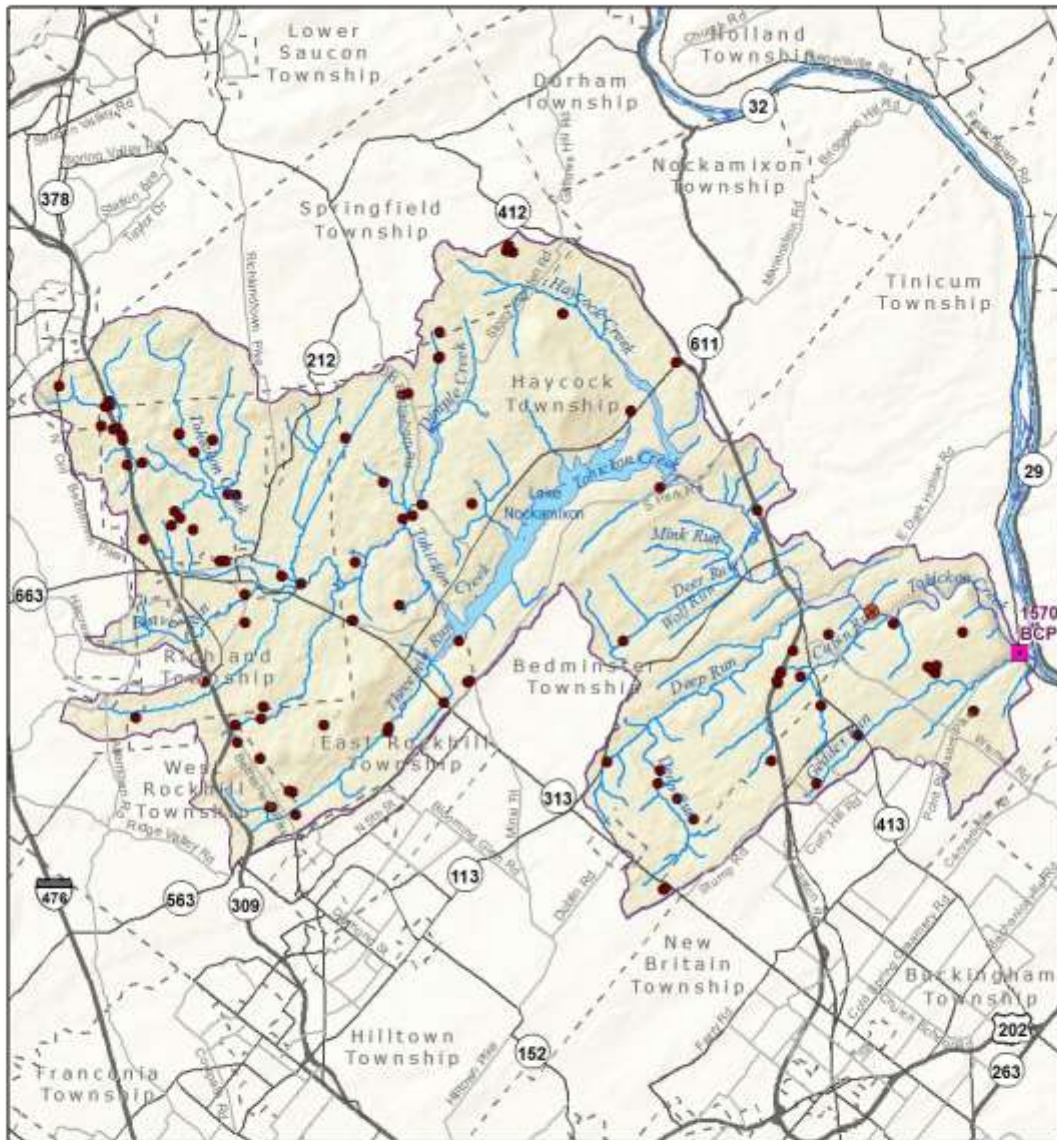


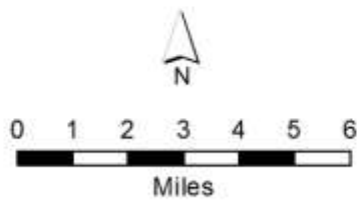
Chapter 9: 1570 BCP Tohickon Creek, Bucks County, PA



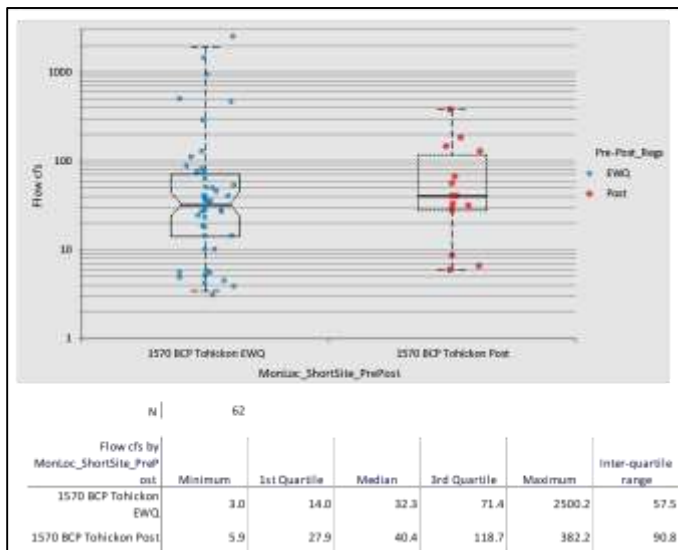
Tohickon Creek

Drainage Area = 113.77 mi²

- Sampling Location
- NPDES
- Stream Gage
- Drainage Area



Analysis of flow differences between the EWQ and post-EWQ periods:



Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period, and the range of flow conditions sampled was narrower. Flow is plotted on a logarithmic scale.

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	67.9	1.45
1570 BCP Tohickon Post	15	212.8	14.19

H statistic	0.86
χ^2 approximation	0.86
DF	1
p-value	0.3530 ¹

H0: $\theta_1 = \theta_2 = 0...$

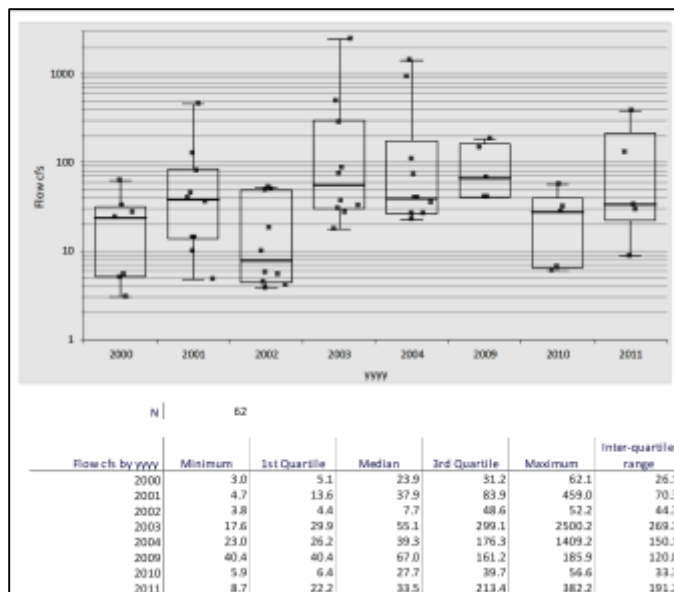
The median of the populations are all equal.

H1: $\theta_i \neq \theta_j$ for at least one i,j

The median of the populations are not all equal.

¹ Do not reject the null hypothesis at the 5% significance level.

The 114 square mile Tohickon Creek watershed is one of the larger tributaries to the Delaware River within the narrow, confined river valley below the Lehigh River confluence. It was included in the Lower Delaware Wild and Scenic designation for its spectacular scenery, good water quality, and recreational value. The Tohickon watershed is about 57% forested, and about 4.4% urban land cover. There is no underlying carbonate bedrock, but water quality is influenced by Lake Nockamixon that controls flow and acts as a pollutant sink for much of the urban influences within the watershed.



Annual May to September flow statistics associated with water quality measurements are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. “Normal” annual median flow for the years that Lake Nockamixon has controlled the flow (1973-Present) is about 173 cfs at this location, but the May-September summer seasonal flow is around 107 cfs. Though a wide range of flows were sampled by DRBC, these data sets appear to be most representative of low to low-normal flow conditions. Flows corresponding to each water quality sample were estimated using flow records for the time of each sample taken from continuous data at the USGS stream gage at Pipersville, PA (USGS 01459500) times a drainage area weighting factor.

Upstream ICP: Delaware River at Milford 1677 ICP
Downstream ICP: Del. River at Bulls Island 1554 ICP

Chapter 9: 1570 BCP Tohickon Creek, PA

Alkalinity as CaCO₃, Total mg/l

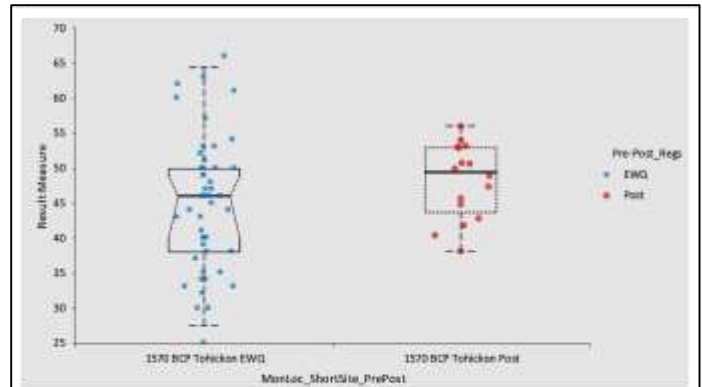
Existing Water Quality (Table 2R):

Median 46 mg/l

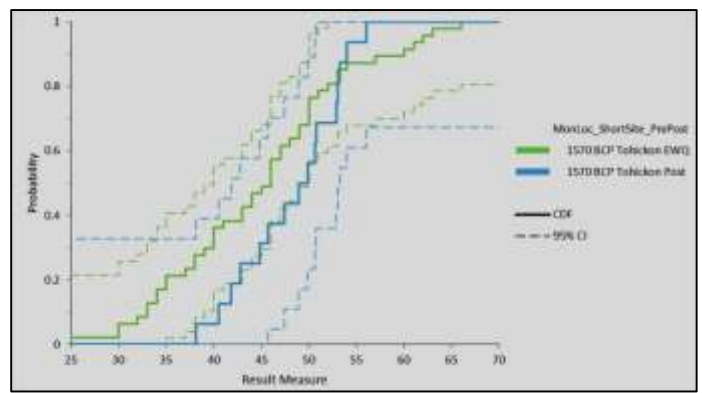
Lower 95% Confidence Interval 40 mg/l

Upper 95% Confidence Interval 49 mg/l

Defined in regulations as a flow-related parameter



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	25	38	46	50	66	12
1570 BCP Tohickon Post	38	44	49	53	56	9

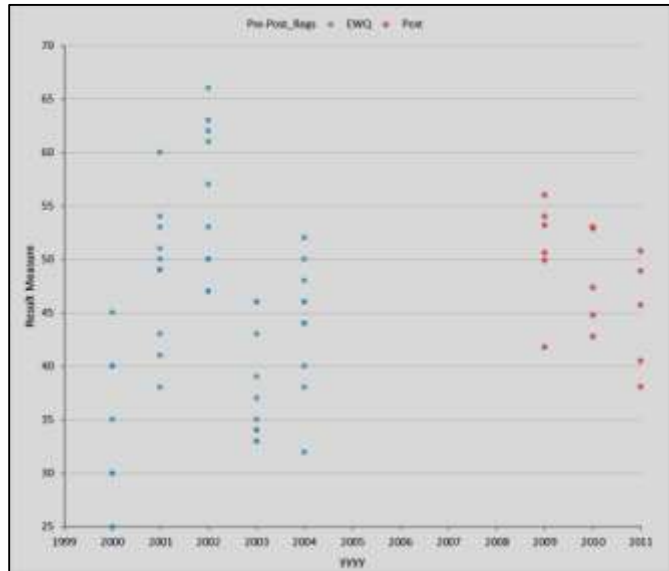
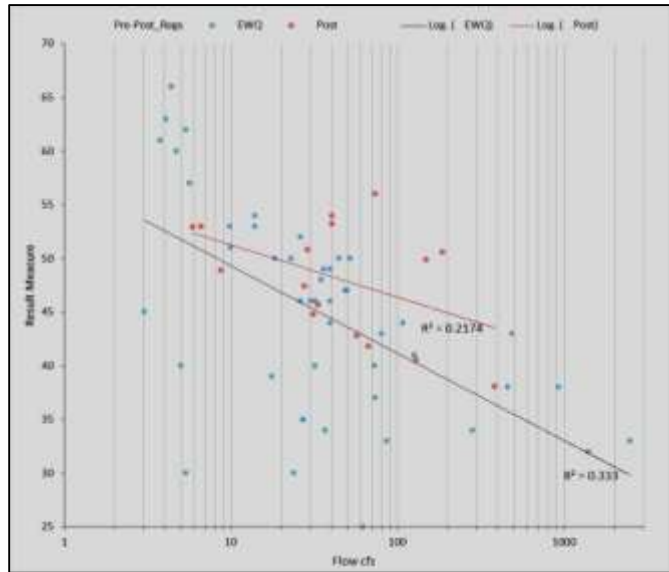


Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	198.1	4.22
1570 BCP Tohickon Post	16	582.0	36.38

H statistic: 2.32
 X² approximation: 2.32
 DF: 1
 p-value: 0.1274¹

H0: θ₁ = θ₂ = 0...
 The median of the populations are all equal.
 H1: θ_i ≠ θ_j for at least one i, j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.



No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

Chapter 9: 1570 BCP Tohickon Creek, PA

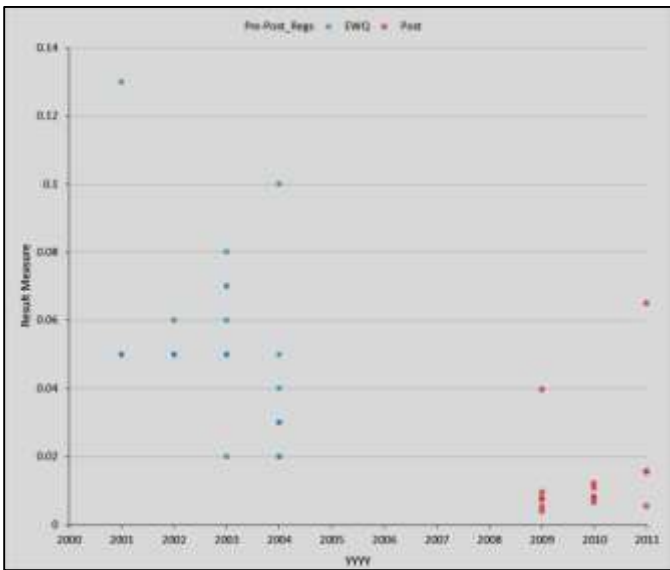
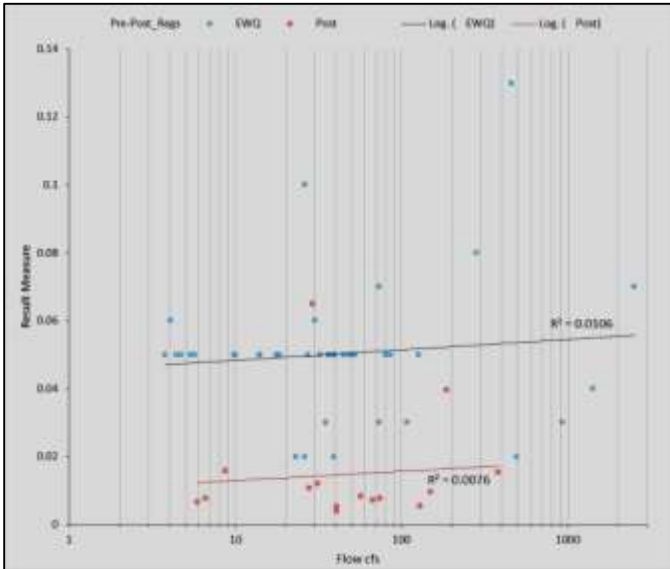
Ammonia Nitrogen as N, Total mg/l

Existing Water Quality (Table 2R):

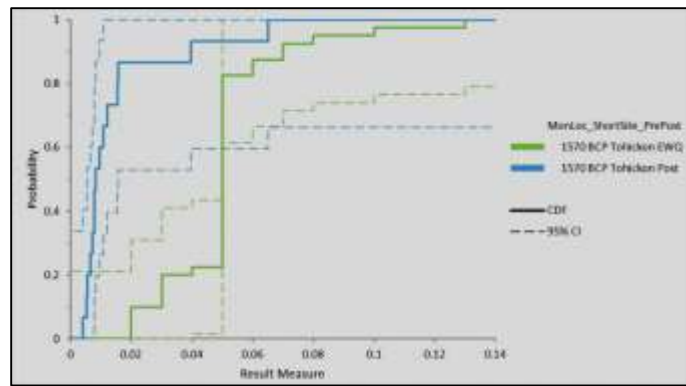
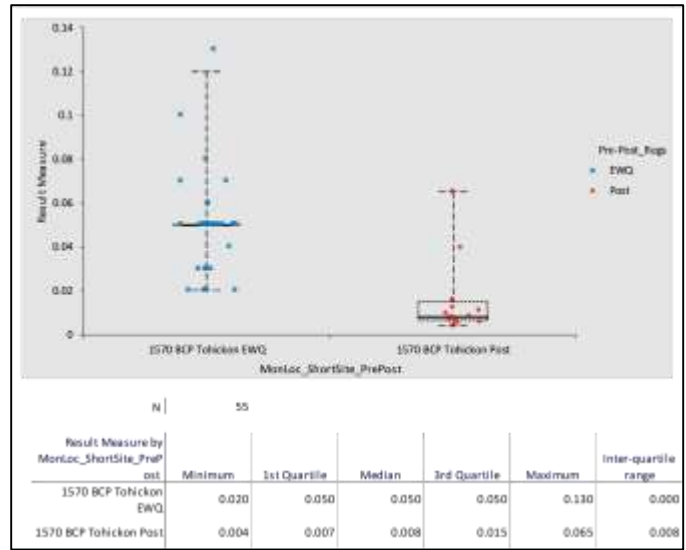
Median <0.05 mg/l

Lower 95% Confidence Interval <0.05 mg/l

Upper 95% Confidence Interval <0.05 mg/l



No water quality degradation is evident. Ammonia concentrations apparently declined. However, differences in detection limits, potential laboratory artifacts, and insufficient post-EWQ sampling frequency contributed uncertainty to conclusions. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	1651.2	41.28
1570 BCP Tohickon Post	15	4403.3	293.55

H statistic	25.75
X ² approximation	25.75
DF	1
p-value	<0.0001 ¹

H0: $\theta_i = \theta_j = \theta...$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j
 The median of the populations are not all equal.

¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

No independent data were available to validate the decline. Post-EWQ detection limits were lower than EWQ limits. EWQ data contain numerous non-detect results (25/40 samples) that interfered with estimation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. In the 2009-2011 period there was 1/15 non-detect result. So we now know what the concentrations really are. Possible evidence for water quality improvement is indicated by post-EWQ concentrations no greater than 0.065 mg/l.

Chapter 9: 1570 BCP Tohickon Creek, PA

Chloride, Total mg/l

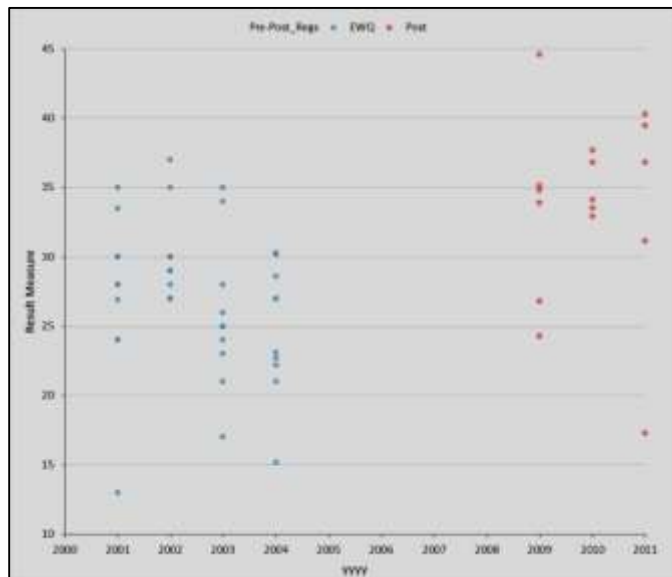
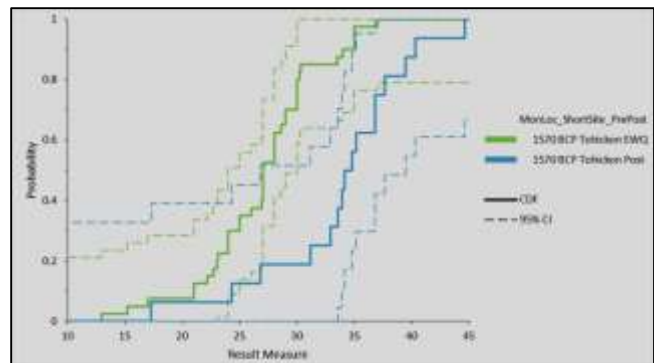
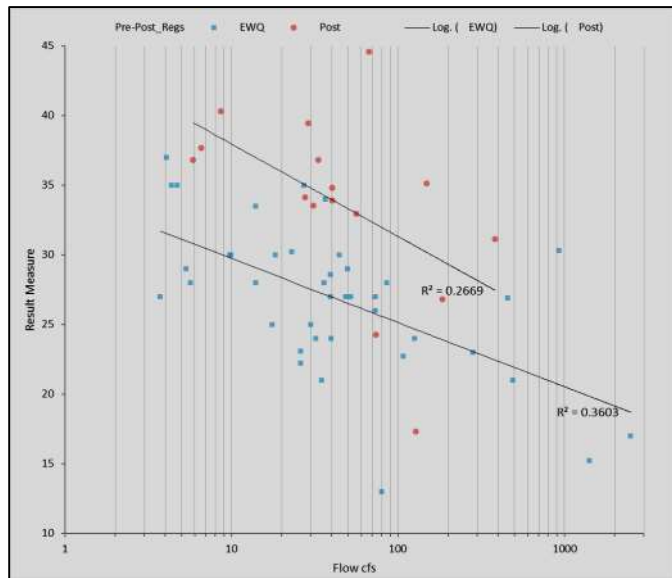
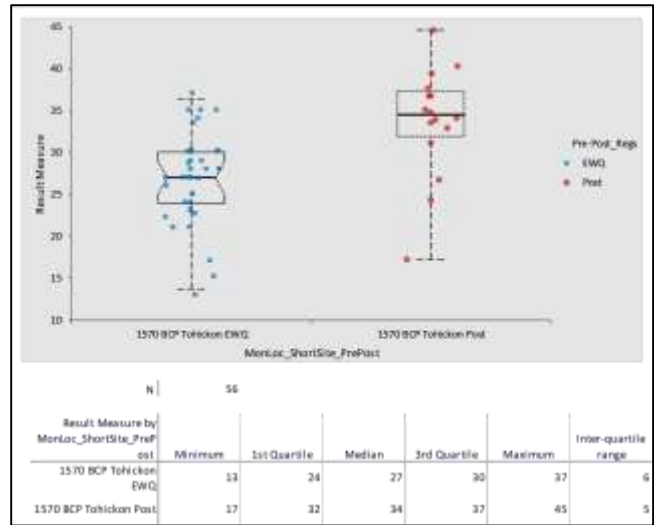
Existing Water Quality (Table 2R):

Median 27 mg/l

Lower 95% Confidence Interval 25 mg/l

Upper 95% Confidence Interval 29 mg/l

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	970.2	24.26
1570 BCP Tohickon Post	16	2425.6	151.60

H statistic 12.79
 X² approximation 12.79
 DF 1
 p-value 0.0003¹

H0: $\theta_1 = \theta_2 = \theta...$

The median of the populations are all equal.

H1: $\theta_i \neq \theta_j$ for at least one i, j

The median of the populations are not all equal.

¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

Water quality degradation is evident. Chloride concentrations increased by 7 mg/l between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. The entire northern U.S. has experienced rising chlorides in fresh waters. Although chloride concentrations in Tohickon Creek remain far better than water quality criteria levels, such an increase over such a short time is problematic given that this is a designated Wild and Scenic watershed.

Chapter 9: 1570 BCP Tohickon Creek, PA

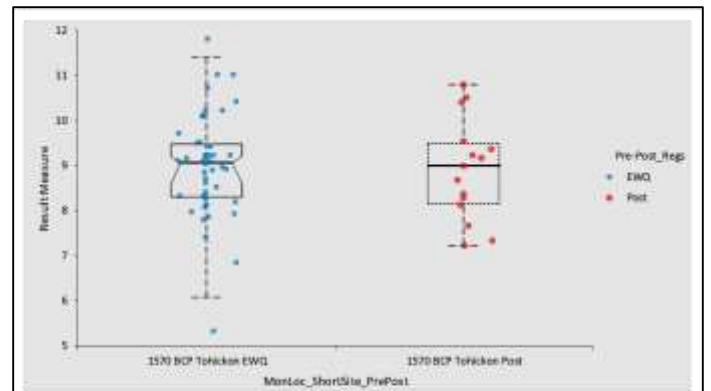
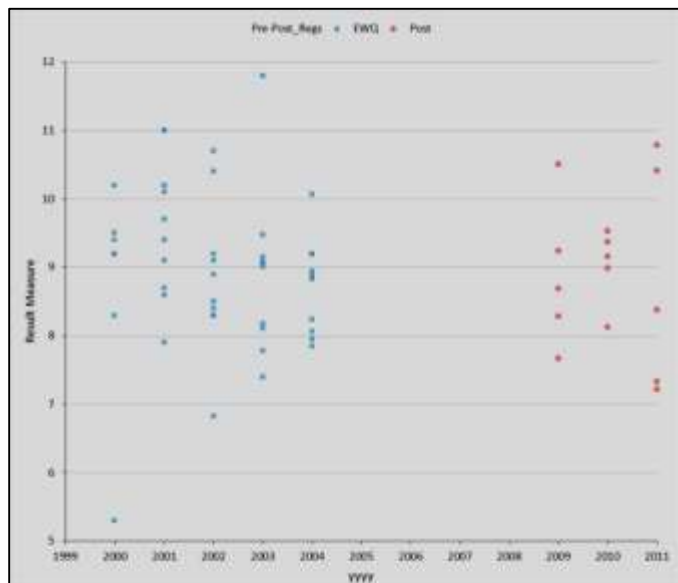
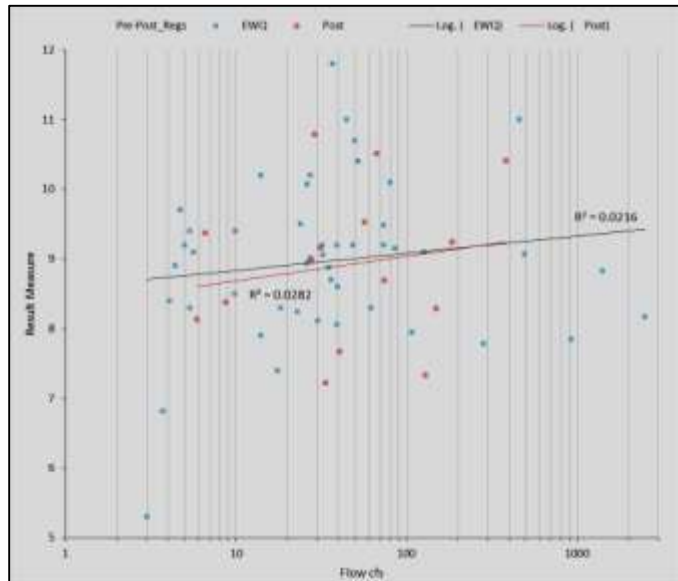
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2R):

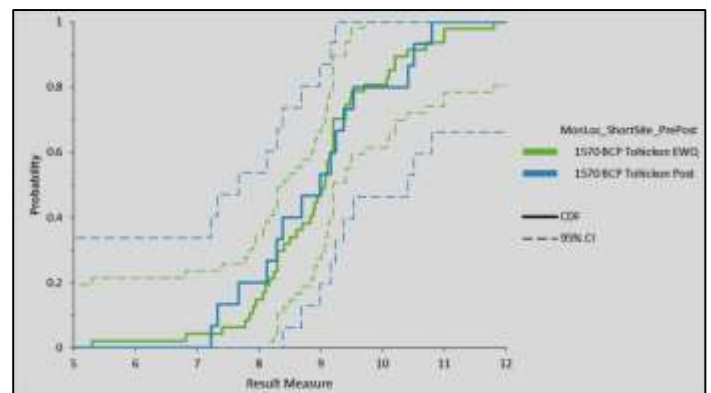
Median 9.06 mg/l

Lower 95% Confidence Interval 8.60 mg/l

Upper 95% Confidence Interval 9.20 mg/l



Result Measure by MonLoc_ShortSite_PrePost		Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	47	5.30	8.30	9.06	9.47	11.80	1.17
1570 BCP Tohickon Post	15	7.22	8.16	8.99	9.50	10.79	1.35



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	2.8	0.06
1570 BCP Tohickon Post	15	8.8	0.59

H statistic	0.04
χ^2 approximation	0.04
DF	1
p-value	0.8500 ¹

H0: $\theta_1 = \theta_2 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets. There was an extreme low DO value in the EWQ data set. That measurement was taken during dry conditions in July 2000 when flow in Tohickon Creek was 3 cfs. There was insufficient flow to wash away decomposing organic matter that drove DO concentration to 5.3 mg/l.

Chapter 9: 1570 BCP Tohickon Creek, PA

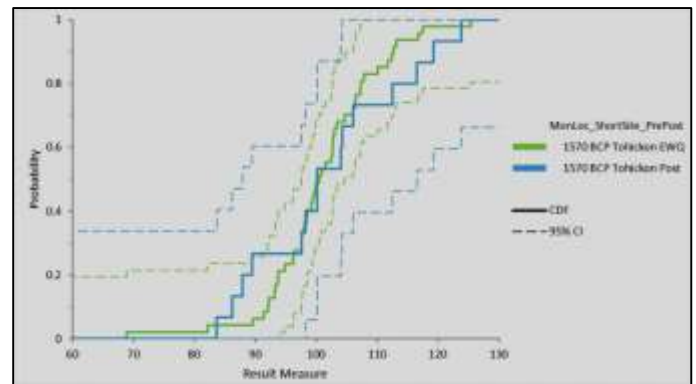
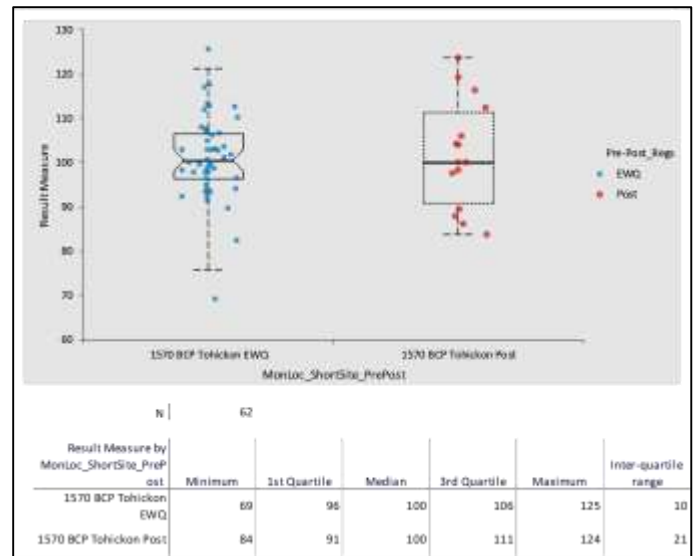
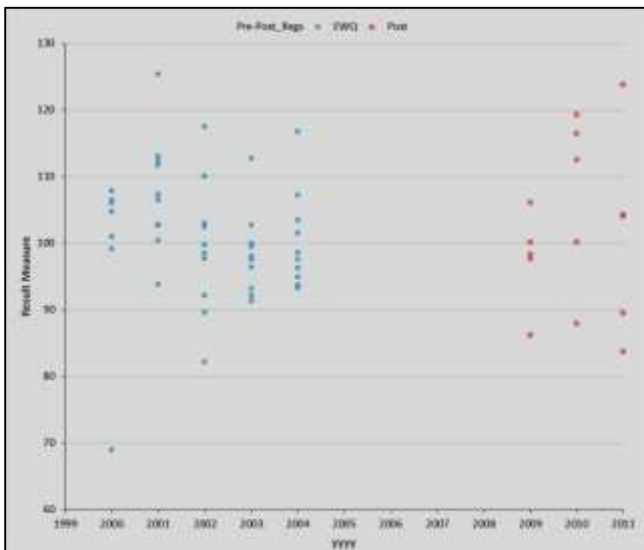
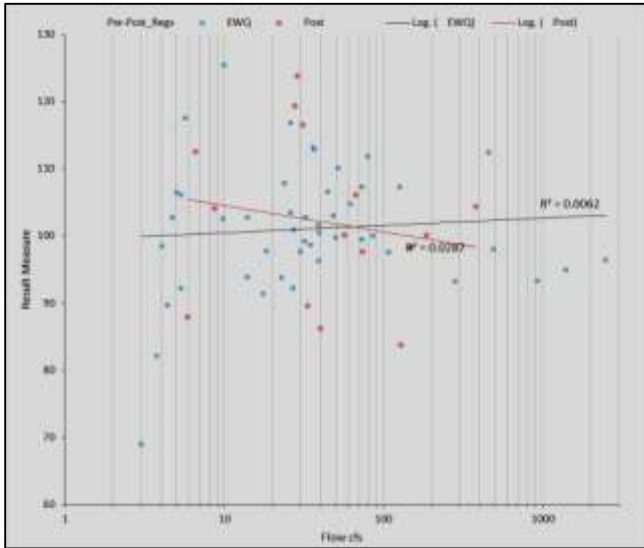
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2R):

Median 100%

Lower 95% Confidence Interval 98%

Upper 95% Confidence Interval 103%



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	1.9	0.04
1570 BCP Tohickon Post	15	6.0	0.40

H statistic	0.02
χ^2 approximation	0.02
DF	1
p-value	0.8759 ¹

H0: $\theta_1 = \theta_2 = \theta_3 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

Tohickon Creek is wide and shallow, without full shading by riparian vegetation in many locations. This promotes increased algal production. During mid-day hours the algae and aquatic plants produce oxygen super-saturation conditions, with frequently observed saturation values over 120%. There was an extreme low DO saturation value in EWQ data. That was taken during dry conditions in July 2000 when flow was an estimated 3 cfs. The flow was probably insufficient to wash out decomposing organic matter that drove DO concentration to 5.7 mg/l, and DO saturation to 68%.

Chapter 9: 1570 BCP Tohickon Creek, PA

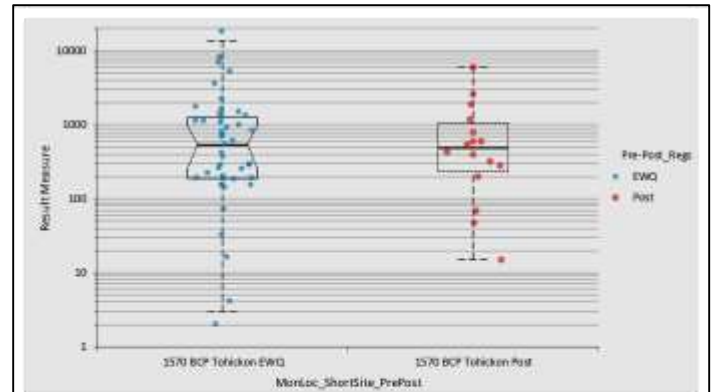
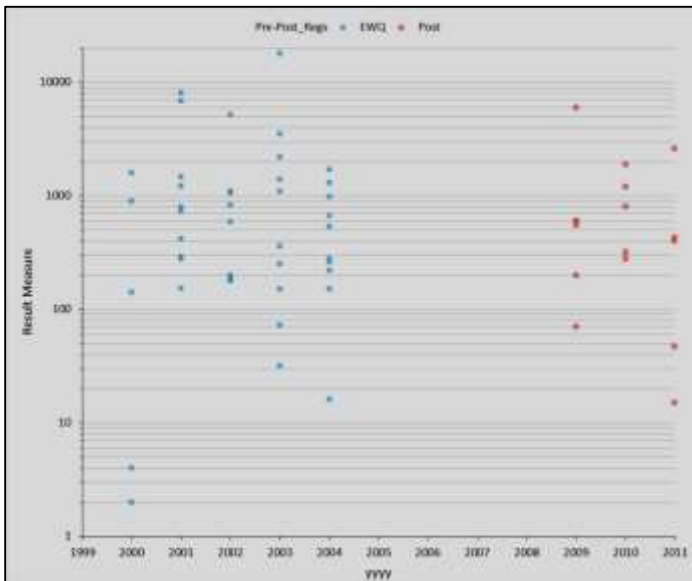
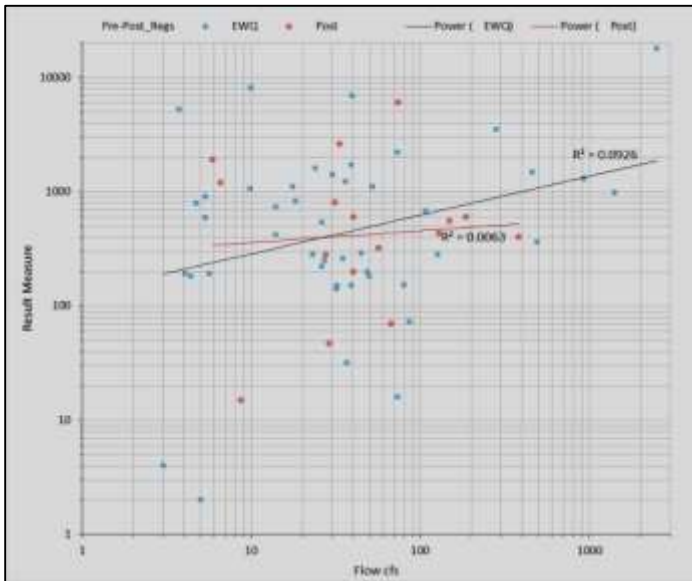
Enterococcus colonies/100 ml

Existing Water Quality (Table 2R):

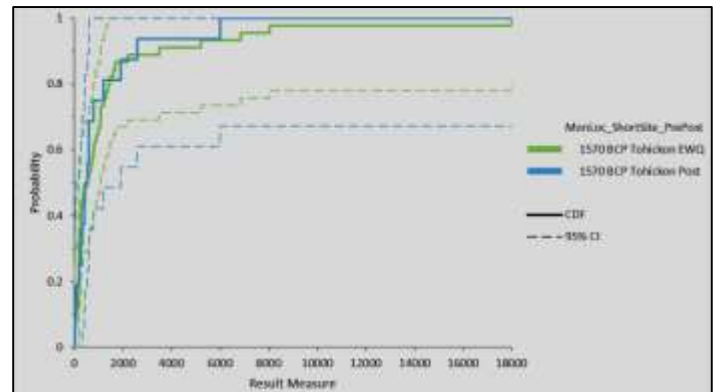
Median 540/100 ml

Lower 95% Confidence Interval 250/100 ml

Upper 95% Confidence Interval 980/100 ml



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	2	187	540	1247	18000	1060
1570 BCP Tohickon Post	15	233	490	1033	6000	800



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	45	0.3	0.01
1570 BCP Tohickon Post	16	0.8	0.05

H statistic: 0.00
 χ^2 approximation: 0.00
 DF: 1
 p-value: 0.9542¹

H0: $\theta_1 = \theta_2 = \theta_3 \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale. Post-EWQ median enterococcus concentrations were within the EWQ 95% confidence intervals.

Chapter 9: 1570 BCP Tohickon Creek, PA

Escherichia coli colonies/100 ml

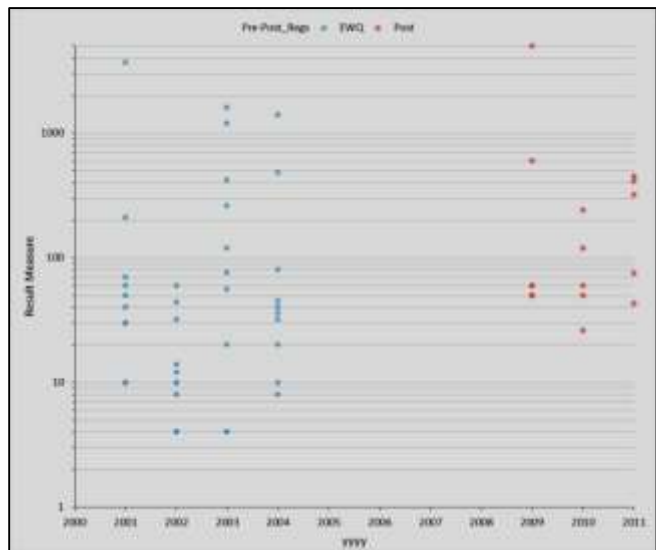
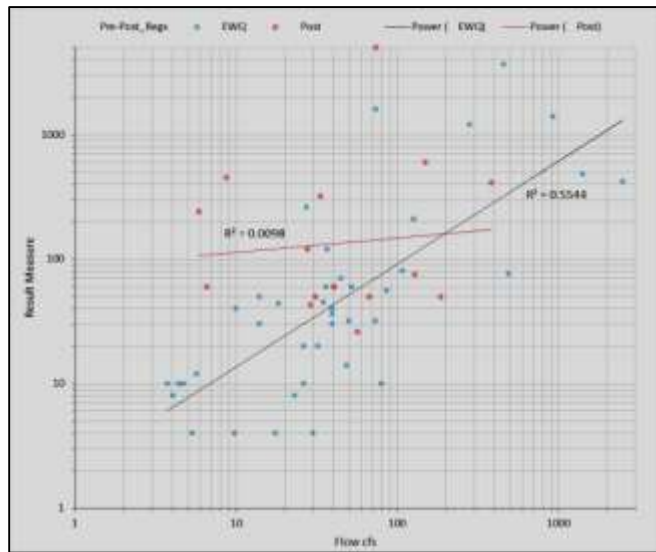
Existing Water Quality (Table 2R):

Median 38/100 ml

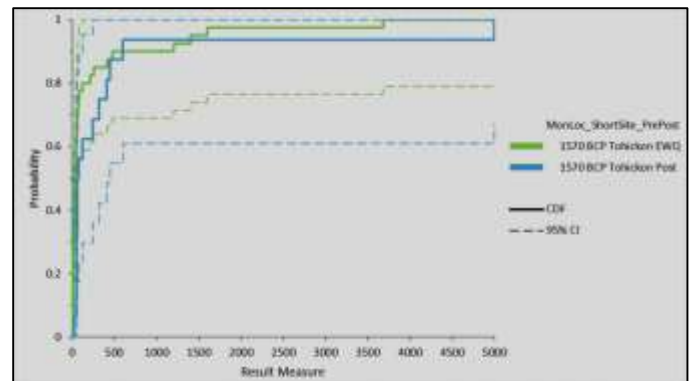
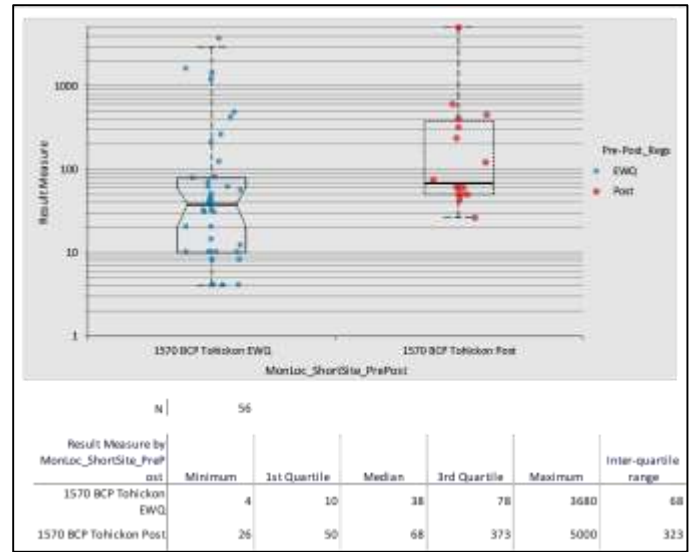
Lower 95% Confidence Interval 20/100 ml

Upper 95% Confidence Interval 60/100 ml

Defined in regulations as a flow-related parameter



Water quality degradation is evident here. E. coli concentrations apparently increased between the EYW and Post-EYW periods. However, potential laboratory artifacts and insufficient post-EYW sampling frequency introduced uncertainty into conclusions. Post-EYW median E. coli rose above the EYW upper 95% confidence interval.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EYW	40	518.4	12.96
1570 BCP Tohickon Post	16	1296.0	81.00

H statistic	6.84
X ² approximation	6.84
DF	1
p-value	0.0089 ¹

H0: $\theta_1 = \theta_2 = \theta_3 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j .
 The median of the populations are not all equal.
¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

Note that concentrations and flows are plotted on a logarithmic scale. E. coli concentrations were positively related to flow in the EYW data set, but unrelated to flow in the post-EYW data set – possibly due to too few post-EYW samples (n=16). No independent data from other agencies were available at this site to validate DRBC’s conclusion.

Chapter 9: 1570 BCP Tohickon Creek, PA

Fecal coliform colonies/100 ml

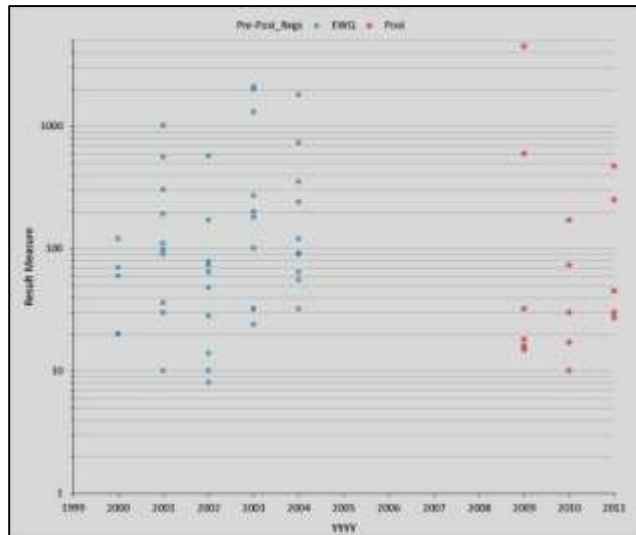
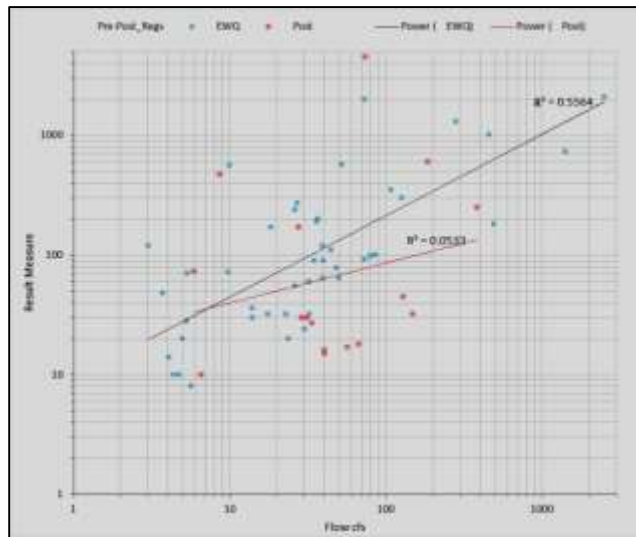
Existing Water Quality (Table 2R):

Median 90/100 ml

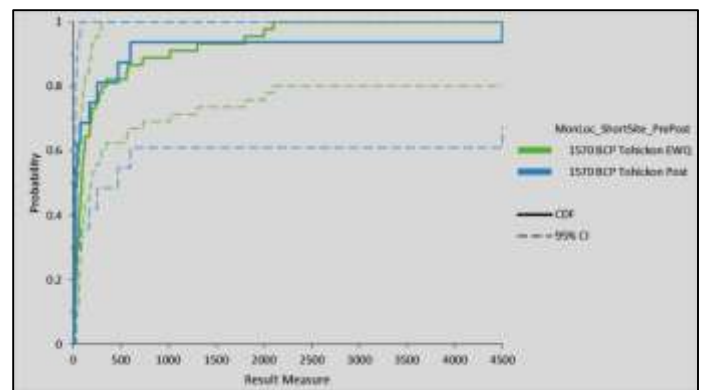
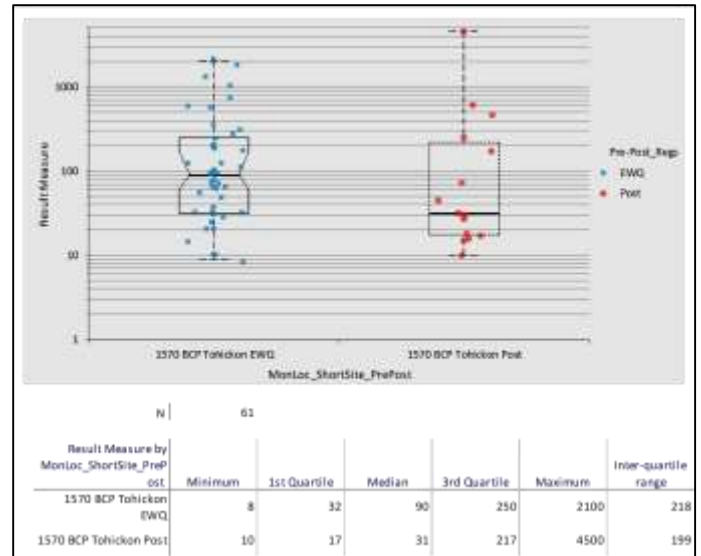
Lower 95% Confidence Interval 60/100 ml

Upper 95% Confidence Interval 170/100 ml

Defined in regulations as a flow-related parameter



No water quality degradation is evident. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Fecal coliform concentrations are positively related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set - probably because of too few post-EWQ samples (n=16).



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	45	180.0	4.00
1570 BCP Tohickon Post	16	506.3	31.64

H statistic: 2.18
 X² approximation: 2.18
 DF: 1
 p-value: 0.1399¹

H0: $\theta_1 = \theta_2 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.

¹ Do not reject the null hypothesis at the 5% significance level.

Insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions. Post-EWQ median concentrations fell below the EWQ lower 95% confidence interval, but the data were naturally variable and post-EWQ N was low so no real change occurred. Note that concentrations and flows are plotted on a logarithmic scale.

Chapter 9: 1570 BCP Tohickon Creek, PA

Hardness as CaCO₃, Total mg/l

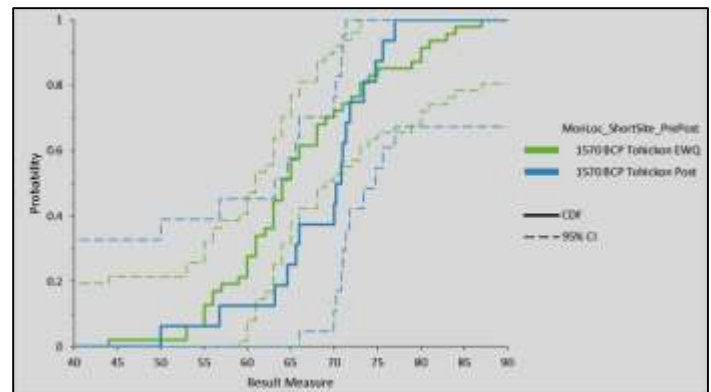
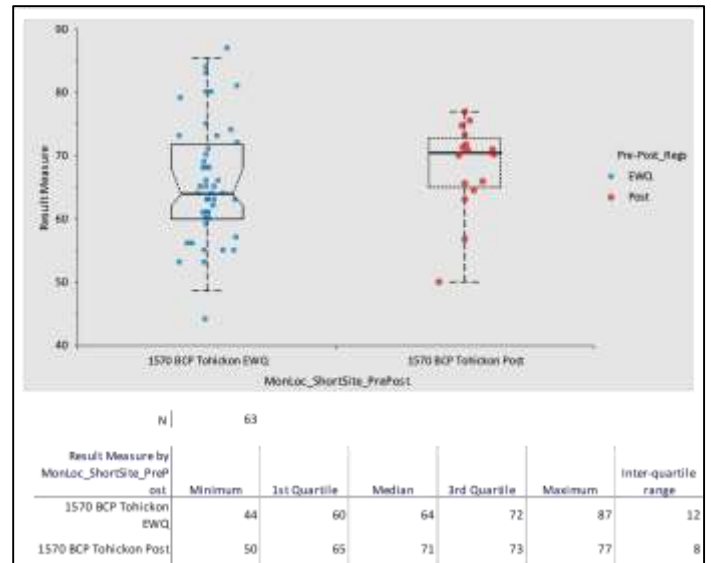
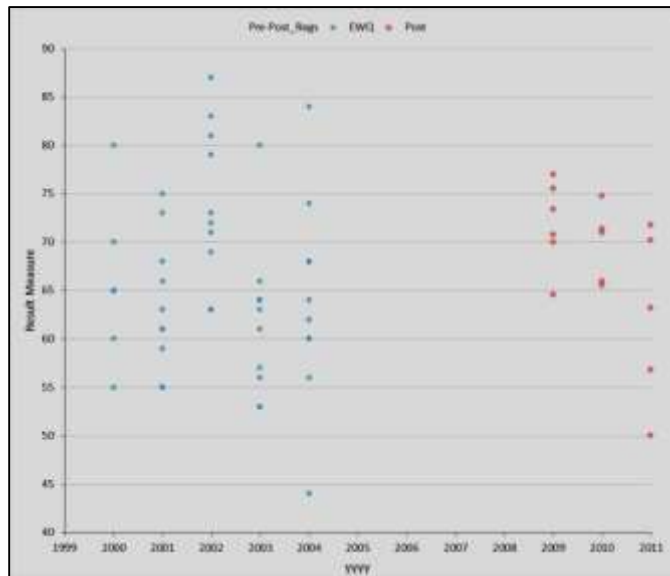
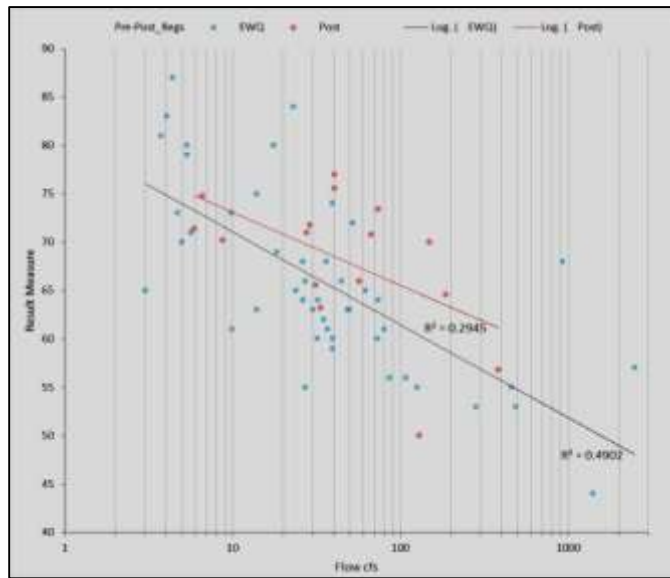
Existing Water Quality (Table 2R):

Median 64 mg/l

Lower 95% Confidence Interval 62 mg/l

Upper 95% Confidence Interval 68 mg/l

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	196.1	4.17
1570 BCP Tohickon Post	16	576.0	36.00

H statistic	2.30
χ^2 approximation	2.30
DF	1
p-value	0.1293 ¹

H₀: $\theta_1 = \theta_2 = 0...$
 The median of the populations are all equal.
 H₁: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was above the EWQ upper 95% confidence interval, but the increase was not significant because too few post-EWQ samples were taken (n=16) to be able to distinguish a real difference between the two periods. Note that flows are plotted on a logarithmic scale.

Chapter 9: 1570 BCP Tohickon Creek, PA

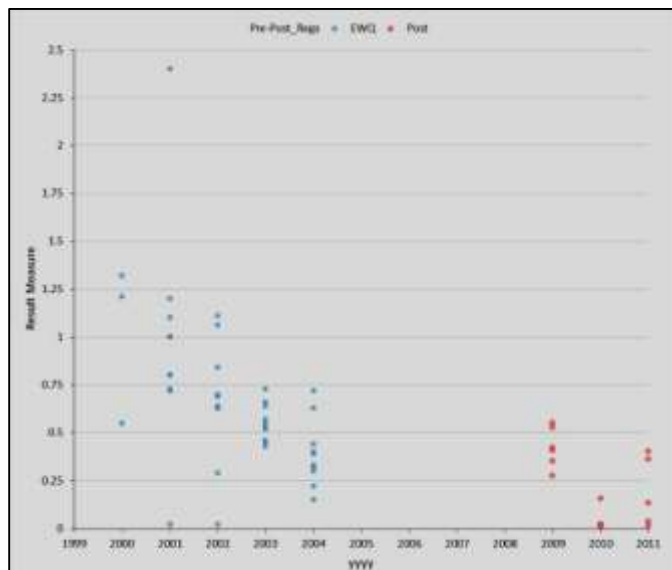
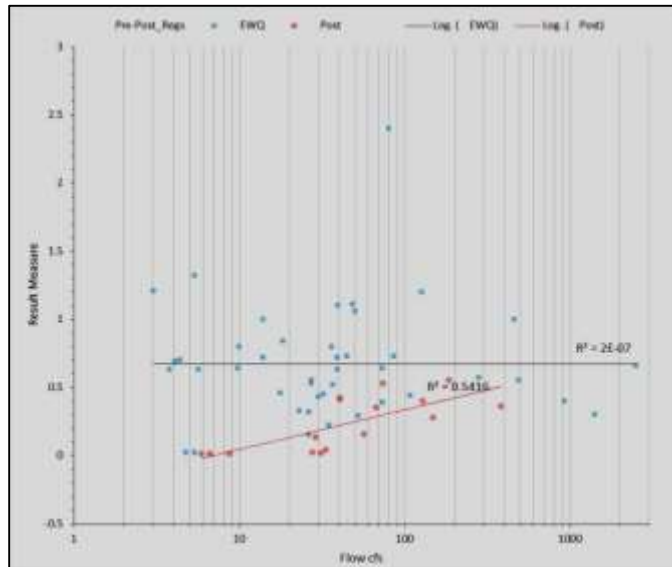
Nitrate + Nitrite as N, Total mg/l

Existing Water Quality (Table 2R, as Nitrate only):

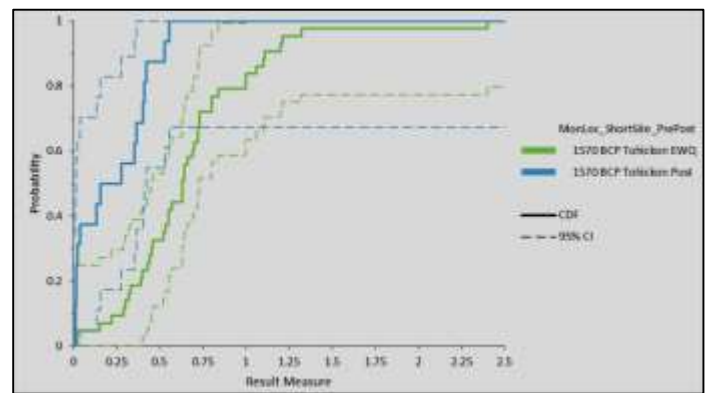
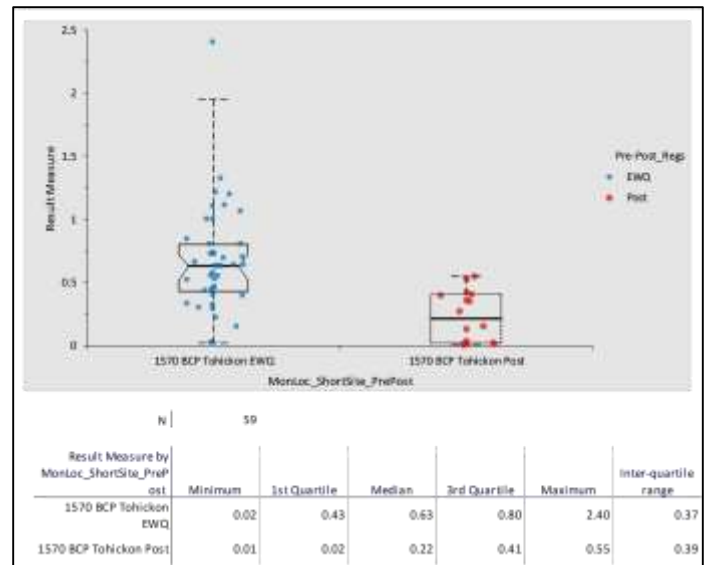
Median 0.63 mg/l

Lower 95% Confidence Interval 0.52 mg/l

Upper 95% Confidence Interval 0.72 mg/l



No water quality degradation is evident. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions. Nitrate is unrelated related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	43	1476.8	34.35
1570 BCP Tohickon Post	16	3969.0	248.06

H statistic: 18.47
 X² approximation: 18.47
 DF: 1
 p-value: <0.0001¹
 H0: θ₁ = θ₂ = θ...
 The median of the populations are all equal.
 H1: θ_i ≠ θ_j for at least one i, j
 The median of the populations are not all equal.
¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Note that flows are plotted on a logarithmic scale. Independent data were not available for validation of the apparent decline. Tohickon Creek possesses the lowest nitrate + nitrite concentrations among all of the tributaries to the Lower Delaware. This is probably due to sequestration of nutrients by Lake Nockamixon, which is located well upstream of the sampling site.

Chapter 9: 1570 BCP Tohickon Creek, PA

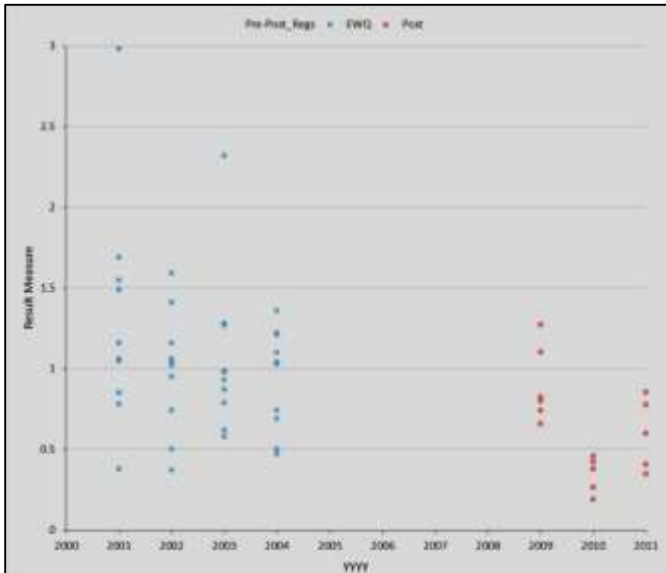
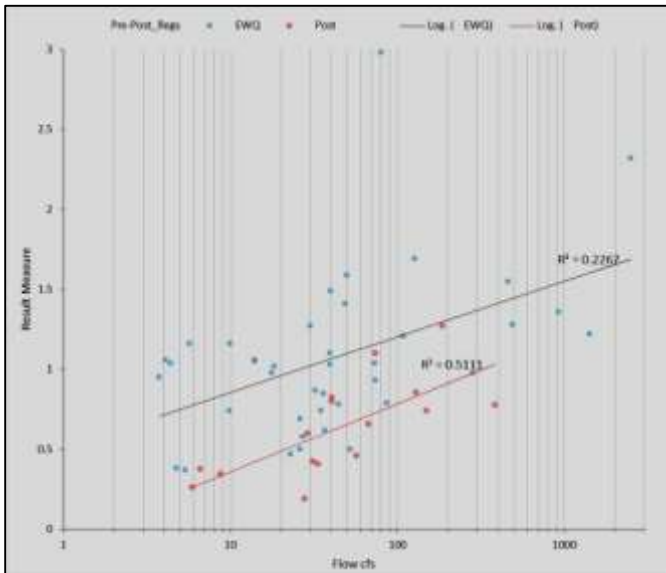
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2R):

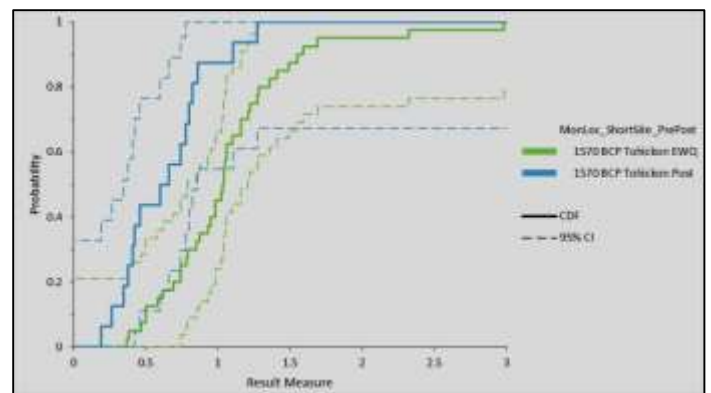
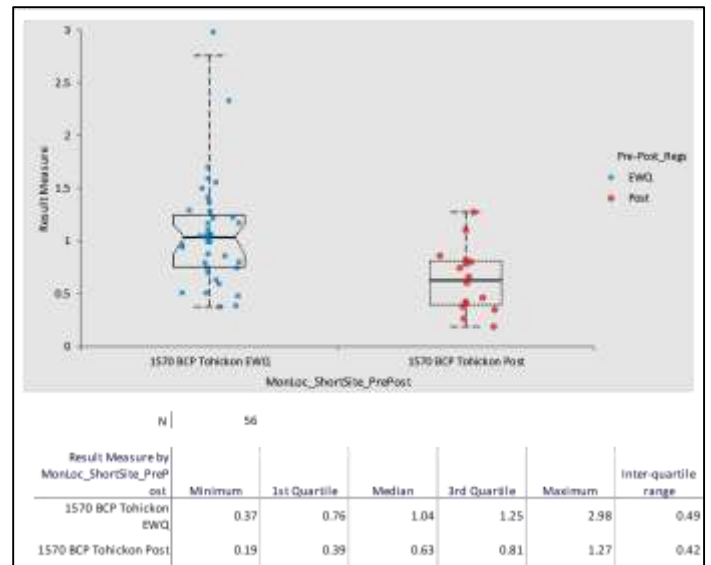
Median 1.03 mg/l

Lower 95% Confidence Interval 0.87 mg/l

Upper 95% Confidence Interval 1.16 mg/l



No water quality degradation is evident. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	864.9	21.62
1570 BCP Tohickon Post	16	2162.3	135.14

H statistic 11.38
 X² approximation 11.38
 DF 1
 p-value 0.0007¹

H0: $\theta_1 = \theta_2 = 0...$

The median of the populations are all equal.

H1: $\theta_i \neq \theta_j$ for at least one i,j

The median of the populations are not all equal.

¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

TN is positively related to flow in both data sets, though weakly so in the EWQ data set. Note that flows are plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell well below the EWQ lower 95% confidence interval.

Chapter 9: 1570 BCP Tohickon Creek, PA

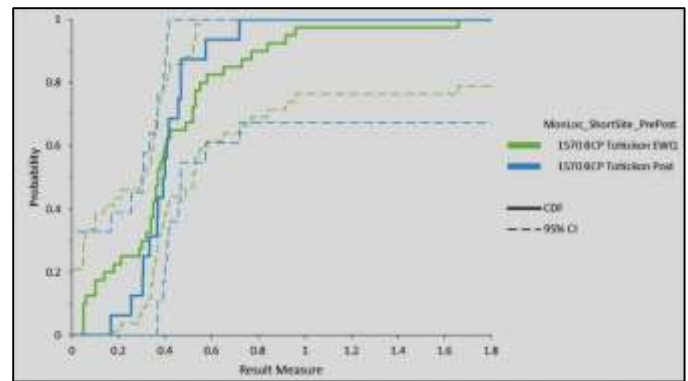
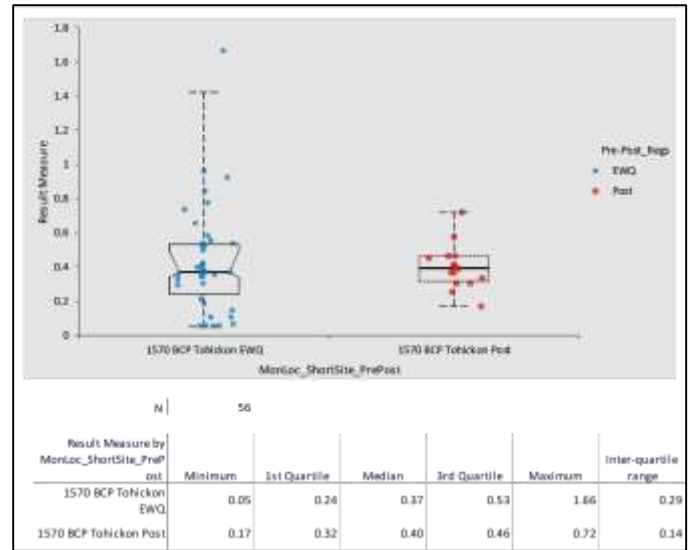
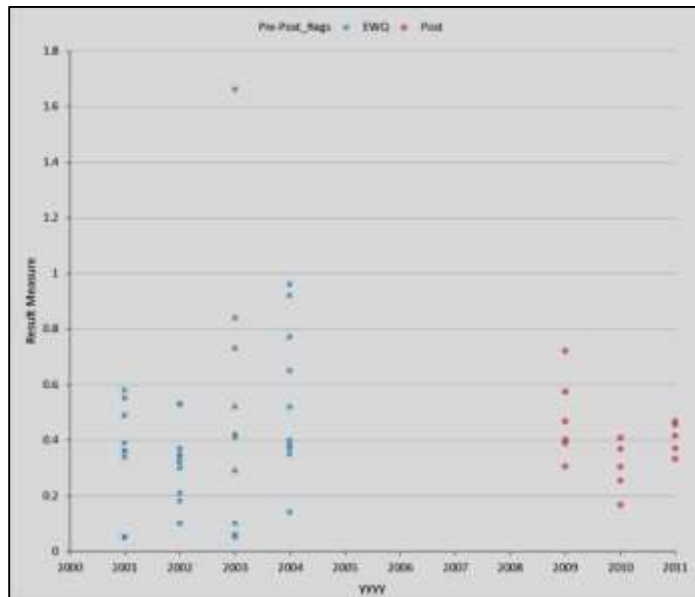
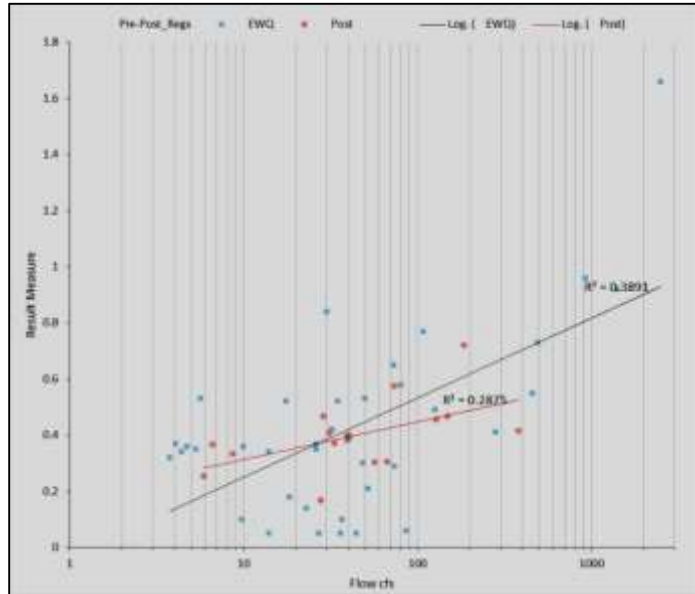
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2R):

Median 0.37 mg/l

Lower 95% Confidence Interval 0.34 mg/l

Upper 95% Confidence Interval 0.49 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	5.6	0.14
1570 BCP Tohickon Post	16	14.1	0.88

H statistic	0.07
X ² approximation	0.07
DF	1
p-value	0.7855 ¹

H0: $\theta_1 = \theta_2 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. TKN concentrations did not measurably change between the EWQ and post-EWQ periods. TKN concentration is related to flow in both data sets, though more weakly related in the post-EWQ data set, which is probably due to fewer samples (n=16). TKN ranges less widely and is less variable in the post-EWQ data set, though this pattern may be attributable to laboratory artifacts. Note that flows are plotted on a logarithmic scale. Post-EWQ median TKN was within the EWQ 95% confidence intervals.

Chapter 9: 1570 BCP Tohickon Creek, PA

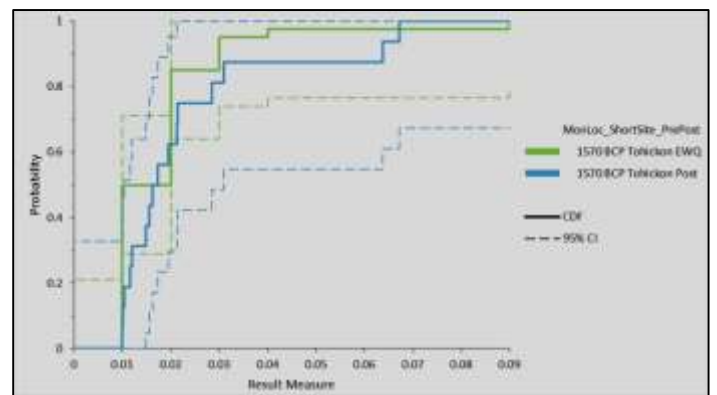
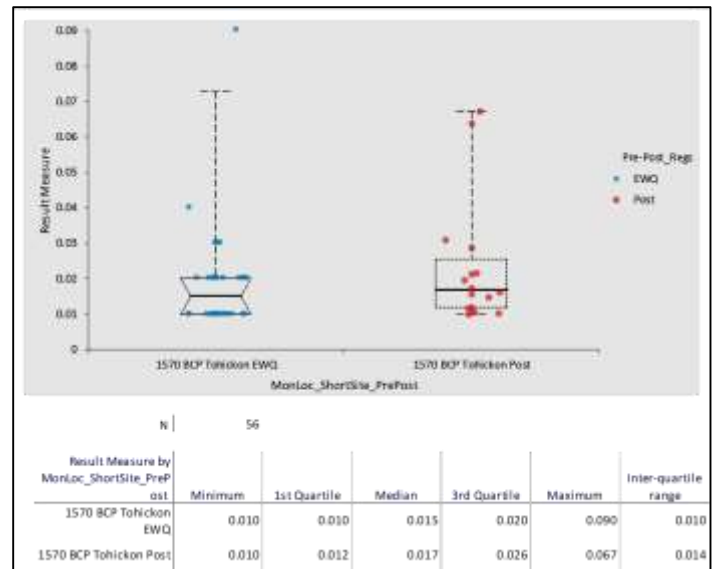
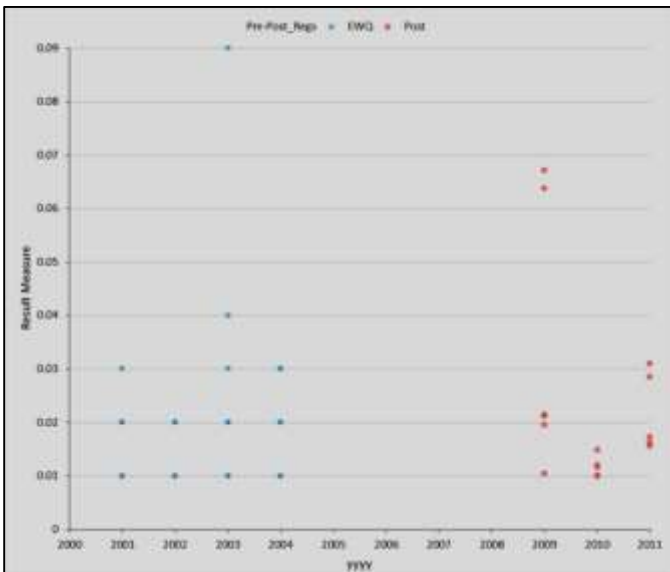
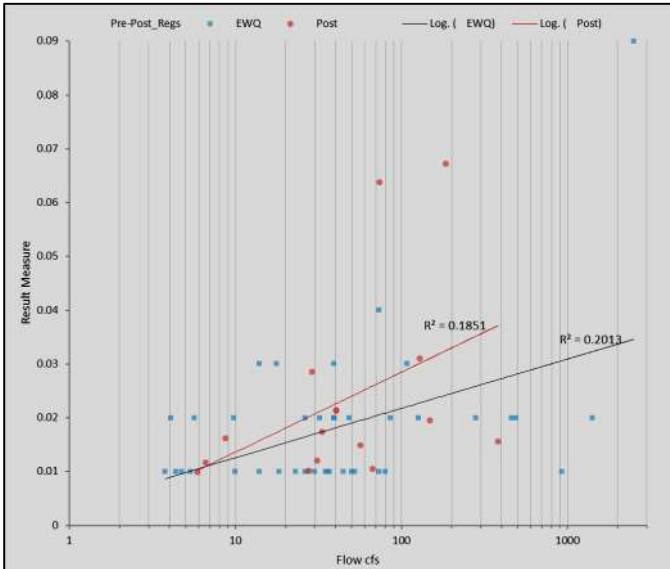
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2R):

Median 0.015 mg/l

Lower 95% Confidence Interval 0.010 mg/l

Upper 95% Confidence Interval 0.020 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	152.1	3.80
1570 BCP Tohickon Post	16	380.3	23.77

H statistic: 2.13
 X² approximation: 2.13
 DF: 1
 p-value: 0.1442¹

H0: $\theta_1 = \theta_2 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j.
 The median of the populations are not all equal.

¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Orthophosphate concentrations did not change between the EWQ and post-EWQ periods. Detection limit differences, laboratory artifacts, and insufficient sampling frequency introduced uncertainty into conclusions.

Orthophosphate is very weakly related to flow in both data sets. Post-EWQ median orthophosphate was within the EWQ 95% confidence intervals. The post-EWQ data describe actually orthophosphate concentrations better than the EWQ data, which had 12 non-detect results. There were no undetected results in the post-EWQ data, as detection limits were lower in that data set. There were no independent data to confirm DRBC results.

Chapter 9: 1570 BCP Tohickon Creek, PA

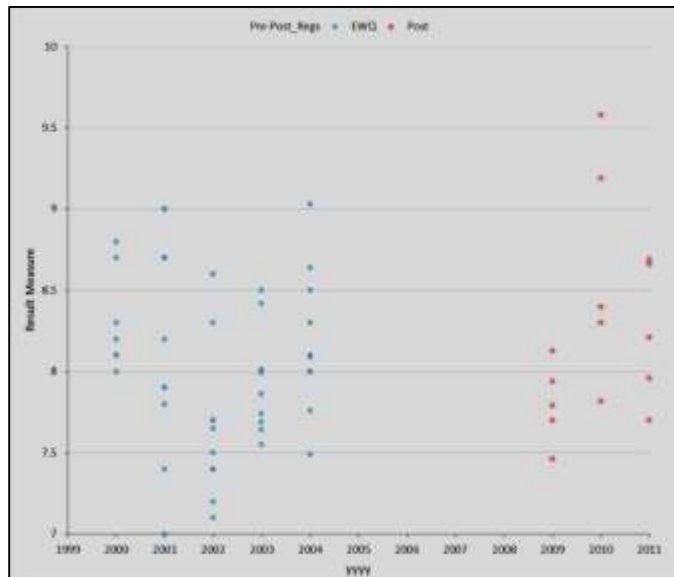
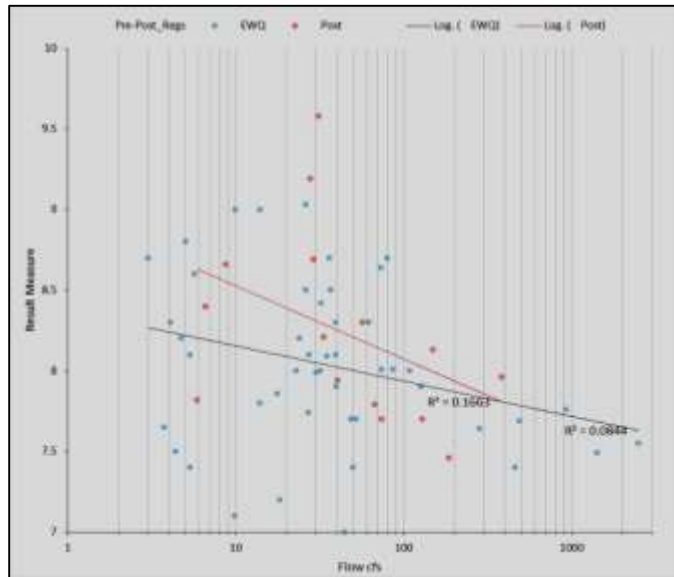
pH, units

Existing Water Quality (Table 2R):

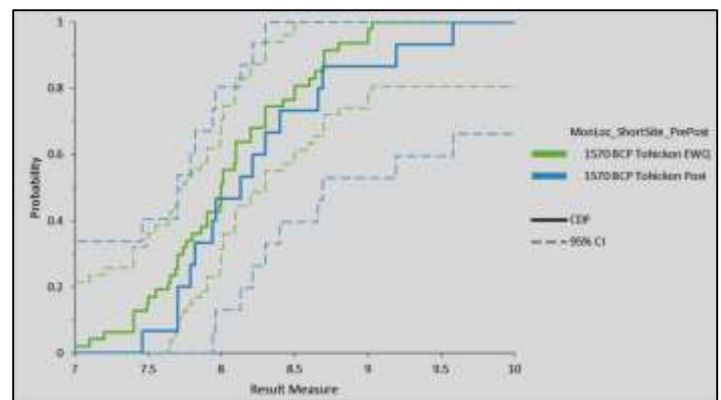
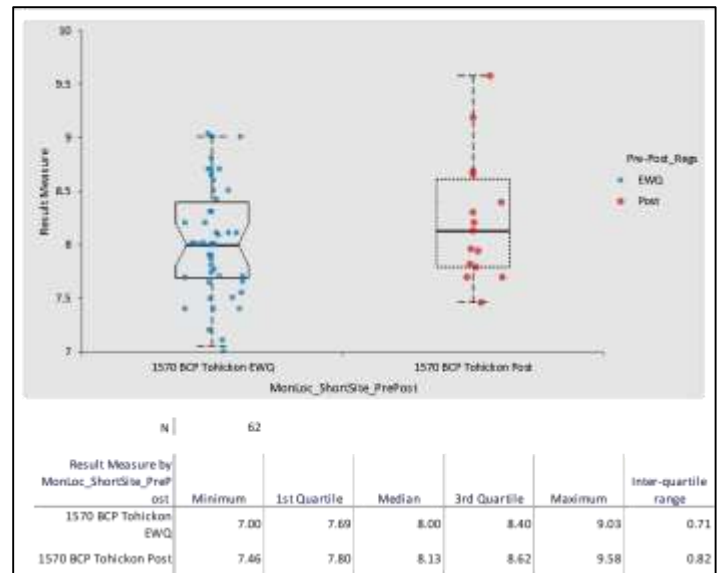
Median 8.00 standard units

Lower 95% Confidence Interval 7.80 standard units

Upper 95% Confidence Interval 8.20 standard units



No water quality degradation is evident. pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in both data sets, but tends toward neutral during higher flow conditions. Post-EWQ median pH was within the EWQ 95% confidence intervals.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	69.1	1.47
1570 BCP Tohickon Post	15	216.6	14.44

H statistic: 0.88
 X² approximation: 0.88
 DF: 1
 p-value: 0.3486¹

H0: $\theta_1 = \theta_2 = \theta_3$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

pH is a bit higher in Tohickon Creek compared to other Delaware River tributaries, which is not surprising given that the Tohickon Creek is more wide, shallow and exposed to sunlight than other tributaries. Algal productivity is high in Tohickon Creek, and in the dry year of 2010 there were two sample results over pH 9.

Chapter 9: 1570 BCP Tohickon Creek, PA

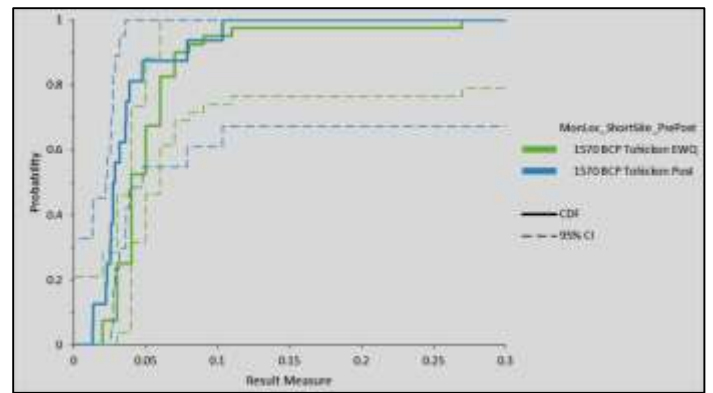
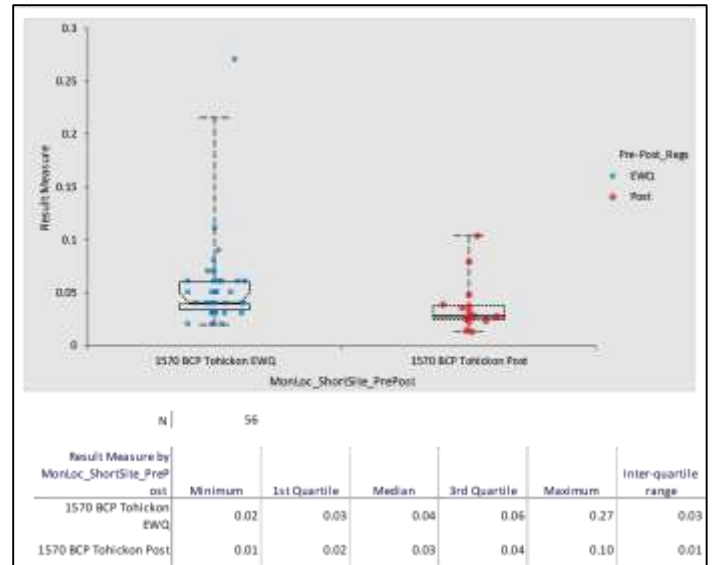
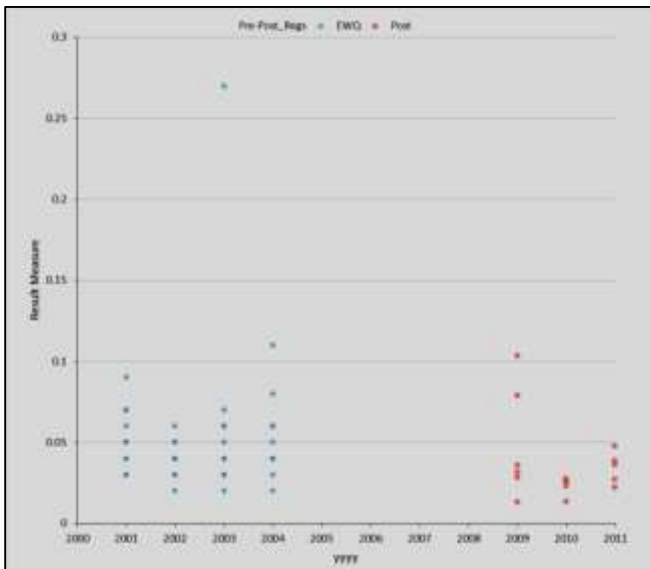
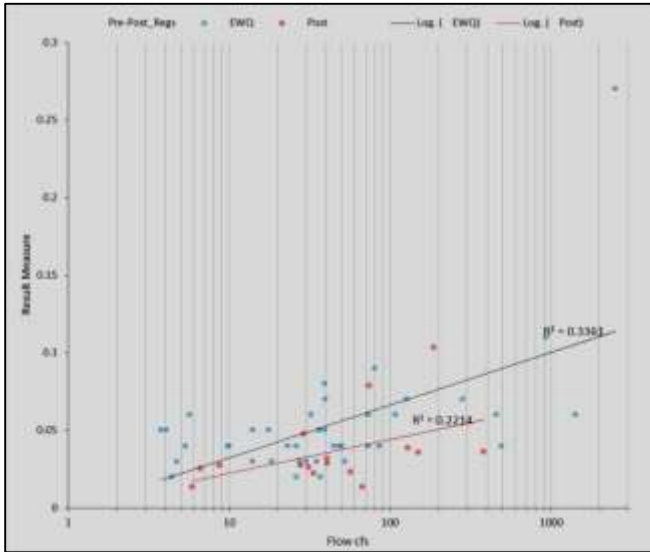
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2R):

Median 0.04 mg/l

Lower 95% Confidence Interval 0.04 mg/l

Upper 95% Confidence Interval 0.05 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	672.4	16.81
1570 BCP Tohickon Post	16	1681.0	105.06

H statistic	8.96
X ² approximation	8.96
DF	1
p-value	0.0028 ¹

H0: $\theta_1 = \theta_2 = 0...$

The median of the populations are all equal.

H1: $\theta_i \neq \theta_j$ for at least one i,j

The median of the populations are not all equal.

¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

No water quality degradation is evident. Total Phosphorus (TP) apparently declined between the EWQ and post-EWQ periods. However, insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. In EWQ data the relationship to flow appears stronger, but the regression is skewed by a single high outlier sample taken in August 2003. No independent data were available to confirm these results.

Chapter 9: 1570 BCP Tohickon Creek, PA

Specific Conductance $\mu\text{mho/cm}$

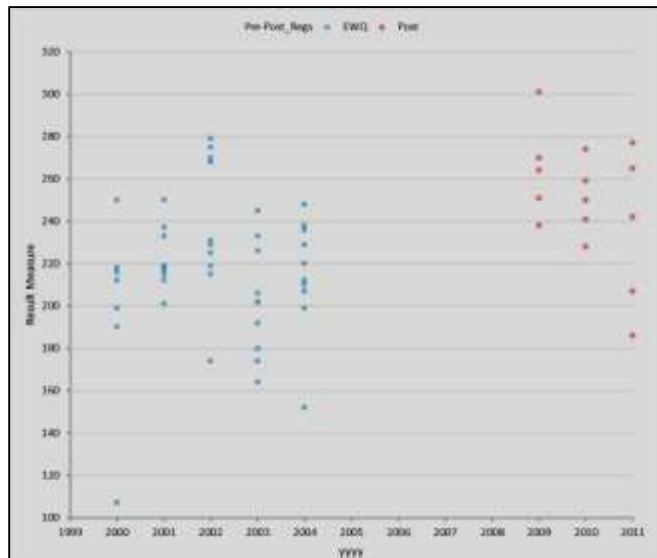
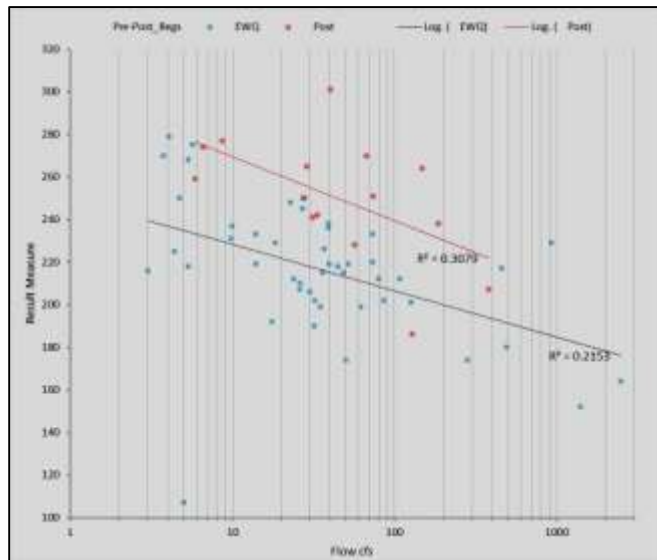
Existing Water Quality (Table 2R):

Median 218 $\mu\text{mho/cm}$

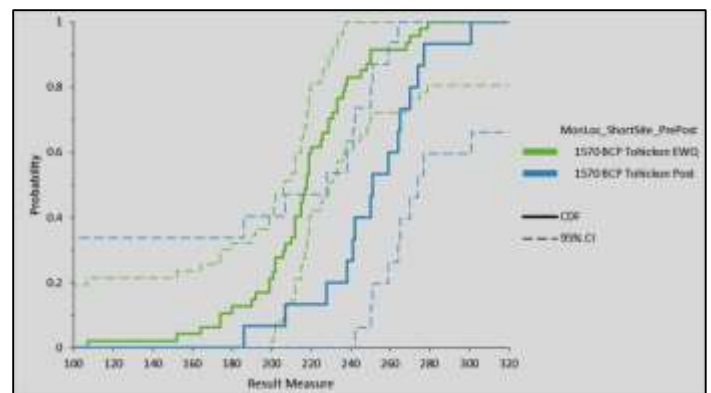
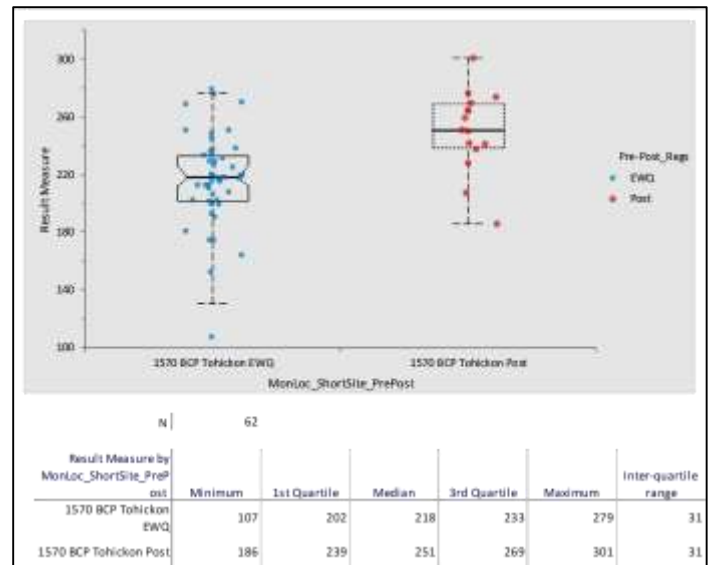
Lower 95% Confidence Interval 212 $\mu\text{mho/cm}$

Upper 95% Confidence Interval 226 $\mu\text{mho/cm}$

Defined in regulations as a flow-related parameter



Water quality degradation is indicated here. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. Specific conductance is weakly and inversely related to flow in both data sets.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	956.3	20.35
1570 BCP Tohickon Post	15	2996.3	199.75

H statistic	12.15
X ² approximation	12.15
DF	1
p-value	0.0005 ¹

H0: $\theta_1 = \theta_2 = 0...$

The median of the populations are all equal.

H1: $\theta_i \neq \theta_j$ for at least one i, j

The median of the populations are not all equal.

¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

Specific conductance was defined as a flow-related parameter in the EWQ data set (DRBC water quality regulations Table 2R), even though the relationship was very weak at this site. Post-EWQ sampling frequency was insufficient. Rising specific conductance may be attributable to the concurrent rise in chloride concentrations. In this Wild and Scenic designated stream, median specific conductance has risen from 218 to 251 $\mu\text{mho/cm}$, a 15% increase over a short time period.

Chapter 9: 1570 BCP Tohickon Creek, PA

Total Dissolved Solids (TDS) mg/l

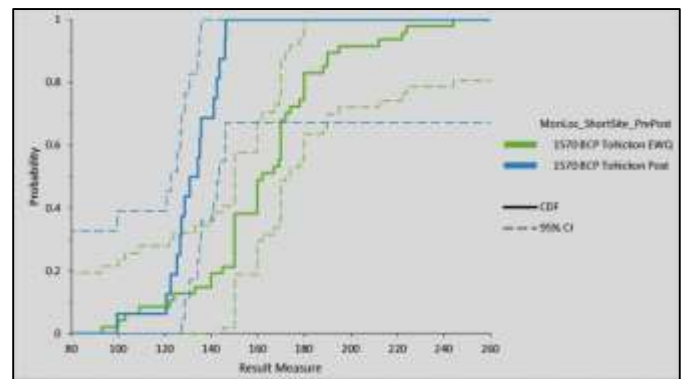
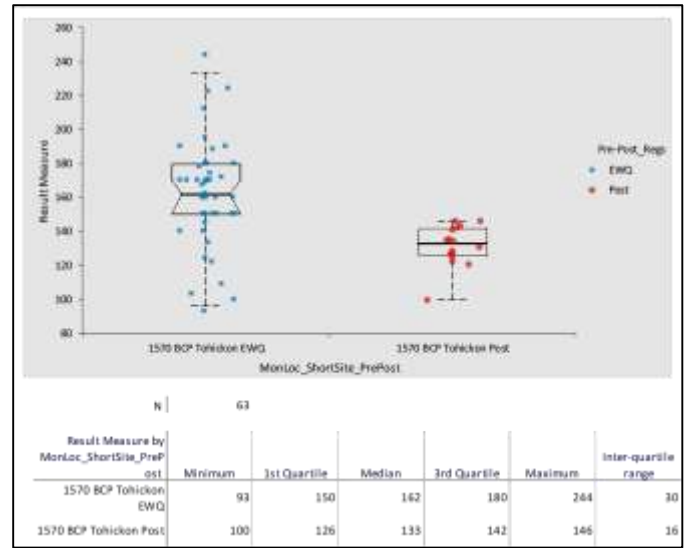
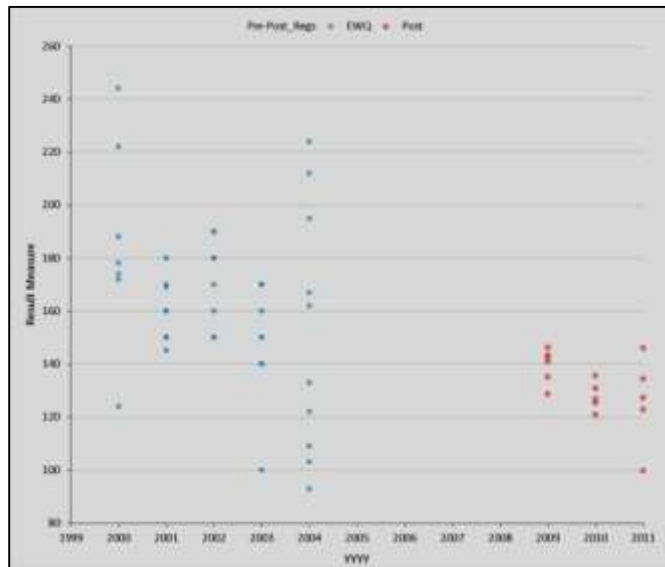
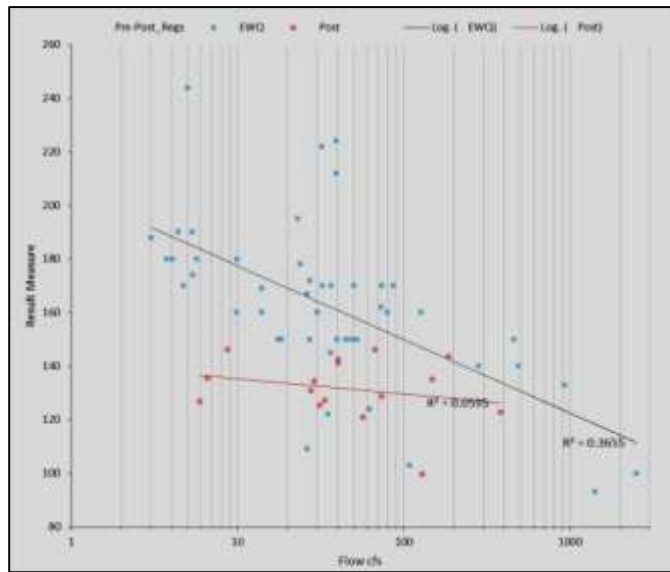
Existing Water Quality (Table 2R):

Median 162 mg/l

Lower 95% Confidence Interval 150 mg/l

Upper 95% Confidence Interval 170 mg/l

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	1528.2	32.51
1570 BCP Tohickon Post	16	4489.0	280.56

H statistic 17.97
 X² approximation 17.97
 DF 1
 p-value <0.0001¹

H0: $\theta_1 = \theta_2 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.

¹ Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

No water quality degradation is evident. TDS apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions. TDS is inversely related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time.

Chapter 9: 1570 BCP Tohickon Creek, PA

Total Suspended Solids (TSS) mg/l

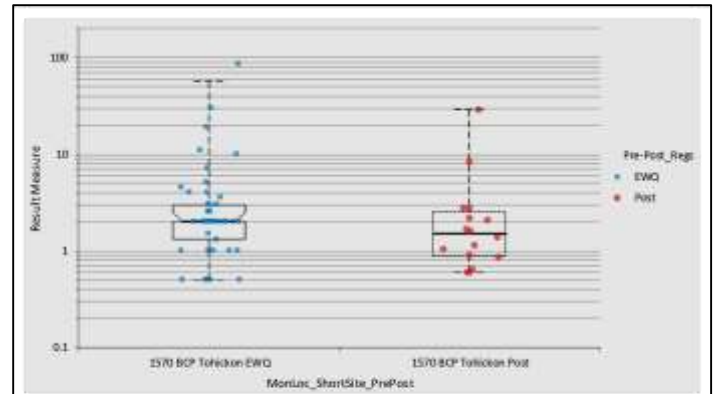
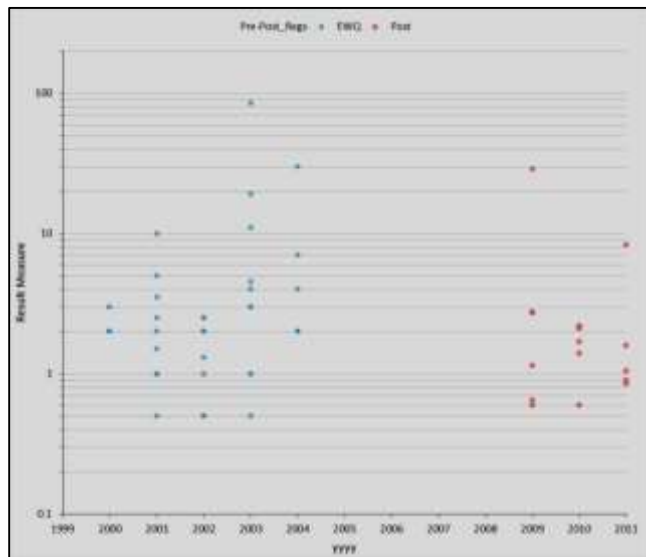
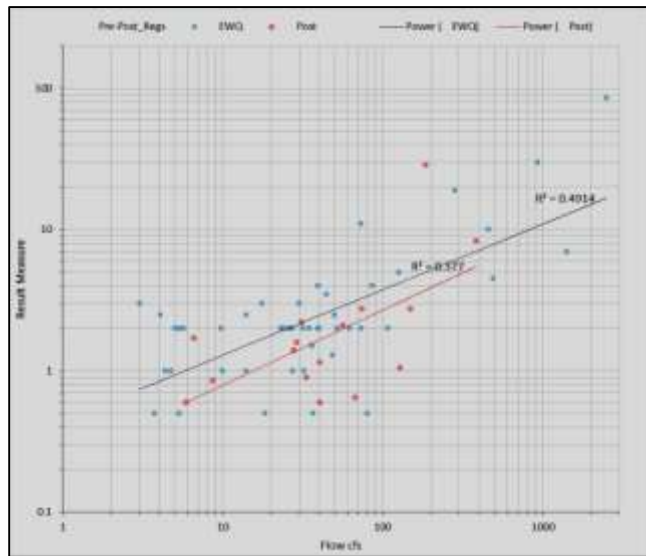
Existing Water Quality (Table 2R):

Median 2.0 mg/l*

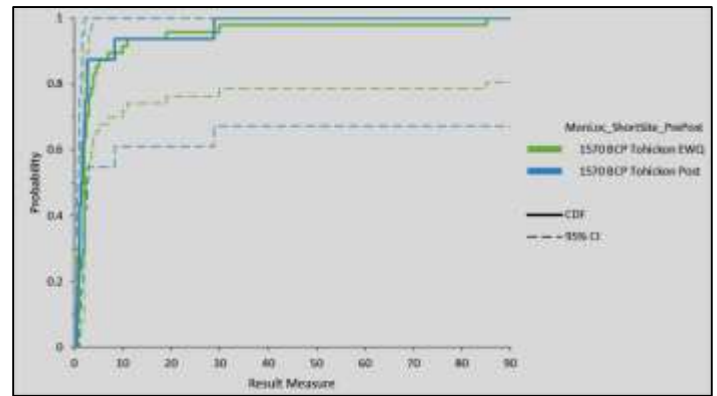
Lower 95% Confidence Interval 1.0 mg/l

Upper 95% Confidence Interval 2.5 mg/l

*Should have been designated in rules as flow-related



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.50	1.33	2.00	3.00	85.00	1.67
1570 BCP Tohickon Post	0.60	0.87	1.50	2.52	28.80	1.65



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	129.4	2.75
1570 BCP Tohickon Post	16	380.3	23.77

H statistic	1.55
X ² approximation	1.55
DF	1
p-value	0.2132 ¹

H0: $\theta_1 = \theta_2 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is positively related to flow in both data sets. Post-EWQ median TSS was within the EWQ 95% confidence intervals. Note that both flow and concentration are plotted on a logarithmic scale.

Note: In the DRBC water quality regulations Table 2R, TSS should have been designated as a flow-related parameter for Tohickon Creek.

Chapter 9: 1570 BCP Tohickon Creek, PA

Turbidity NTU

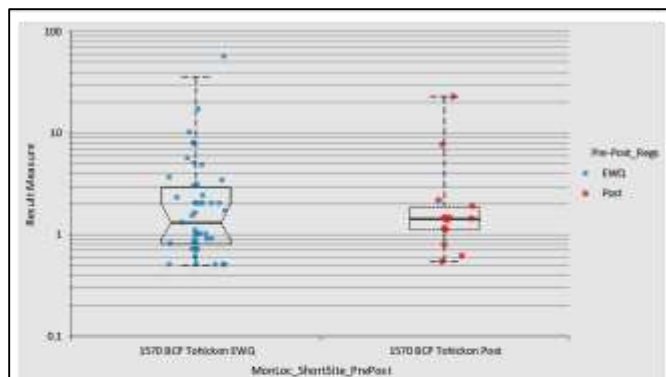
Existing Water Quality (Table 2R):

Median 1.3 NTU

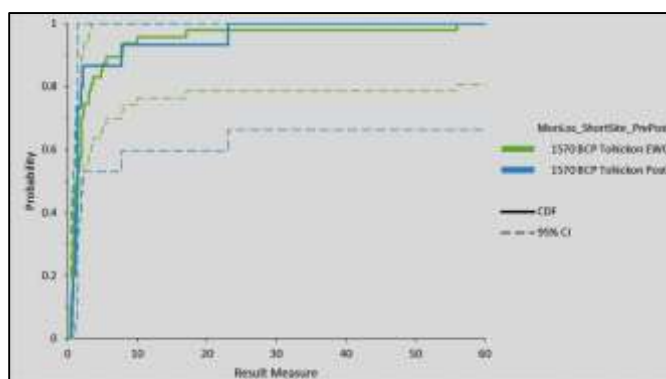
Lower 95% Confidence Interval 0.9 NTU

Upper 95% Confidence Interval 2.0 NTU

Defined in regulations as a flow-related parameter



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.5	0.8	1.3	2.9	56.0	2.1
1570 BCP Tohickon Post	0.6	1.1	1.4	1.9	25.1	0.7



Kruskal-Wallis test

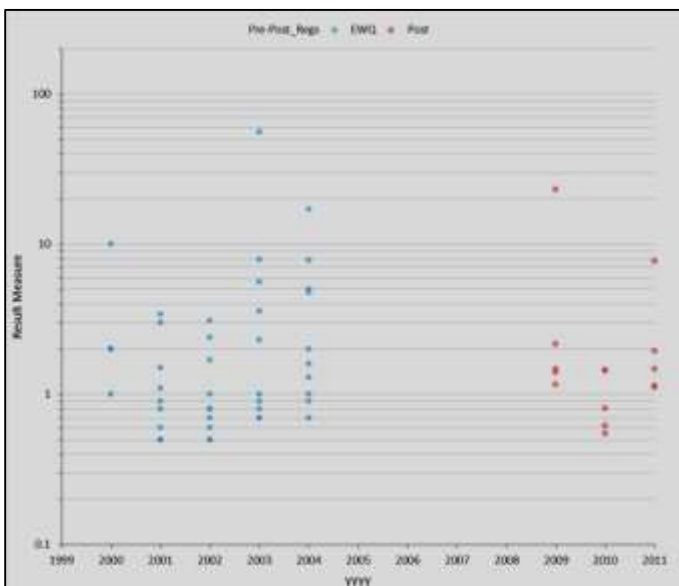
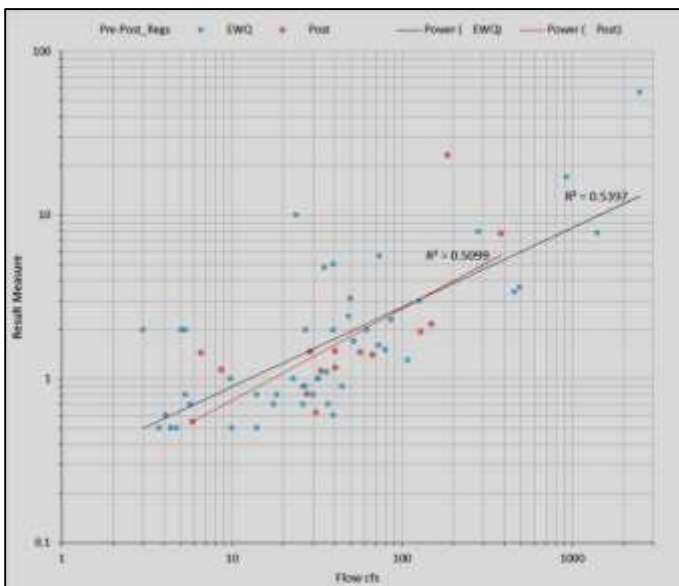
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	2.8	0.06
1570 BCP Tohickon Post	15	8.8	0.59

H statistic | 0.04
 X² approximation | 0.04
 DF | 1
 p-value | 0.8499¹

H0: $\theta_1 = \theta_2 = \theta_3 \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i, j
 The median of the populations are not all equal.

¹ Do not reject the null hypothesis at the 5% significance level.

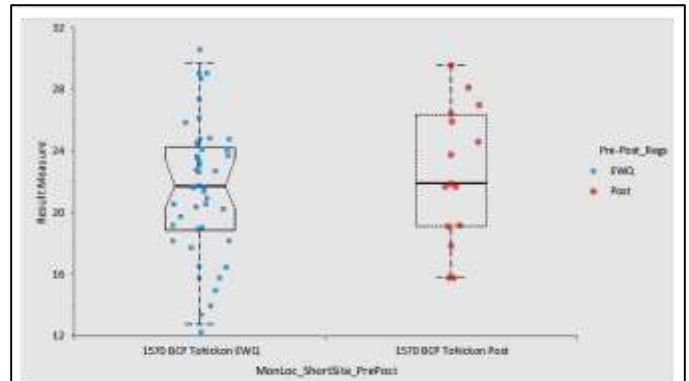
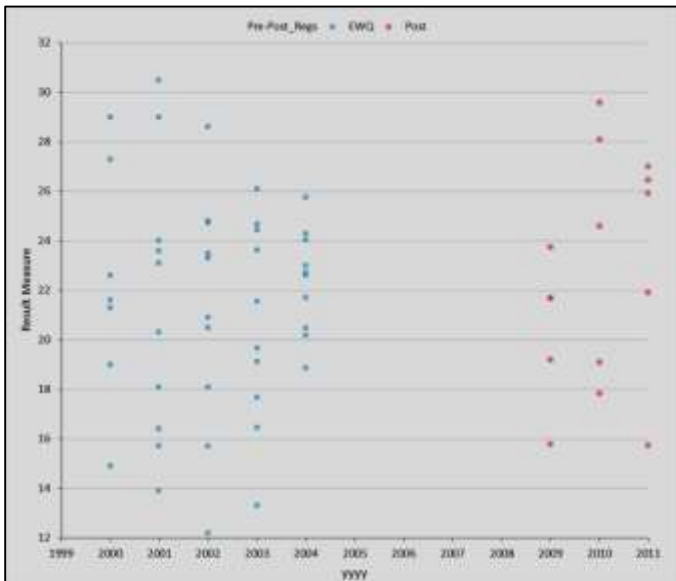
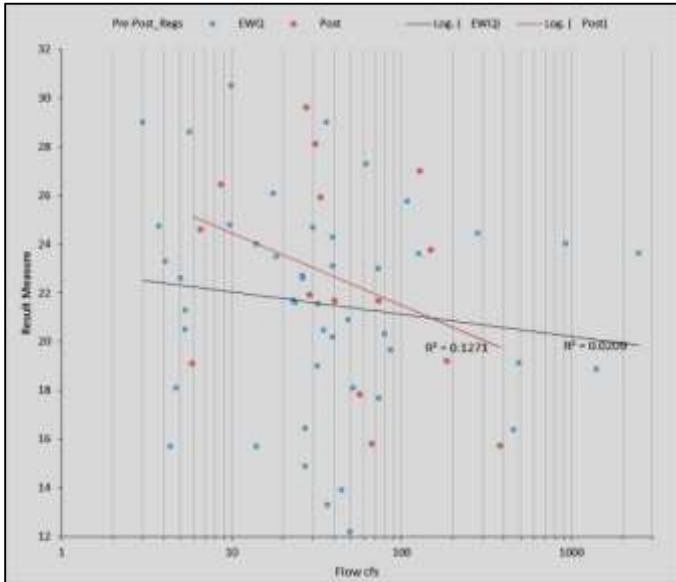
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is related to flow in both data sets. Note that concentration and flow is represented on logarithmic scale.



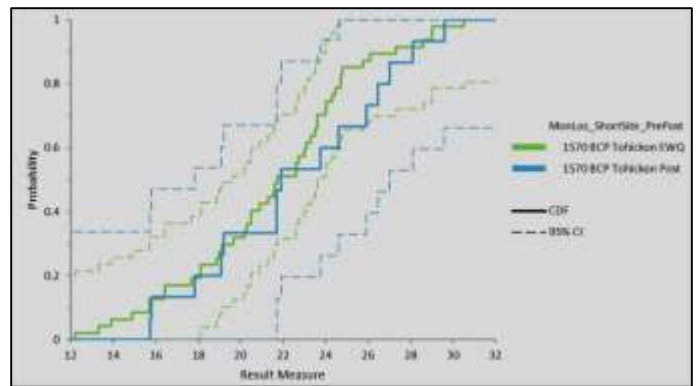
Chapter 9: 1570 BCP Tohickon Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	12.2	18.9	21.7	24.2	30.5	5.4
1570 BCP Tohickon Post	15.7	19.1	21.9	26.4	29.6	7.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	52.1	1.11
1570 BCP Tohickon Post	15	163.4	10.89

H statistic 0.66
 X² approximation 0.66
 DF 1
 p-value 0.4158¹
 H0: $\theta_1 = \theta_2 = \theta_3$...
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale.