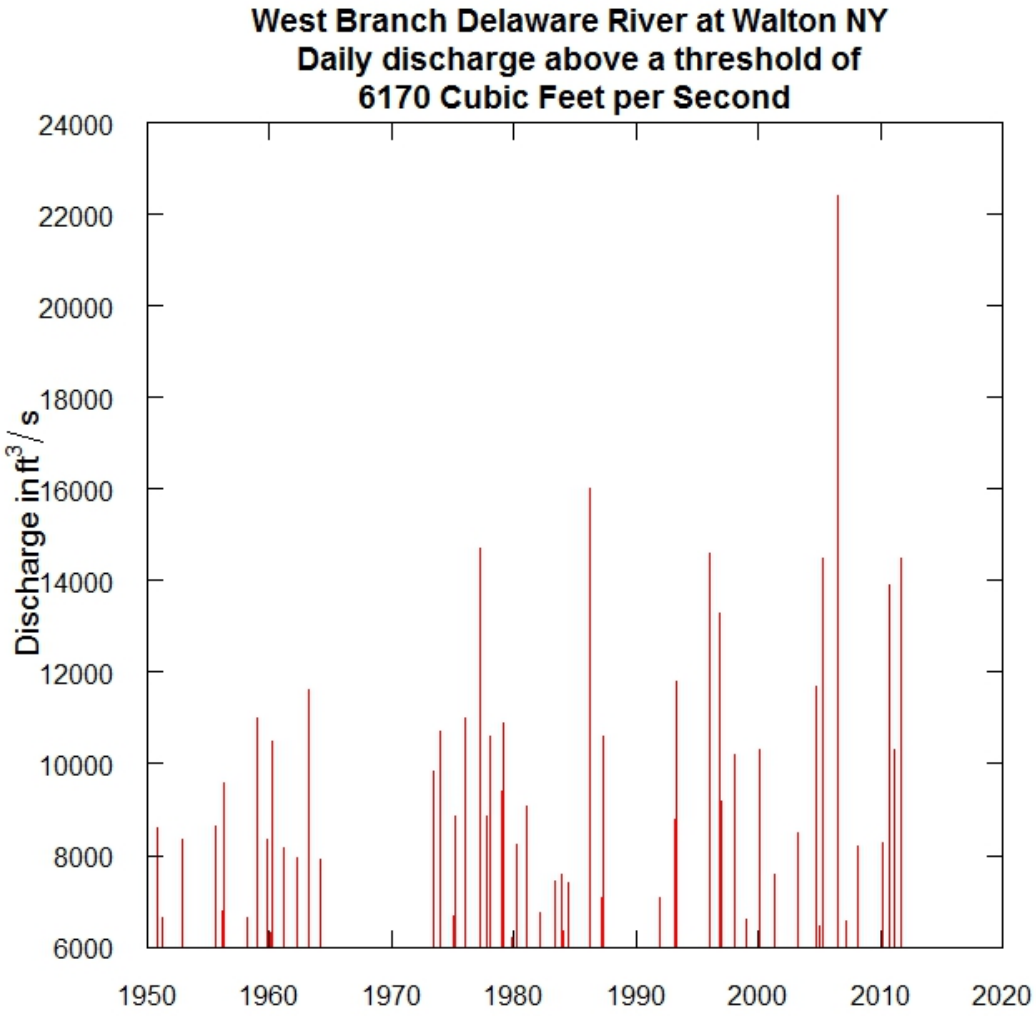
Total Phosphorus Concentration



- Flood of record on June 26-29, 2006 resulted in highest observed TP concentration. Since TP reflects sediment-bound P, it isn't surprising that the flood yielded the highest TP, even after watershed protection programs had a demonstrated impact on P-reduction.

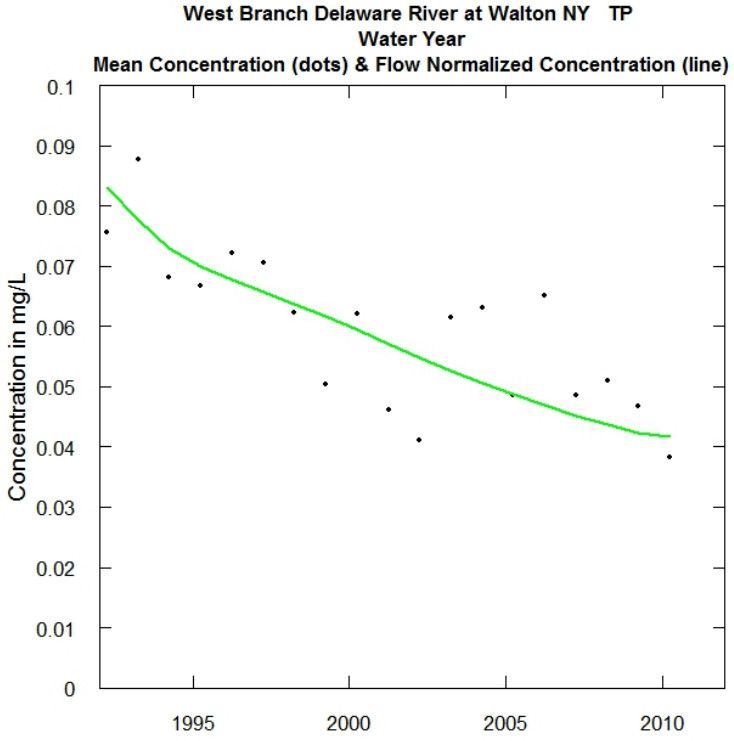
- Note scale is influenced by this anomalous event in 2006. The EGRET package allows the user to change the units. TP is typically expressed in µg L^{-1} units.

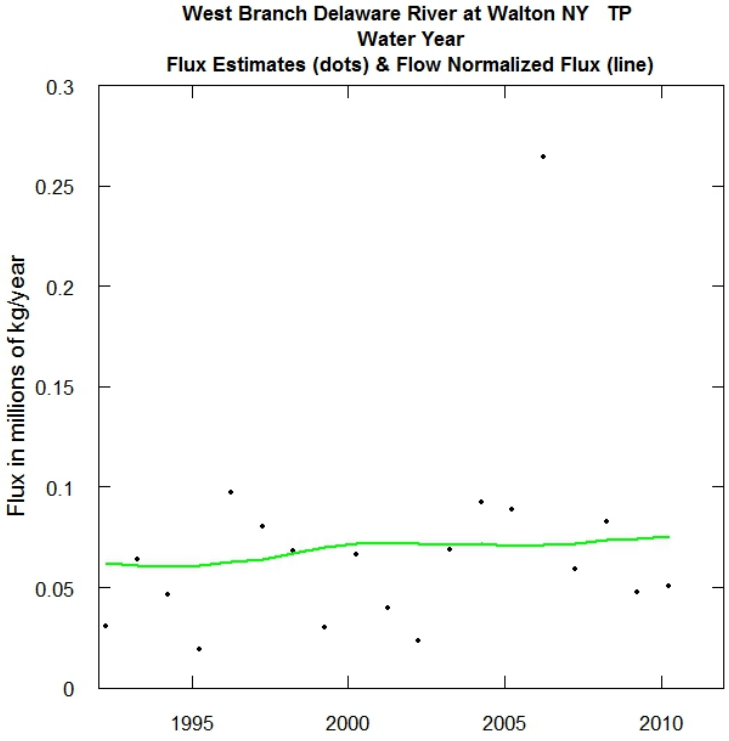
Flow History in EGRET



EGRET allows flexibility in screening data. Only those events at or above flood stage are shown here.

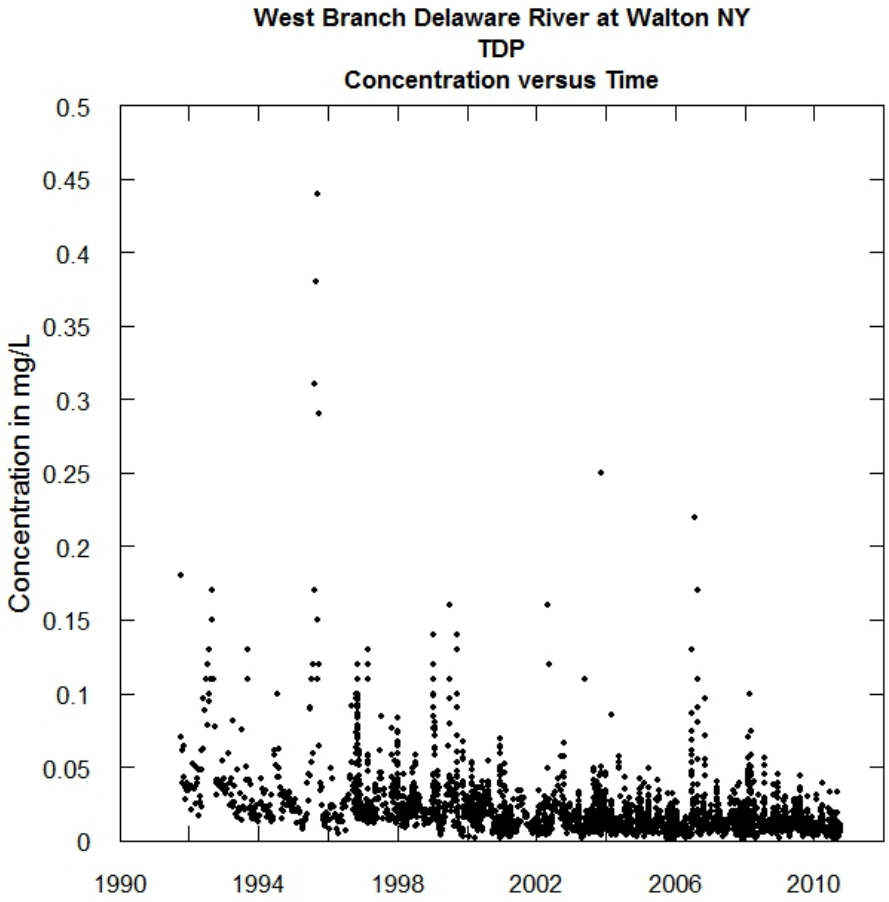
Total Phosphorus – Flow-Normalized





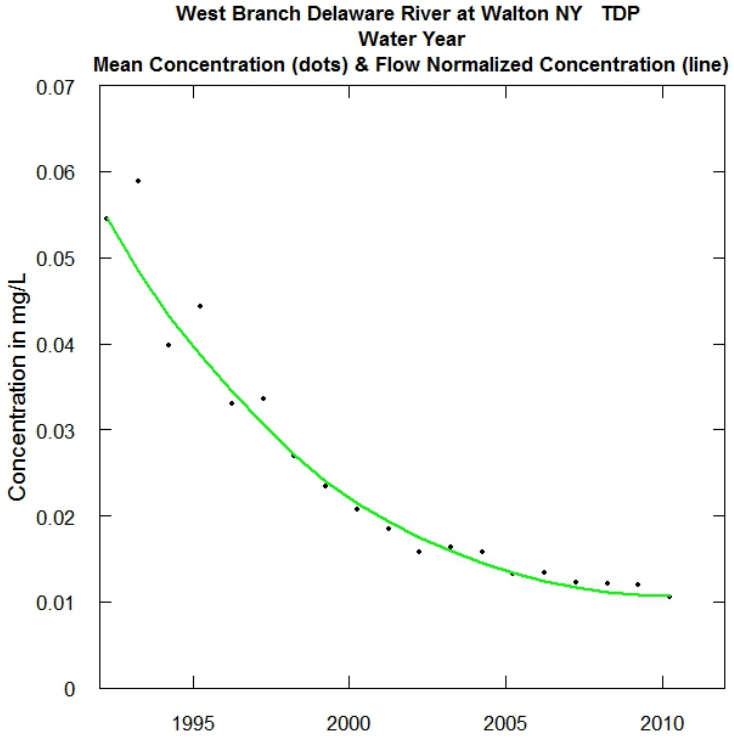
Flow-normalized concentration and flux give a picture of progress or effectiveness of programs by filtering out the year-to-year variations in discharge (green line), while estimates of concentration and flux alone (dots showing mean annual concentration and flux) are important for understanding the actual history of river water quality.

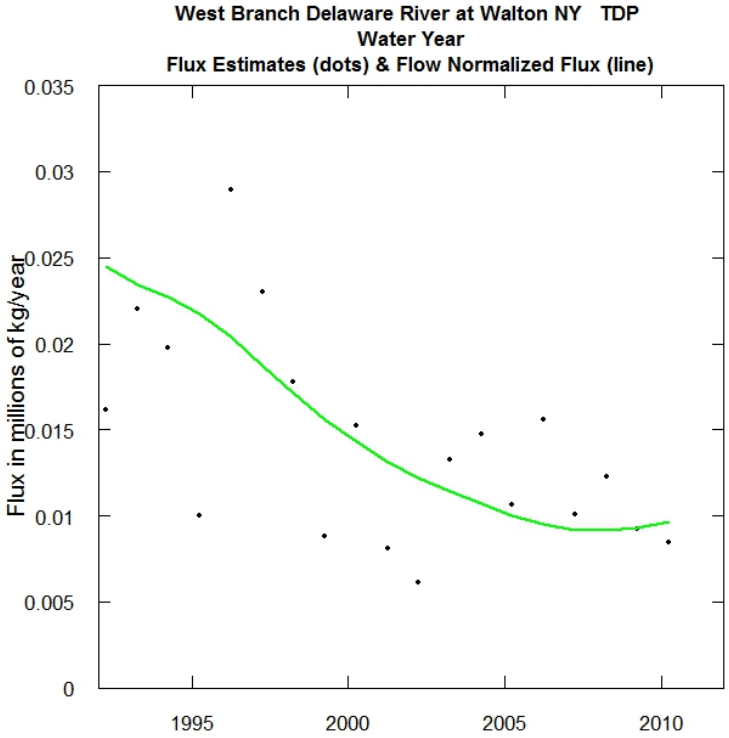
Total Dissolved Phosphorus Concentration



- Total Dissolved Phosphorus gives a clearer picture of the impacts of point-source control measures. The storm event of June 2006 still shows a pulse of incoming P, but it is lower than some events in the period before phosphorus reduction measures were implemented.

Total Dissolved Phosphorus – Flow-Normalized





Flow-normalized TDP concentration dropped by 78% from 1993-2010, a decline of 4.6% yr^{-1}.

Flow-normalized TDP flux dropped by 59% from 1993-2010, a decline of 3.5% yr^{-1}.

Total Dissolved Phosphorus Summary

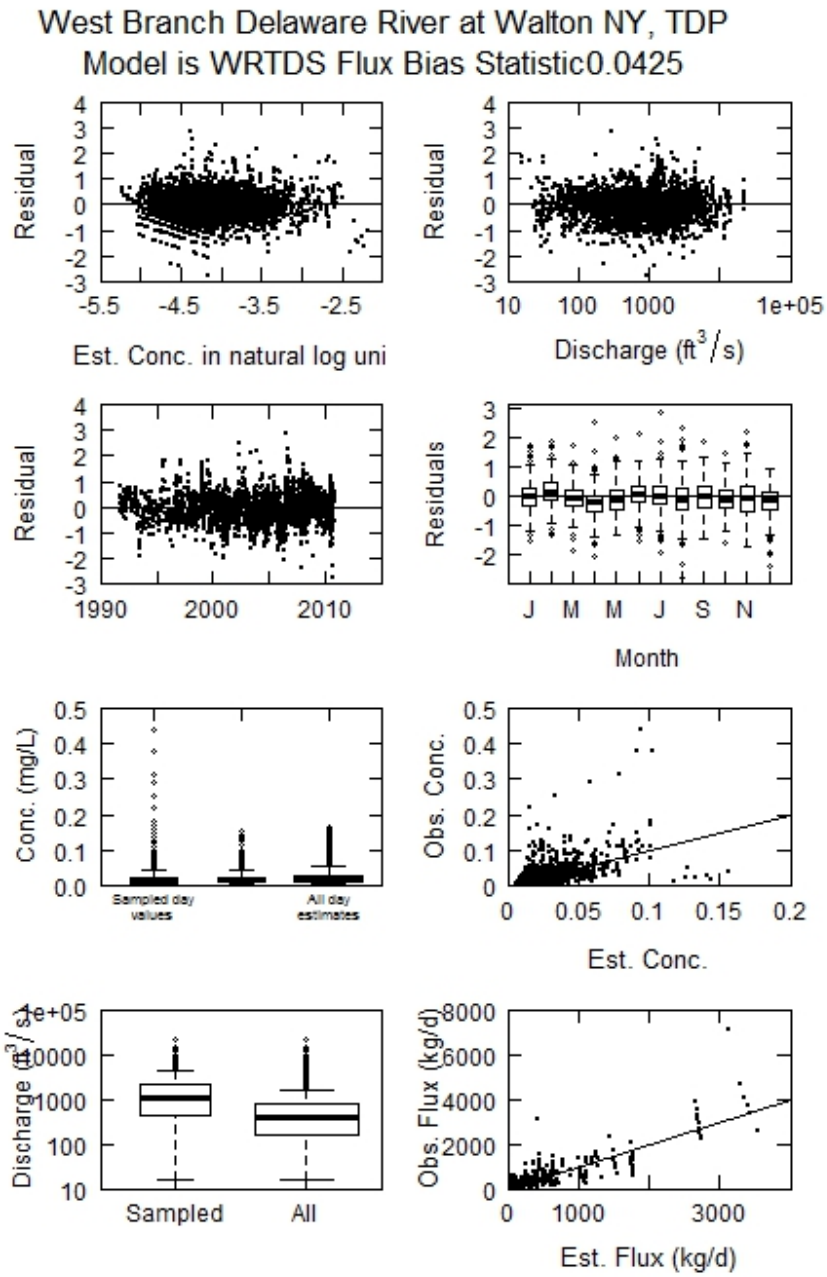
Change in Flow-normalized Concentration and Flux for selected periods as estimated by WRTDS for West Branch Delaware River at Walton, NY

Period	ΔConc. ($\mu g\ L^{-1}$)	% change	ΔFlux ($10^3\ kg\ yr^{-1}$)	% change
2003-2005	-2.5	-16%	-1.4	-12%
2005-2007	-1.7	-6.5%	-0.85	-8.5%
2007-2010	-0.9	-2.6%	+0.48	+5.2%

- It is possible to see trends in flow-normalized concentration and flux that are opposite in sign.
- If, for example, there were large decreases in point sources but increases in non-point sources of TDP associated with high flow events, we could expect to see a negative trend in concentration and a positive trend in flux.

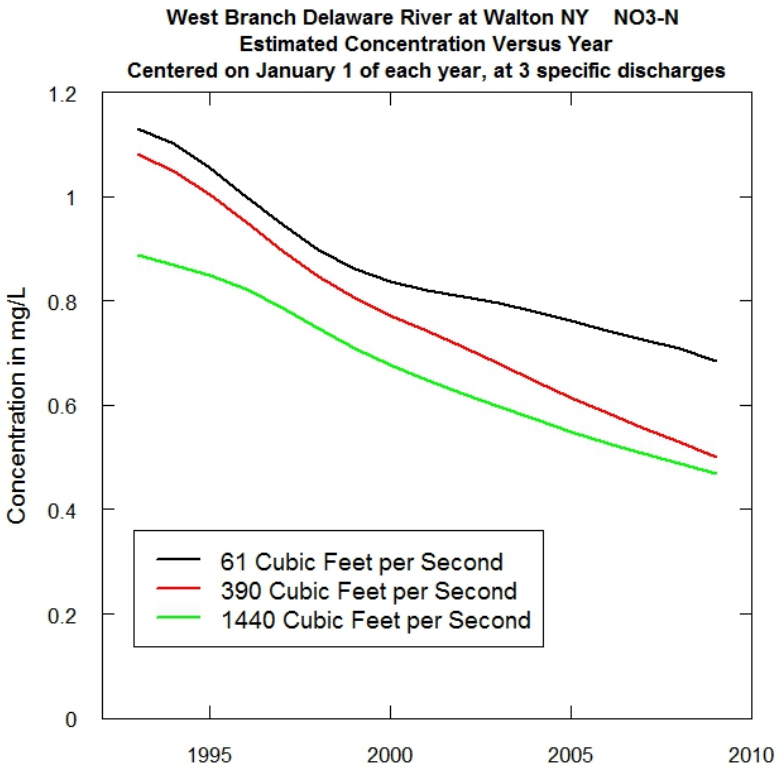
WRTDS Model Diagnostics

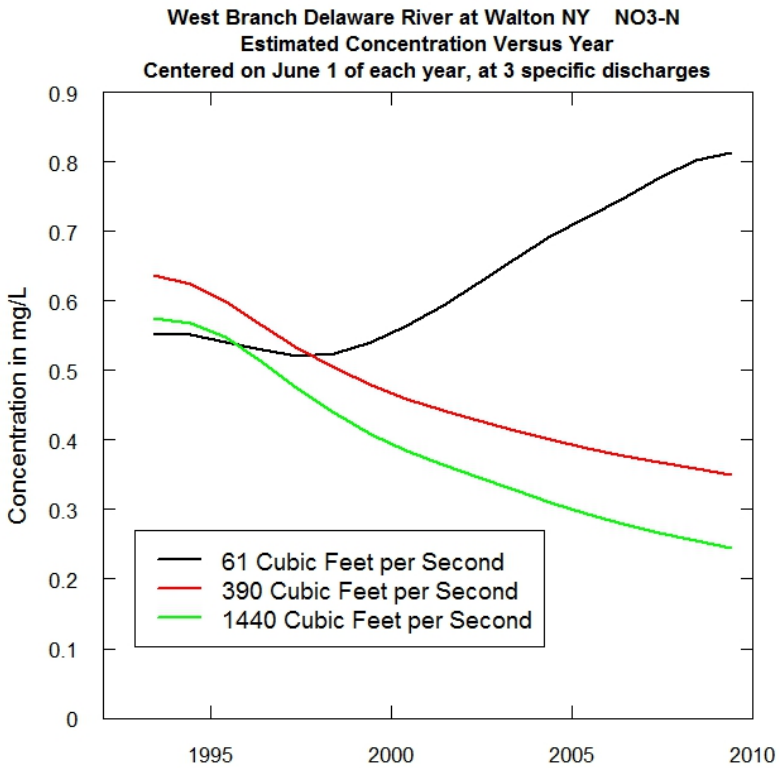
- All models have biases.
- The WRTDS diagnostic plots give clues to how well the model performs.
- The Flux Bias Statistic indicates that flux is overestimated by about 4%.
- If bias is too large, then consider using a different model.



Concentration – Flow Relationships

EGRET has flexible time periods for data viewing. In this view January (left) and June (right) nitrate concentration at low flow (10%ile in black), median flow (50%ile in red), and high flow (90%ile in green) is averaged for a 60-day period for WY 1992-2010.





The explanation for increases in nitrate at baseflow in the summer months needs to be pursued further by looking at additional data.

Where to Next?

- There are at least 15 additional sites with a 27-year record of NYCDEP water quality data that can be examined using EGRET.
- Further exploration of connections between water quality patterns, changes in the watershed, and program implementation is expected to give insights relevant to management.
- One of the advantages of this approach is that the data can be quickly re-visited as the record builds over time.

Applying a Novel Approach to Trend Analysis of Water Quality Data

Karen Moore & Jim Mayfield

New York City Department of Environmental Protection
71 Smith Avenue, Kingston, NY 12401 USA

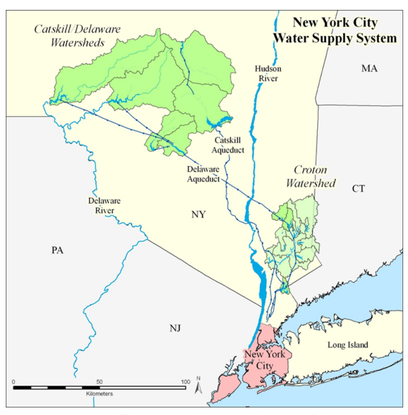
Environmental Protection

Abstract

Years of investment in watershed water quality monitoring have given New York City Environmental Protection (DEP) scientists insights into potential issues and solutions in water resources management over time. With 25+ years of routine monitoring of the upstate reservoirs, streams, and wastewater treatment plants, careful assessments of data have informed policy and planning efforts. We took advantage of the wealth of accumulated streamflow and water quality data for the West Branch of the Delaware River and other long-term monitoring sites in the Catskill/Delaware System, the unfiltered portion of the NYC Water Supply (Figure 1), to apply the "Weighted Regressions on Discharge, Time, and Season" approach described by Hirsch et al. (2010) to gain insights into the long-term record and look for new revelations in the data. We think there is great value in re-examining the long-term record as the record builds, and this particular approach may help us further evaluate patterns in inputs of nutrients and other constituents of interest to water supply reservoirs.

Introduction

DEP is using graphical and statistical tools developed by scientists at the U.S. Geological Survey to view historical water quality and river flow data from the Catskill region to get a new perspective on old data. EGRET (**E**xploration and **G**raphics for **R**iver **T**rends) and dataRetrieval, two packages in the R programming language, facilitate extracting information from long-term (20+ year) records (Hirsch et al., 2010). Using these powerful tools, USGS river discharge data can be combined with data from other sources to identify trends and create graphical and statistical summaries of into changes occurring over years, seasons, and discharge. Examples from DEP's historical data for flow history and water quality are used to evaluate the benefits these tools offer to water managers.



NYC Water Supply Overview

- Approx. 9 million consumers
- Average daily demand ~1.1 BGD
- Storage capacity 580 BG
- Dependable yield 1.3 BGD
- Watershed area 1972 sq. mi.
- Catskill/Delaware System is unfiltered

Fig. 1: New York City Watersheds

New Tools Developed by USGS

R (free, open source software) packages developed by the U.S. Geological Survey: https://github.com/USGS-R/EGRET

- **dataRetrieval:** An R package that facilitates rapid acquisition of USGS daily streamflow data, water quality data, and meta data from USGS Web-repositories or from user-supplied files.
- **EGRET** (**E**xploration and **G**raphics for **R**iv**E**r **T**rends): An R package that generates graphics and summary statistics to aid in understanding the hydrologic system in a changing world.
- A tool-within-a tool: **WRTDS** (Weighted Regression for Time, Discharge, and Season) for river water quality analysis is part of the EGRET package.

Application of the Tools to NYC reservoirs

The main inflows to the Catskill/Delaware System reservoirs were analyzed for flow history and dissolved constituents with a long-term (20+ year) record using the EGRET package. Flow history is based on 15-minute USGS gage data summarized at the level of mean daily flow. Using the dataRetrieval package, station data and metadata are easily downloaded from the USGS-NWIS website and organized for analysis with the EGRET package. External data (such as our DEP water quality data) can be combined with daily discharge data. EGRET provides a picture of long-term flow history through a series of graphical and tabular summaries..

The WRTDS model is also a component of the EGRET package. WRTDS is a locally-weighted regression where weights are based on time, discharge, and season. WRTDS models are constructed for a large number of discharge (Q) and times (T) using only observed concentration data that are similar in time, season, and discharge to the day being estimated. WRTDS produces estimates of concentration and flux (load) along with "flow-normalized" concentration and flux that removes the variability in water quality that are associated with random variations in discharge (Moyer et al., 2012).

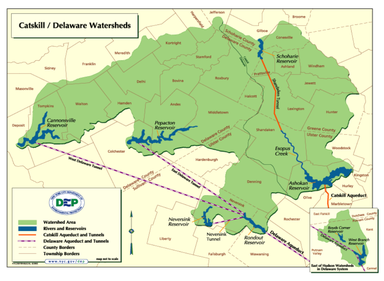


Fig. 2: Catskill/Delaware Watershed

Results & Discussion

A summary of the mean daily discharge data stored in EGRET and calculations made using the modelEstimation function in the WRTDS component of EGRET are saved in a data frame that can be used to produce a series of visualization plots for flow history and WRTDS model estimates of concentration and flux (load). Table summaries are also among the available functions in the EGRET package.

Figures 3a-8a show an example of output for six stream gages that represent the primary inflow to each of the Catskill/Delaware system reservoirs. All flow history plots shown are based on water year (Oct. 1-Sep. 30) with the exception of the 7-day minimum flow plots, which are based on climate year (Apr. 1-Mar. 31). A plot of the standard deviation of the natural log of discharge (logQ) shown in the bottom right panel of Fig. 3a-8a gives a picture of relative variability in streamflow. Similar to a moving coefficient of variation, it allows insights into changes in hydrologic variability. In the case of Esopus Creek at Coldbrook, the inflow to Ashokan Reservoir (West Basin), the sharp decline in the standard deviation of logQ reflects river regulation due to an inter-basin transfer of water from the Schoharie basin via the Shandaken Tunnel Outlet. Note that WRTDS model calculations were not made for the inflow to Ashokan Reservoir due to river regulation and a lack of stationarity in flow, a requirement for the model. The impacts of a diversion to Esopus Creek at Coldbrook (Fig. 8a) are shown in the flow history.

The EGRET package facilitates plotting estimated annual mean concentrations and flux (points) and a flow-normalized trend line (green line) for concentration and flux (shown in Figures 3b-7b). The estimates come from WRTDS calculations and the examples shown are for total phosphorus (TP). Note that concentrations in EGRET are always expressed in mg L^{-1} units, but flow units are more flexible and can be expressed in a variety of ways. Initial results for historical concentration and flux (Figs. 3b-7b) need to be compared with the record of methods changes.

WRTDS gives a dynamic picture of trends over time and can be expanded as the record builds. There are no statistical tests of significance or levels of confidence associated with the estimates, but the performance of the model can be evaluated by comparing measured and modeled fluxes. For all WRTDS estimates of flux shown (Figs. 3b-7b), the bias statistic (a measure of how well measured and modeled data compare) is 10% or less. If bias is greater than 10%, it would be advisable to use a different model.

Summary

- The use of EGRET is intended to give a big-picture view of historical data.
- One of the advantages of using EGRET is that the data can be quickly re-visited as the record builds over time.
- The initial steps of data visualization can help in identifying anomalies in the record. The patterns seen can be confounded by method changes and gaps in the record.
- Once any data quality issues are identified, we see this tool as an instructive way to examine changes over time, inform data and monitoring needs, and compare with other methods of evaluation.

References

EGRET manual: Hirsch, R.M. and De Cicco, 2014. User guide to Exploration and Graphics for RivEr Trends (EGRET) and dataRetrieval: R packages for hydrologic data. U.S. Geological Survey Techniques and Methods, User guide version 2014-04-14, 166 p.

Foundational papers:

Chesapeake Bay: Hirsch, R.M., Moyer, D.L., and Archfield, S.A., 2010. Weighted Regressions on Time, Discharge, and Season (WRTDS), with an Application to Chesapeake Bay River Inputs. JAWRA 46(5): 857-880.

Moyer, D.L., Hirsch, R.M., and Hyer, K.E., 2012. Comparison of two regression-based approaches for determining nutrient and sediment fluxes and trends in the Chesapeake Bay watershed. U.S. Geological Survey Scientific Investigations Report 2012-5244, 118 p.

Mississippi River: Sprague, Lori A.; Hirsch, Robert M.; Aulenbach, Brent T., 2011. Nitrate in the Mississippi River and its tributaries, 1980 to 2008: Are we making progress? ACS Publications, 8 p.

Lake Champlain: Medalie, L., Hirsch, R.M., and Archfield, S.A., 2012, Use of flow-normalization to evaluate nutrient concentration and flux changes in Lake Champlain tributaries, 1990-2009, Journal of Great Lakes Research, 38, Supplement 1, p. 58-67.

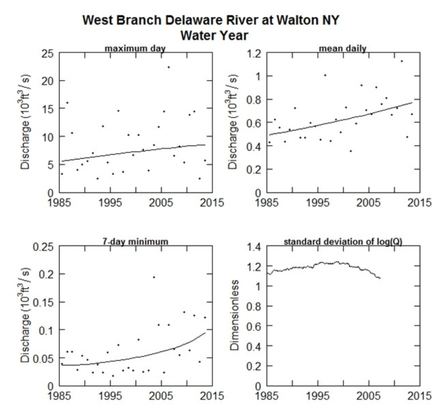


Fig. 3a: Cannonsville inflow history

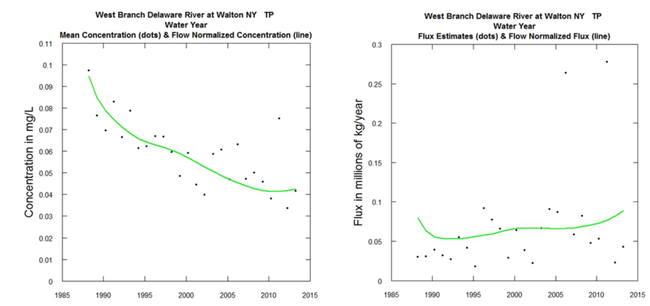


Fig. 3b: Cannonsville inflow Total Phosphorus

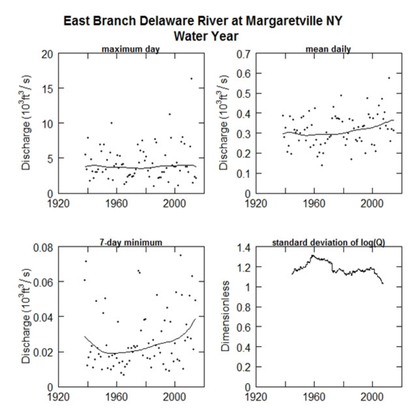


Fig. 4a: Pepacton inflow history

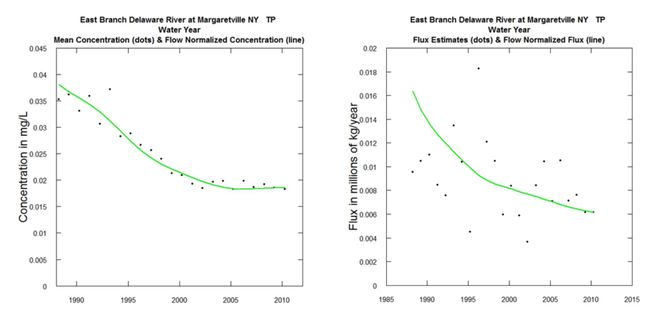


Fig. 4b: Pepacton inflow Total Phosphorus

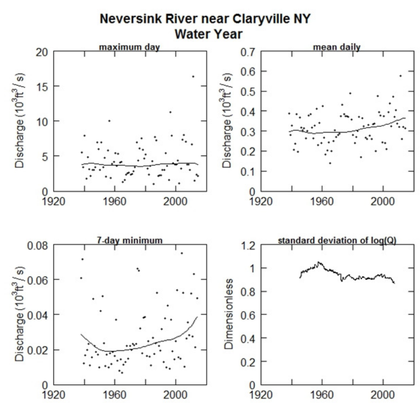


Fig. 5a: Neversink inflow history

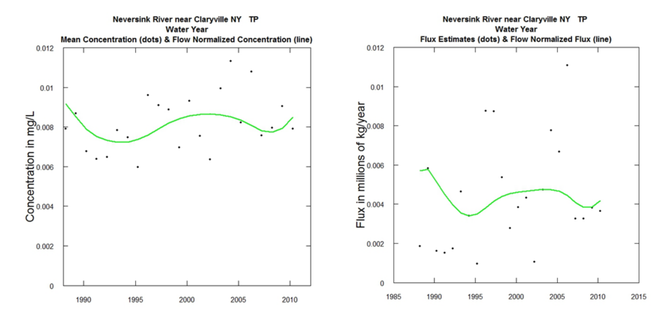


Fig. 5b: Neversink inflow Total Phosphorus

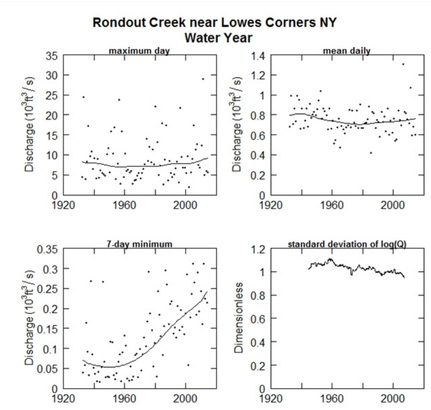


Fig. 6a: Rondout inflow history

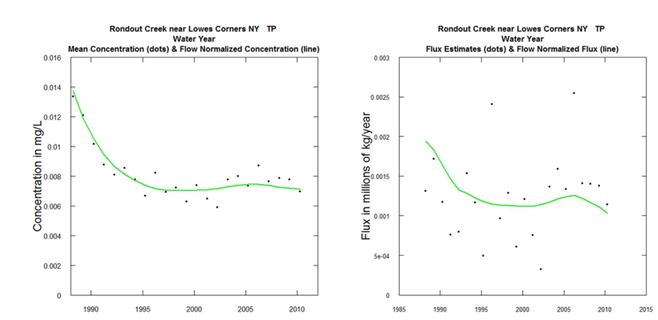


Fig. 6b: Rondout inflow Total Phosphorus

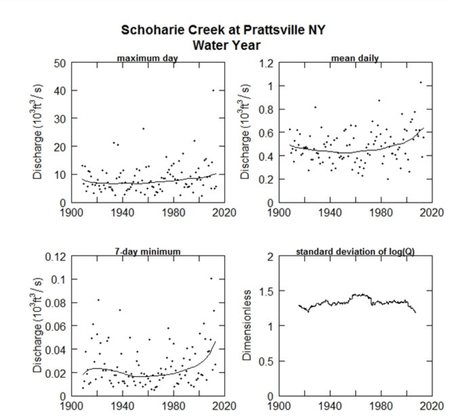


Fig. 7a: Schoharie inflow history

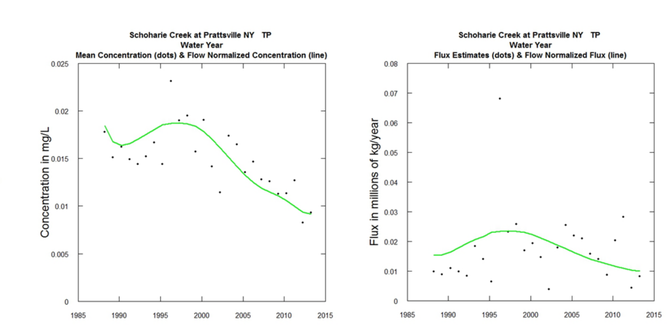


Fig. 7b: Schoharie inflow Total Phosphorus

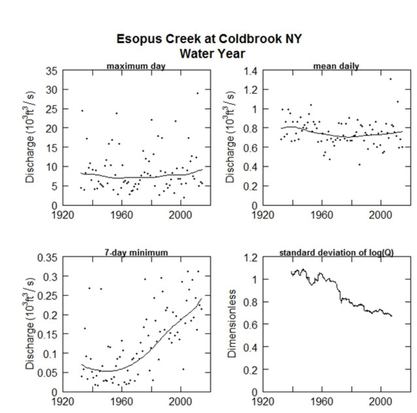


Fig. 8a: Ashokan inflow history

CRYPTOSPORIDIOSIS QUESTIONNAIRE

EVENTID _____ LAST NAME _____ FIRST NAME _____

BOX 1: ADMINISTRATIVE INFORMATION

Interview Status:
☐ Complete ☐ Partially Completed ☐ Needs interview ☐ Not needed ☐ Unable to interview patient or proxy

Reason interview not done:
☐ Died ☐ Incapacitating Illness ☐ Other ☐ Refused ☐ Unable to locate

Specify other reason patient not interviewed _____

Reason patient refused (e.g., too ill, language barrier, etc.) _____

Interviewer (if different from investigator): _____

Tracking attempted contacts

	Patient attempt 1	Patient attempt 2	Patient attempt 3
	☐	☐	☐
Date	_____	_____	_____
Time (military)	_____	_____	_____
Able to interview?	☐ Yes ☐ No ☐ N/A	☐ Yes ☐ No ☐ N/A	☐ Yes ☐ No ☐ N/A

Date of interview: ____/____/____

Interview method:
☐ Phone ☐ In person ☐ Email ☐ Web ☐ Mail/paper ☐ Other _____

Type of person interviewed:
☐ Patient ☐Provider ☐ Next of Kin/Friend ☐ Caretaker/Parent ☐ Other

Name of person interviewed _____

Relationship of person interviewed to patient _____

If type of person interviewed is "Other", specify other source of information _____

Interview Language: ☐ English ☐ Spanish ☐ Other _____

Provider Interviewed? ☐ Yes ☐ No

Date of provider interview ____/____/____

Provider name _____ *Provider title* _____

Contact information for provider interviewed _____

Specify type of provider

☐ Primary care provider ☐ Infection control practitioner ☐ Specialist ☐ Laboratorian ☐ Other

If "Specialist" or "Other" selected, specify provider type _____

If medical record was reviewed, date reviewed ____/____/____

Summary of investigation—action taken and outcome :

EVENTID _____

Investigation code _____

Investigation notes:

Note written by: _____ Date and time: _____

Is this part of an outbreak investigation? ☐ Yes ☐ No ☐ Unknown Linked outbreak event _____

Outbreak/study status: ☐ Ill person ☐ Case ☐ Cohort member ☐ Control ☐ Other _____

Is patient suspected to be part of a common source outbreak? ☐ Yes ☐ No ☐ Unknown

What is the source of the outbreak?

☐ Foodborne associated with a foodhandler ☐ Foodborne not associated with a foodhandler
☐ Waterborne-drinking water and person to person contact ☐ Waterborne – recreational water
☐ Waterborne – not intended for drinking or recreational water ☐ Source not identified

If foodborne, specify food item associated with common source outbreak _____

Would patient like to receive information in the mail? ☐ Yes ☐ No ☐ Unknown

What language was requested? _____

Was information sent to the patient? ☐ Yes ☐ No ☐ Unknown

What language was the information sent in? _____

BOX 2: DEMOGRAPHICS

Patient's first name:_____ **Patient's last name:**_____

Date of birth: __ __ / __ __ / __ __ __ __ (M M D D Y Y Y Y) **Sex:** ☐ Male ☐ Female ☐ Unknown

Ethnicity? ☐ Hispanic ☐ Non-Hispanic ☐ Unknown

How would you describe your race? ☐ White ☐ Black/ African American ☐ American Indian/Alaska Native ☐ Asian ☐ Native Hawaiian/Other Pacific Islander ☐ Other (specify): _____ ☐ Unknown

Country of birth: _____

Patient's street address: _____

City: _____ **State:** _____ **Zip:** _____ **Borough/County**_____

Phone numbers: (home) _____ **(cell)** _____**ext**_____ **(work)** _____**ext**_____

Is patient employed or a student? ☐ Employed ☐ Neither employed nor a student ☐ Student ☐ Unknown

Occupation _____ **Work/school name** _____

Street address _____ **Suite number** _____

City _____ **State** _____ **Zip code** _____ **Borough** _____

Phone number _____

Highest level of education ☐ Less than elementary ☐ Elementary or middle school ☐ High school graduate/GED ☐ Technical/Vocational School or Community College (associate's degree) ☐ Some college ☐ College (bachelor's) ☐ Some graduate school ☐ Graduate degree ☐ Refused ☐ Unknown

EVENTID _____

BOX 3: HOSPITALIZATION

Yes	No	Don't Know	
☐	☐	☐	1. **Were you hospitalized?**
			1a. Admit date: _____ /_____ /_____ 1b. What hospital? _____ 1c. Hospital Medical Record Number _____ 1d. If not still hospitalized, discharge date: _____ /_____ /_____ 1e. Your primary health care provider(s) for this illness _____ Your primary health care provider(s) type _____ Your primary health care provider(s) phone (__ __ __) __ __ __ - __ __ __ __ Your primary health care provider(s) other contact information _____

BOX 4: CLINICAL

Diagnosis date: _____ /_____ /_____ Date of symptom onset: _____ /_____ /_____

Yes	No	Unknown	Refused	Did you (your child) have:
☐	☐	☐	☐	2. **Any symptoms? (If no, skip to Box 5)**
☐	☐	☐	☐	3. **A fever?**
				3a. Maximum fever _____.___ Temperature (units) ☐ Centigrade ☐ Fahrenheit
☐	☐	☐	☐	4. **Weight loss**
				4a. Weight loss amount (lbs.) _____
☐	☐	☐	☐	5. **Fatigue**
☐	☐	☐	☐	6. **Diarrhea (3 or more unformed stools in 24 hours)?**
				6a. Max # stools per day _____ 6b. Was diarrhea bloody? ☐ Yes ☐ No ☐ Unknown ☐ Refused 6c. Was diarrhea watery? ☐ Yes ☐ No ☐ Unknown ☐ Refused
☐	☐	☐	☐	7. **Vomiting?**
☐	☐	☐	☐	8. **Abdominal pain/discomfort**
☐	☐	☐	☐	9. **Abdominal cramps**
☐	☐	☐	☐	10. **Anorexia/loss of appetite**
☐	☐	☐	☐	11. **Nausea**
☐	☐	☐	☐	12. **Bloating/gas**
				13. **Other symptoms** _____

Notes on clinical history and symptom progression:

EVENTID _____

BOX 5: MEDICAL HISTORY AND UNDERLYING CONDITIONS

Yes	No	Don't Know	Refused	Do you (your child) have:
☐	☐	☐	☐	14. **Any underlying medical conditions? (Questions 15-18)** ***Interviewer**: If the patient answered "NO", specify how the information was verified [i.e chart review, physician contact] and verification date:* *How verified:* _____ *Date:* _____ /_____ /_____
☐	☐	☐	☐	15. **Cancer?**
				15a. Specify type of cancer: _____ 15b. Is patient immunocompromised due to cancer? ☐Yes ☐ No ☐ Unknown ☐ Refused 15c. Was cancer diagnosed in the last 12 months? ☐Yes ☐ No ☐ Unknown 15d. Did patient take chemotherapy for cancer? ☐Yes ☐ No ☐ Unknown 15e. Specify chemotherapy medications: _____ 15f. Specify dates: _____
☐	☐	☐	☐	16. **Immunodeficiency or Immunosuppression?**
				16a. AIDS? ☐ Yes ☐ No Date of AIDS diagnosis _____ /_____ /_____ 16b. Specify immunodeficiency other than AIDS _____
☐	☐	☐	☐	17. **HIV?**
				17a. Date of HIV diagnosis _____ /_____ /_____
☐	☐	☐	☐	18. **Did you (your child) take an antibiotic as treatment for this illness?**
				18a. Antibiotic(s) _____
☐	☐	☐	☐	19. **Was antiparasitic treatment taken for this illness?**
				19a. Antiparasitic(s) _____
☐	☐	☐	☐	20. **Did you (your child) take any antidiarrheals for this illness?**
				20a. ☐ Imodium ☐ Kaopectate ☐ Lomotil ☐ Pepto-Bismol ☐ Unknown ☐ Other _____
☐	☐	☐	☐	21. **Have you (your child) been tested for cryptosporidiosis previously?**
				Provide appropriate dates and test results:

BOX 6: RISK HISTORY

Period of interest: Symptom onset date: _____ /_____ /_____

BEGINNING: _____ /_____ /_____ (Two weeks prior to symptom onset)

ENDING: _____ /_____ /____ (Symptom onset)

BOX 7: TRAVEL

The following questions refer to travel that occurred during the period of interest indicated above.

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	22. **Did you (your child) travel outside the US?**

EVENTID _____

22a. ***Country 1:***

Destination country: _____

Arrival date destination country: _____ /_____ /_____

Approximate arrival date destination country, if exact date unknown _____ /_____ /_____

Departure date destination country: _____ /_____ /_____

Approximate departure date destination country, if exact date unknown _____ /_____ /_____

Where did you (your child) stay while traveling in this country?

☐ Hotel/Motel/Resort ☐ Family/friend's house ☐ Camping outdoors
☐ Hostel ☐ 2nd home owned by patient ☐ Other _____

Did anyone who traveled with you (your child) get ill? ☐ Yes ☐ No ☐ Unknown

22b. ***Country 2 (if applicable):***

Destination country: _____

Arrival date destination country: _____ /_____ /_____

Approximate arrival date destination country, if exact date unknown _____ /_____ /_____

Departure date destination country: _____ /_____ /_____

Approximate departure date destination country, if exact date unknown _____ /_____ /_____

Where did you (your child) stay while traveling in this country?

☐ Hotel/Motel/Resort ☐ Family/friend's house ☐ Camping outdoors
☐ Hostel ☐ 2nd home owned by patient ☐ Other _____

Did anyone who traveled with you (your child) get ill? ☐ Yes ☐ No ☐ Unknown

☐	☐	☐	☐	23. **Did you (your child) travel outside NYC, but within the US?**

23a. ***State 1:***

Which state did you (your child) travel to? _____

What cities or regions did you (your child) travel to? _____

Arrival date destination outside NYC: _____ /_____ /_____

Approximate arrival date at US destination, if exact date unknown _____ /_____ /_____

Departure date from destination outside NYC: _____ /_____ /_____

Approximate departure date at US destination, if exact date unknown _____ /_____ /_____

During period of interest did a member of your household travel within the US but outside NYC? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did anyone who traveled with you (your child) get ill? ☐ Yes ☐ No ☐ Unknown

23b. ***State 2 (if applicable):***

Which state did you (your child) travel to? _____

What cities or regions did you (your child) travel to? _____

Arrival date destination outside NYC: _____ /_____ /_____

Approximate arrival date at US destination, if exact date unknown _____ /_____ /_____

Departure date from destination outside NYC: _____ /_____ /_____

Approximate departure date at US destination, if exact date unknown _____ /_____ /_____

During period of interest did a member of your household travel within the US but outside NYC? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did anyone who traveled with you (your child) get ill? ☐ Yes ☐ No ☐ Unknown

☐	☐	☐	☐	24. **During period of interest did a member of your household travel outside the US?**

EVENTID _____

	24a. ***Country 1:*** Country _____ Date departed from NYC _____ /_____ /_____ Date returned to NYC _____ /_____ /_____ Did the household member who traveled get sick with symptoms like yours (your child's)? ☐ Yes ☐ No ☐ Unknown ☐ Refused
	24b. ***Country 2 (if applicable):*** Country _____ Date departed from NYC _____ /_____ /_____ Date returned to NYC _____ /_____ /_____ Did the household member who traveled get sick with symptoms like yours (your child's)? ☐ Yes ☐ No ☐ Unknown ☐ Refused?
☐ ☐ ☐ ☐	25. **Was the infection likely acquired outside US?**
	25a. Country where infection likely occurred _____

BOX 8: WATER				
All questions below refer to possible exposures you (your child) may have had during the period of interest (incubation period) indicated above.				
Yes	**No**	**Don't Know**	**Refused**	
☐	☐	☐	☐	26. **Did you (your child) use a whirlpool spa, Jacuzzi, hot tub, or hydrotherapy pool?**
				26a. What is the name of the place where spa/Jacuzzi/hot tub/hydrotherapy pool is located? _____ Street address of place _____ City _____ State _____ Zip _____
				26b. Date used spa/Jacuzzi/hot tub/ hydrotherapy pool _____ /_____ /_____
				26c. Did you (your child) submerge your head under water? ☐ Yes ☐ No ☐ Unknown ☐ Refused
				26d. Did you (your child) swallow any water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Yes	**No**	**Don't Know**	**Refused**	
☐	☐	☐	☐	27. **Did you (your child) visit a recreational water park?**
				27a. What is the name of the water park? _____ Street address _____ City _____ State _____ Zip _____
				27b. Date visited water park _____ /_____ /_____
				27c. Did you (your child) submerge your head under water? ☐ Yes ☐ No ☐ Unknown ☐ Refused
				27d. Did you (your child) swallow any water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

EVENTID _____

☐	☐	☐	☐	28. **Did you (your child) swim or go wading in any pool or other body of water?**

28a. Did you (your child) swim in a swimming pool? ☐ Yes ☐ No ☐ Unknown ☐ Refused

If yes, complete information below. If not, skip to b.

Name of swimming pool _____

Street address _____

City _____ State _____ Zip _____

Date you (you child) swam in pool _____ /_____ /_____

Did you (your child) submerge your head under water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did you (your child) swallow any water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did anyone else who swam in the swimming pool get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Is this pool a public pool or at a private home? ☐ Public ☐ Private ☐ Unknown

28b. ***Other body of water #1:***

Did you (your child) swim or go wading in any other body of water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

What was the other type of water in which you (your child) swam or waded (if more than one, include all, such as pond, ocean, river, kiddie pool) _____

What is the name(s) of the body of water? _____

Street address _____

City _____ State _____ Zip _____

Date you (your child) swam in body of water _____ /_____ /_____

Did you (your child) submerge your head under water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did you (your child) swallow any water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did anyone else who swam in the body of water get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

28c. ***Other body of water #2 (if applicable):***

Did you (your child) swim or go wading in any other body of water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

What was the other type of water in which you (your child) swam or waded (if more than one, include all, such as pond, ocean, river, kiddie pool) _____

What is the name(s) of the body of water? _____

Street address _____

City _____ State _____ Zip _____

Date you (your child) swam in body of water _____ /_____ /_____

Did you (your child) submerge your head under water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did you (your child) swallow any water? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Did anyone else who swam in the body of water get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	29. **Did you (your child) drink any NYC tap water? This includes any NYC municipal water that you may have drank directly from the faucet or which you may have boiled or filtered before drinking, including water used to make tea or coffee that came directly from the tap.** *For patients who reported that they do NOT drink <u>any</u> NYC municipal water (they answered "NO" to Question 29), ask 30 - 33:*

EVENTID _____

29a. How many cups of NYC tap water did you (your child) drink on average per day, including directly from the tap, or boiled, or filtered water? _____

29b. How many cups of NYC tap water were directly from the tap without being boiled or filtered? _____

29c. How many cups of NYC tap water were boiled? _____
How many minutes did you boil NYC tap water? _____

29d. How many cups of NYC tap water were filtered? _____
Filter manufacturer _____ Filter Model Name and number _____
Type of filter ☐ Pour through ☐ Attached to faucet ☐ Under the sink ☐ Other

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	30. Did you (your child) use unboiled/unfiltered NYC tap water to brush his/her teeth?
☐	☐	☐	☐	31. Did you (your child) use unboiled/unfiltered NYC tap water to wash vegetables or fruit?
☐	☐	☐	☐	32. Did you (your child) use unboiled/unfiltered NYC tap water to make ice?
☐	☐	☐	☐	33. Did you (your child) use unboiled/unfiltered NYC tap water to make juice from concentrate?
☐	☐	☐	☐	34. **Did you (your child) drink water from a private well?**

34a. Location of private well _____

☐	☐	☐	☐	Interviewer: Please complete 35 and 36 if patient travelled. 35. **Did you (your child) drink tap water or a drink made with tap water when traveling outside of the US?**
☐	☐	☐	☐	36. **Did you (your child) drink municipal water outside NYC, but within the US?**

36a. Location of municipal drinking water _____

☐	☐	☐	☐	37. **Did you (your child) drink water from a spring?**

37a. Location of spring _____

37b. Date _____ /_____ /_____

37c. Did anyone else who was with you get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

☐	☐	☐	☐	38. **Did you (your child) drink water from a pond/lake/river or stream?**

38a. Location of pond/lake/river/stream _____

38b. Date _____ /_____ /_____

38c. Did anyone else who was with you get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Always	Usually	Sometimes	Rarely	Never	
☐	☐	☐	☐	☐	39. **Did you (your child) drink commercially bottled water?**

39a. Bottled water brand _____

39b. How many cups of bottled water did you (your child) drink? _____

39 c. Location _____

Additional comments pertaining to exposure to water:

EVENTID _____

BOX 9: FOOD

The following questions refer to the period of interest indicated above. Please ask whether the exposure occurred during that time frame. Did you (your child):

Yes	No	Unknown	Refused	
☐	☐	☐	☐	40. **Did you (your child) eat at any restaurants, delis, fast-food establishments, cafeterias, etc. for breakfast, lunch, or dinner- either dining in or for takeout?**

Specify type of restaurant (i.e. Italian, fast food. Deli, etc.)	Specify name of restaurant	Address/Cross Streets	Date you ate at the restaurant
1.			_____ /_____/_____
2.			_____ /_____/_____
3.			_____ /_____/_____

40a. Did anyone else who ate at these places get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

☐	☐	☐	☐	41. **Eat raw or unpasteurized cheese?**

41a. Type of raw or unpasteurized cheese: _____

Where was it purchased?	What store/restaurant was it purchased from?	Complete street address (or cross streets)	Variety or brand	Was it purchased at a deli counter?
☐ Grocery store				☐ Yes ☐ No ☐ Unknown
☐ Deli/small market				☐ Yes ☐ No ☐ Unknown
☐ Restaurant				☐ Yes ☐ No ☐ Unknown
☐ Other venue				☐ Yes ☐ No ☐ Unknown
☐ Don't know				

☐	☐	☐	☐	42. **Drink raw or unpasteurized milk?**

What store/restaurant was it purchased from?	Complete street address (or cross streets)	Variety or brand	Date of purchase
1.			_____ /_____/_____
2.			_____ /_____/_____
3.			_____ /_____/_____

☐	☐	☐	☐	43. **Did anyone else who drank the raw milk or ate the raw cheese get sick?**

EVENTID _____

Yes	No	Unknown	Refused	
☐	☐	☐	☐	44. **Drink raw/unpasteurized apple juice/cider?**

What store/restaurant was it purchased from?	Complete street address (or cross streets)	Variety or brand	Date of purchase
			_____ /_____/_____
			_____ /_____/_____
			_____ /_____/_____

44a. Did anyone else who drank the cider get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

Yes	No	Unknown	Refused	
☐	☐	☐	☐	45. **Eat unpeeled fruit or vegetables?**

Type of unpeeled fruit or vegetable	How often did you wash the fruit or vegetable?
	☐ Always ☐ Never ☐ Rarely ☐ Sometimes ☐ Usually
	☐ Always ☐ Never ☐ Rarely ☐ Sometimes ☐ Usually
	☐ Always ☐ Never ☐ Rarely ☐ Sometimes ☐ Usually

Yes	No	Unknown	Refused	
☐	☐	☐	☐	46. **Eat shellfish?**

46a. Type of shellfish: _____

Date Consumed	From which store/restaurant did you purchase the shellfish?	Complete street address (or cross streets)	Was the shellfish raw or undercooked?	Date of purchase
			☐ Yes ☐ No ☐ Unknown ☐ Refused	_____ /_____/_____
			☐ Yes ☐ No ☐ Unknown ☐ Refused	_____ /_____/_____
			☐ Yes ☐ No ☐ Unknown ☐ Refused	_____ /_____/_____

46b. Did anyone else who ate the shellfish get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused

EVENTID _____

BOX 10: ANIMAL

All questions below refer to possible exposures you (your child) may have had during the period of interest (incubation period) indicated above.

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	47. **Did you (your child) visit a farm or petting zoo at which there were animals?**
				47a. Date of visit? _____ /_____ /_____ 47b. Name and full address of farm or petting zoo: _____ _____ 47 c. What type of animal (s)? _____ 47 d. Did you (your child) touch/feed any animals at the farm or petting zoo? ☐ Yes ☐ No ☐ Unknown 47 e. Did anyone else who was with you get sick? ☐ Yes ☐ No ☐ Unknown ☐ Refused
☐	☐	☐	☐	48. **Do you (your child) own a pet?**
				48a. Type of pet (s)? ☐ Dog ☐ Cat ☐ Other_____ 48b. Did you (your child) pick up dog stool or feces when walking the dog? ☐ Yes ☐ No ☐ Unknown ☐ Refused 48c. Did you (your child) change litter in the cat's little box? ☐ Yes ☐ No ☐ Unknown ☐ Refused 48d. Did the pet have diarrhea? ☐ Yes ☐ No ☐ Unknown ☐ Refused
☐	☐	☐	☐	49. **Did you (your child) have contact with another animal during the period of interest?**
				49a. What type of animal? _____ Date of exposure to animal? _____ /_____ /_____ Location of contact with animal (type of place) i.e. zoo, farm, home, etc _____ Name of place where contact occurred _____ Full address of place where contact occurred _____
				49 b. If contact with a second animal, what type of animal? _____ Date of exposure to animal? _____ /_____ /_____ Location of contact with animal (type of place) i.e. zoo, farm, home, etc. _____ Name of place where contact occurred _____ Full address of place where contact occurred _____

BOX 11: CHILD CARE

All questions below refer to possible exposures you (your child) may have had during the period of interest (incubation period) indicated above.

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	50. **Any children in the house in diapers?**
				50a. During the period of interest, how many children wearing diapers lived in the home? _____ 50b. During the period of interest, did you (your child) change or handle a child's diapers? ☐ Yes ☐ No ☐ Unknown ☐ Refused 50c. Did the child whose diapers were handled have diarrhea? ☐ Yes ☐ No ☐ Unknown ☐ Refused 50d. Was the child diagnosed with cryptosporidiosis? ☐ Yes ☐ No ☐ Unknown ☐ Refused

EVENTID _____

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	51. **[If the patient is a child:] Does the child attend daycare/group babysitting?**
				*51a. **Daycare #1:*** Name of daycare/group babysitting/nursery/preschool _____ Full address of daycare/group babysitting/nursery/preschool _____ Phone Number of daycare/group babysitting/nursery/preschool_____ Dates of attendance prior to onset and during illness (provide the earliest and last date of attendance) _____ -- _____
				*51b. **Daycare #2 (if applicable):*** Name of daycare/group babysitting/nursery/preschool _____ Full address of daycare/group babysitting/nursery/preschool _____ Phone Number of daycare/group babysitting/nursery/preschool_____ Dates of attendance prior to onset and during illness (provide the earliest and last date of attendance) _____ -- _____
				51c. **How many children who lived in your house during the period of interest attend daycare?** _____

BOX 12: RESIDENTIAL/OCCUPATIONAL

All questions below refer to possible exposures you may have had during the period of interest (incubation period) indicated above.

Yes	No	Don't Know	Refused	
☐	☐	☐	☐	52. **Do you work (paid or volunteer) in a health care facility (acute or long-term care)?**
				52a. Type of health care facility ☐ Acute care Hospital ☐ Long term care facility ☐ Emergency room ☐ Outpatient clinic or private office ☐ Dialysis center ☐ Short-stay surgery ☐ Other _____
				52b. Name of workplace _____ 52c. Type of work performed _____ 52d. Date of attendance _____ 52e. Address of workplace _____ City_____ State _____ Zip_____
				Additional notes on health care work exposure (including job duties):

EVENTID _____

☐	☐	☐	☐	53. **Do you do work (paid or volunteer) that involves caring for young children (e.g. nursery/daycare/group babysitting)?**
→		53a. Name of workplace _____ 53b. Type of work performed _____ 53c. Date of attendance _____ 53d. Address of workplace _____City _____State _____ Zip _____		
Yes	**No**	**Don't Know**	**Refused**	
☐	☐	☐	☐	54. **Do you do any work in a clinical or research laboratory?**
→		54a. Name of workplace _____ 54b. Type of work performed _____ 54c. Date of attendance _____ 54d. Address of workplace_____ City _____ State _____ Zip _____		
☐	☐	☐	☐	55. **Do you do any work that involves routine contact with animals?**
→		55a. Name of workplace _____ 55b. Type of work performed _____ 55c. Date of attendance _____ 55d. Address of workplace _____ City _____ State_____ Zip _____		
☐	☐	☐	☐	56. **Did you work or volunteer during the period of interest?**
→		56a. Name of workplace _____ 56b. Type of work performed _____ 56c. Dates of attendance _____ 56d. Address of workplace _____City_____State_____Zip_____		
☐	☐	☐	☐	57. **Did you care for a person with diarrhea as part of your work (volunteer or paid) or at home?**
→		57a. Specify location(s) where you cared for a person with diarrhea: ☐ Hospital ☐ Daycare Center ☐ Nursing home ☐ Home ☐ Other		
		58. **Total number of people that reside in household (sleep >1 night per week) _____**		
		59. **How many children under 5 live in the household? _____**		
☐	☐	☐	☐	60. **During the period of interest, did you know or have contact with anyone else with similar symptoms?**
☐	☐	☐	☐	61. **Has anyone else in your home or apartment ever tested positive for cryptosporidiosis?**
→		61a. Test date: ____ /_____ /_____		

EVENTID _____

Yes	No	Don't Know	Refused	
		62. **Other than you (your child), how many people who lived in your home during the period of interest had diarrhea? _____**		
☐	☐	☐	☐	63. **Has anyone at home had a similar illness?**

BOX 13: BEHAVIORAL				
All questions below refer to possible exposures you may have had during the period of interest (incubation period) indicated above. (REMINDER: ONLY ASK IF PATIENT IS 18 OR OVER)				
Yes	**No**	**Don't Know**	**Refused**	
☐	☐	☐	☐	64. **During the specified time period, did you have anal sex?**
→		64a. [If YES to # 64 <u>and</u> patient is male:] Did you have insertive anal sex with your penis in your partner's anus? ☐ Yes ☐ No ☐ Unknown ☐ Refused		
☐	☐	☐	☐	65. **Did you put finger in partner's anus?**
☐	☐	☐	☐	66. **Was your mouth or tongue in contact with partner's anus?**
☐	☐	☐	☐	67. **During the specified time period, did you have oral sex?**
→		67a. Did you perform oral sex on a man (his penis in your mouth)? ☐ Yes ☐ No ☐ Unknown ☐ Refused		
		67b. Did you perform oral sex on a woman (your mouth in or around her vagina)? ☐ Yes ☐ No ☐ Unknown ☐ Refused		
☐	☐	☐	☐	68. **Were any of your sex partners experiencing diarrhea at the time patient had sex with them?**
☐	☐	☐	☐	69. **Were any of your sexual partners diagnosed with cryptosporidiosis?**