

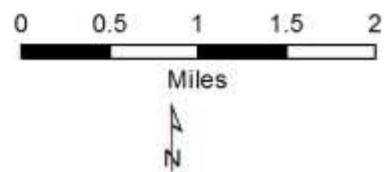
Chapter 15: 1748 ICP Delaware River at Riegelsville



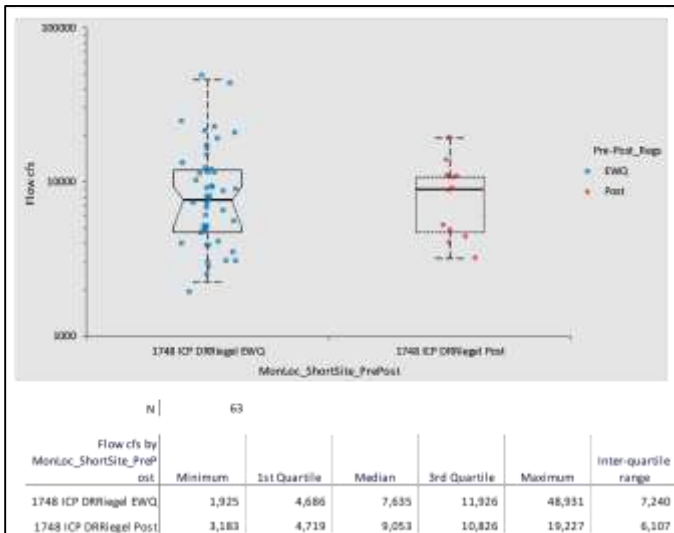
1748 ICP
Delaware River at Riegelsville Bridge



- Sampling Location
- - - County Boundary



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



Flow was roughly the same between the EWQ and post-EWQ periods. Too few samples were collected in the post-EWQ period (n=13) for confident statistical comparisons. The range of flow conditions sampled was wider in the EWQ period, and the EWQ data represented the full range of flow conditions better than the post-EWQ data.

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRIegel EWQ	50	2.9	0.06
1748 ICP DRRIegel Post	13	11.1	0.85

H statistic	0.04
X ² approximation	0.04
DF	1
p-value	0.8385 ¹

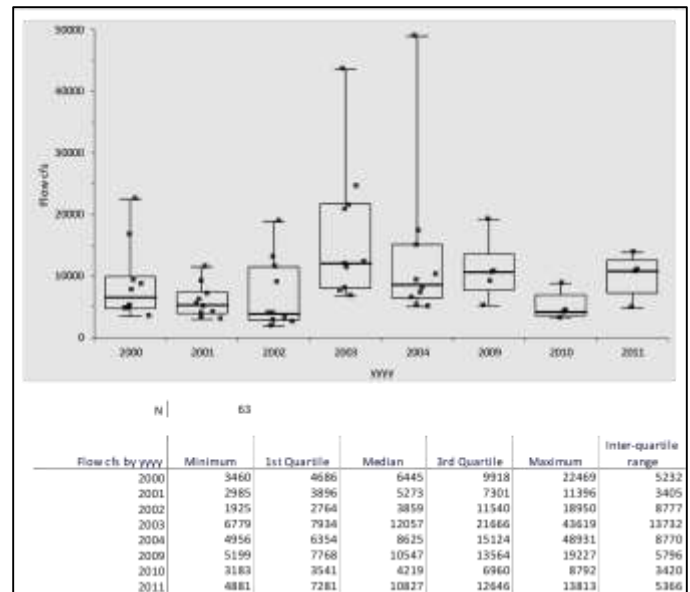
H0: $\theta_1 = \theta_2 = \theta_3 = \dots$
 The median of the populations are all equal.
 H1: $\theta_i \neq \theta_j$ for at least one i,j
 The median of the populations are not all equal.
¹ Do not reject the null hypothesis at the 5% significance level.

Upstream ICP: Delaware River at Easton 1838 ICP
 Downstream ICP: Delaware River at Milford 1677 ICP

Tributary BCP Watersheds in Upstream Reach:

- Lehigh River, PA – 1837 BCP
- Lopatcong Creek, NJ – 1820 BCP (see Appendix A)
- Pohatcong Creek, NJ – 1774 BCP

All other tributaries are less than 20 square miles drainage area and have little effect upon the Delaware River.



Annual May to September flow statistics associated with water quality measurements are plotted above. These are flow measurements or sometimes estimates associated with the time of each water quality sample. Mean annual flow is about 9,000 cfs; and harmonic mean flow is about 5,000 cfs which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were calculated using instantaneous water stage data from the USGS gage No. 01457500 on the Delaware River at Riegelsville.

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Alkalinity as CaCO₃, Total mg/l

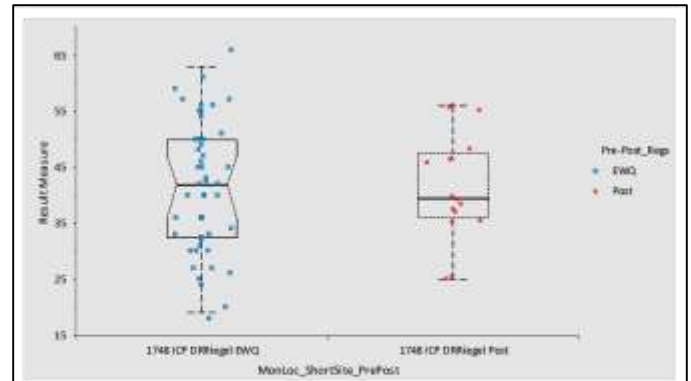
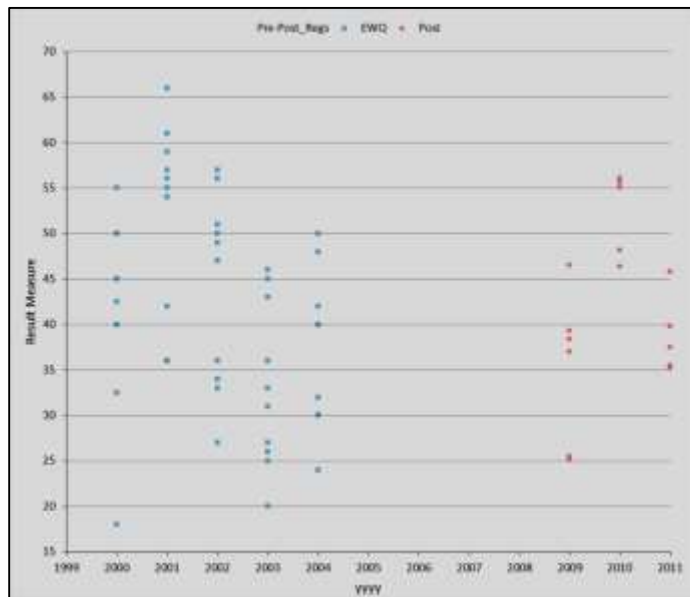
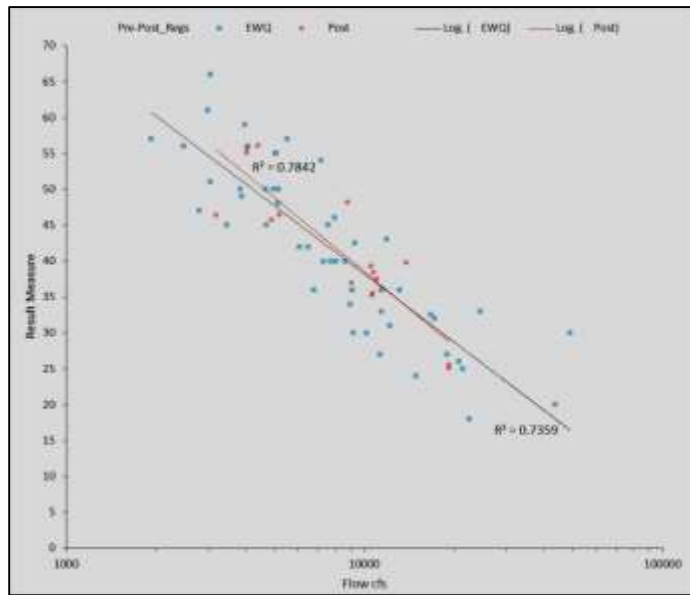
Existing Water Quality (Table 2L):

Median 42 mg/l

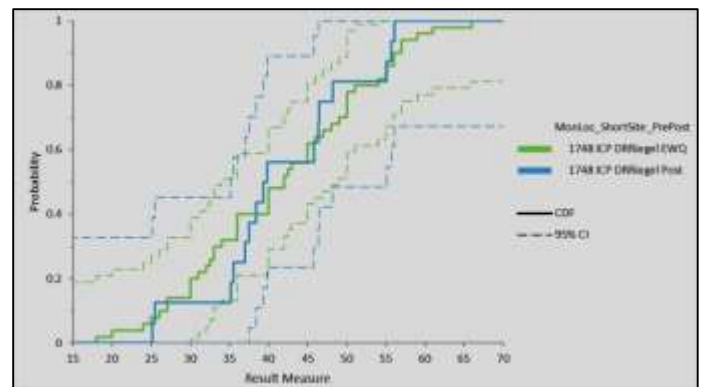
Lower 95% Confidence Interval 36 mg/l

Upper 95% Confidence Interval 48 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
1748 ICP DRRiegel EWQ	18	32	42	50	66	18
1748 ICP DRRiegel Post	25	36	40	47	56	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	0.0	0.00
1748 ICP DRRiegel Post	16	0.0	0.00

H statistic 0.00
 X² approximation 0.00
 DF 1
 p-value 1.0000¹
 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 Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. 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. One outlier value of 180 mg/l was removed from the data set (sample taken 5/22/2000). The full flow regime was not well-represented in the post-EWQ data set, as noted by the short regression line in the flow vs. concentration plot.

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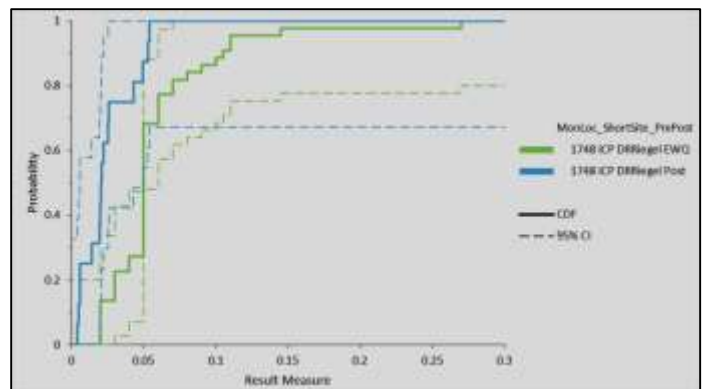
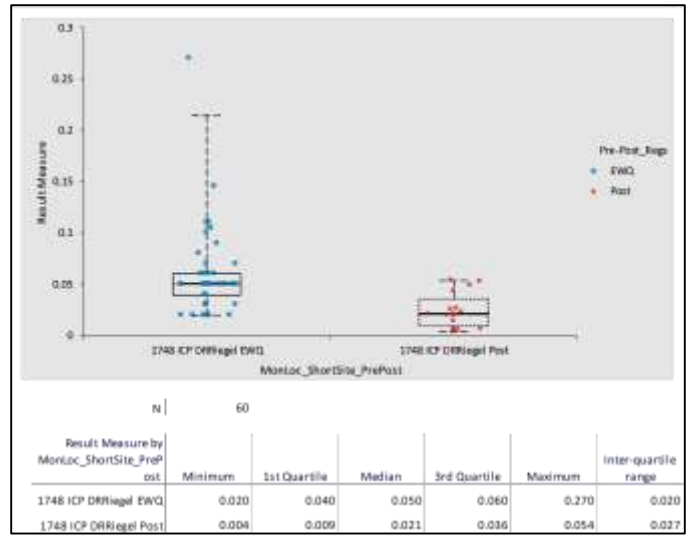
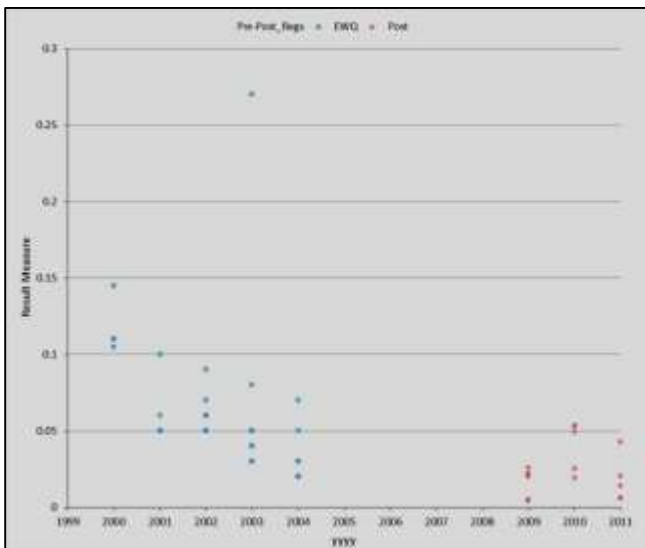
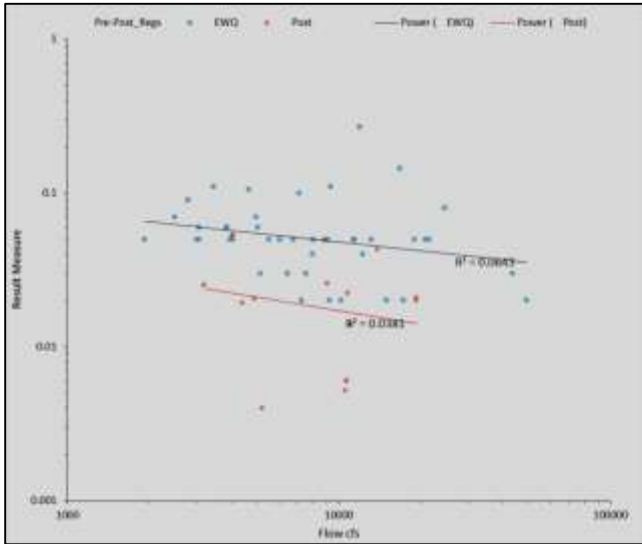
Ammonia Nitrogen as N, Total mg/l

Existing Water Quality (Table 2L):

Median <0.05 mg/l

Lower 95% Confidence Interval <0.05 mg/l

Upper 95% Confidence Interval 0.05 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	44	1255.1	28.53
1748 ICP DRRiegel Post	16	3451.6	215.72

H statistic	15.90
X ² approximation	15.90
DF	1
p-value	<0.0001 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 Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

No water quality degradation is evident here. Ammonia concentrations apparently declined. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.

Too few independent data were available to validate these results. Flow and concentration are plotted on a logarithmic scale. DRBC’s post-EWQ detection limit (0.004-0.006 mg/l) was much lower than during the EWQ period (0.02-0.05 mg/l). EWQ data included 29/44 undetected results, interfering with calculation of the median. Under 2009-2011 lower detection levels, there were 3/16 undetected results. So rather than a real change in ambient concentrations it is likely that we are now able to measure actual low-level concentrations. Evidence of possible water quality improvement is that post-EWQ DRBC and USGS data contained no concentrations higher than 0.054 mg/l.

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Chloride, Total mg/l

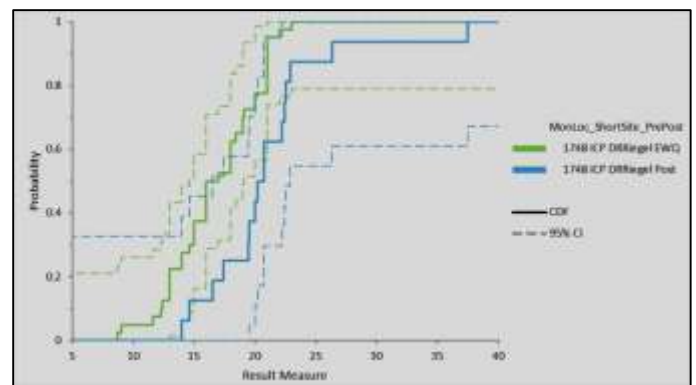
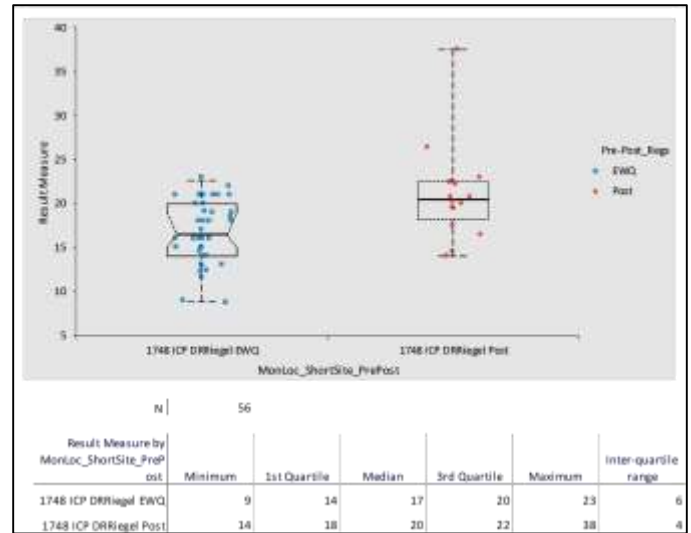
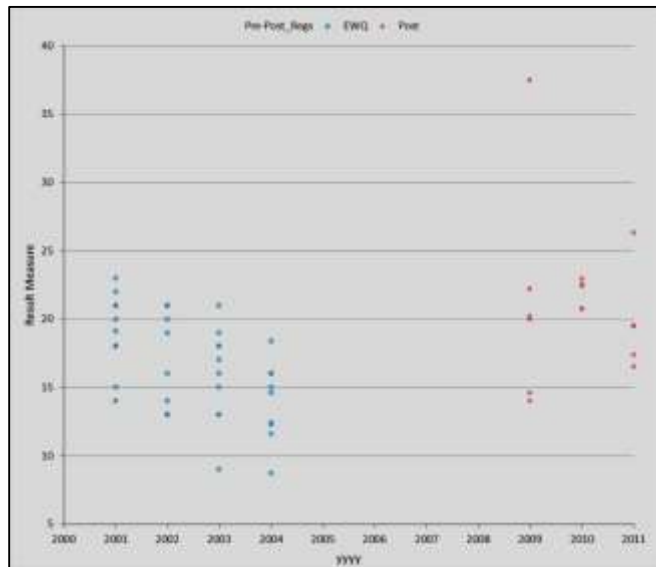
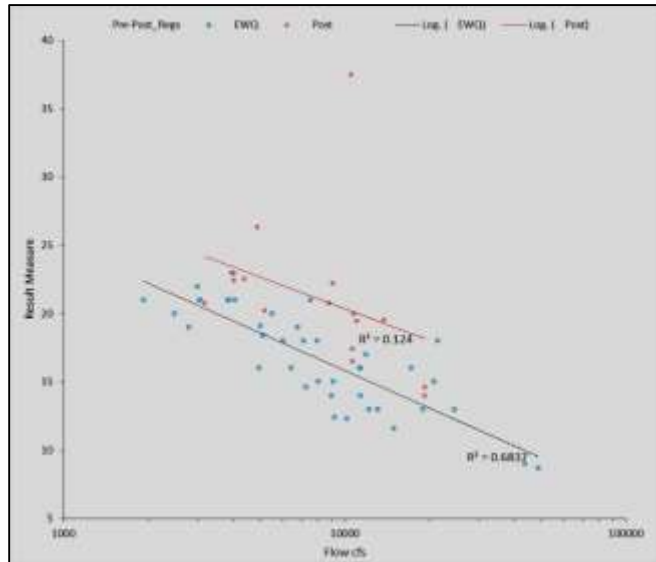
Existing Water Quality (Table 2L):

Median 17 mg/l

Lower 95% Confidence Interval 15 mg/l

Upper 95% Confidence Interval 19 mg/l

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	40	636.0	15.90
1748 ICP DRRiegel Post	16	1590.0	99.38

H statistic: 8.40
 X² approximation: 8.40
 DF: 1
 p-value: 0.0038¹
 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.

Water quality degradation is evident here. Chloride concentrations apparently rose by about 3 mg/l between the two periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is related to flow in the EWQ data, but unrelated to flow in the post-EWQ data due to insufficient data (n=16). Note that flow is plotted on a logarithmic scale. No other data were available to validate this conclusion.

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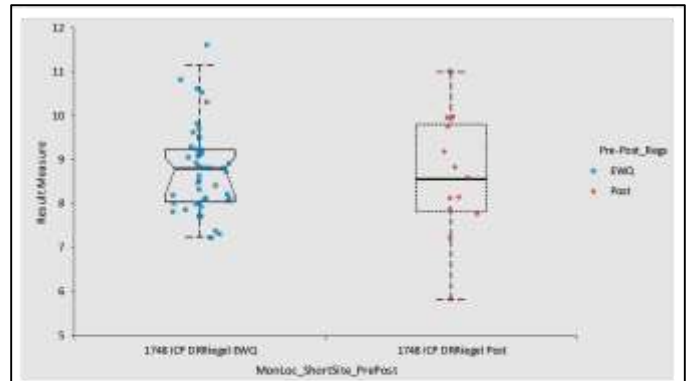
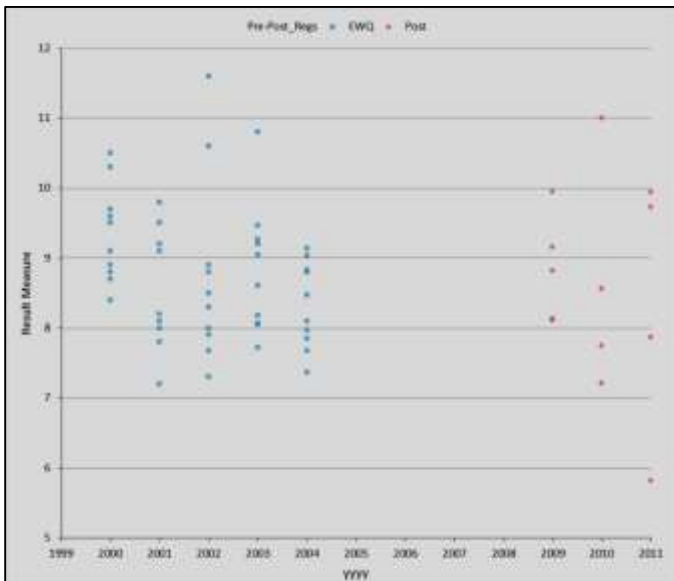
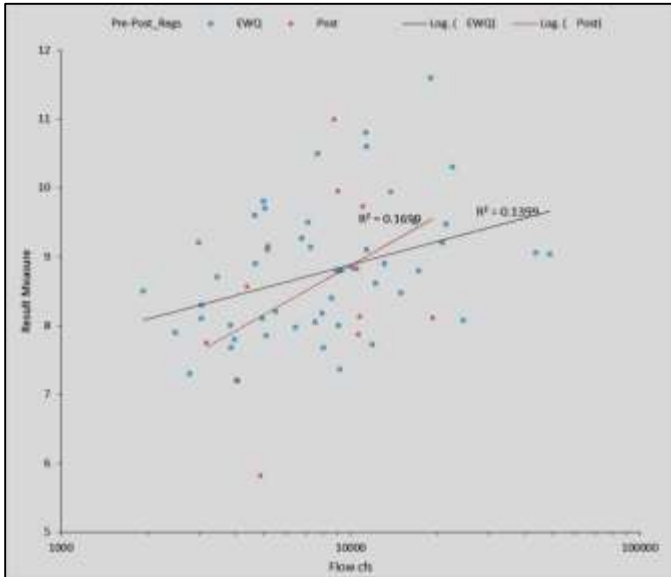
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2L):

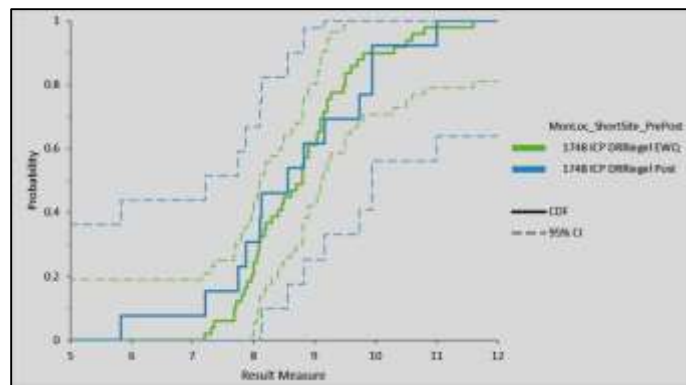
Median 8.80 mg/l

Lower 95% Confidence Interval 8.20 mg/l

Upper 95% Confidence Interval 9.05 mg/l



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	7.20	8.05	8.80	9.22	11.60	1.19
1748 ICP DRRiegel Post	5.82	7.83	8.56	9.80	11.00	1.97



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	49	1.5	0.03
1748 ICP DRRiegel Post	13	5.6	0.43

H statistic 0.02
 X² approximation 0.02
 DF 1
 p-value 0.8831¹

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 here. No measurable change took place between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. DO concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. One 2011 sample result was less than 6 mg/l, which might have been a measurement probe malfunction. However, there are treatment plants upstream that historically had problems, so the low result might have been a sporadic pollution event.

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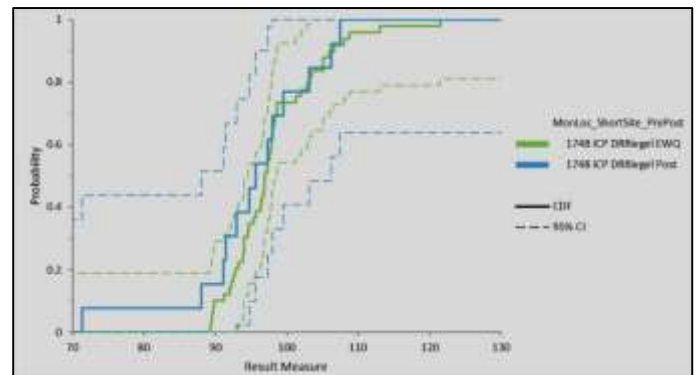
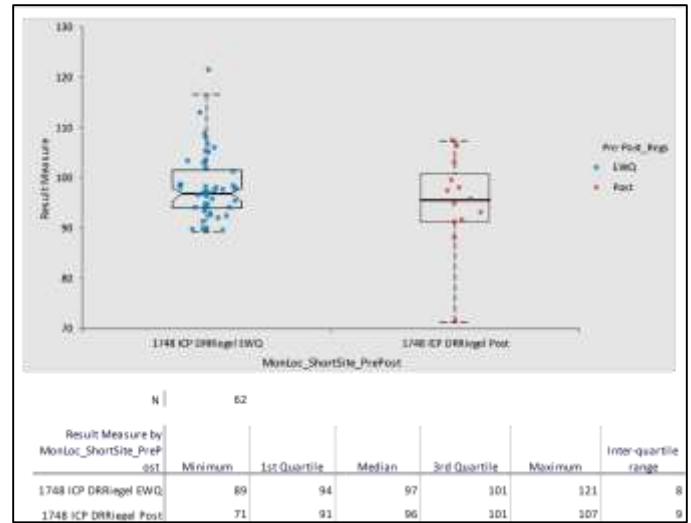
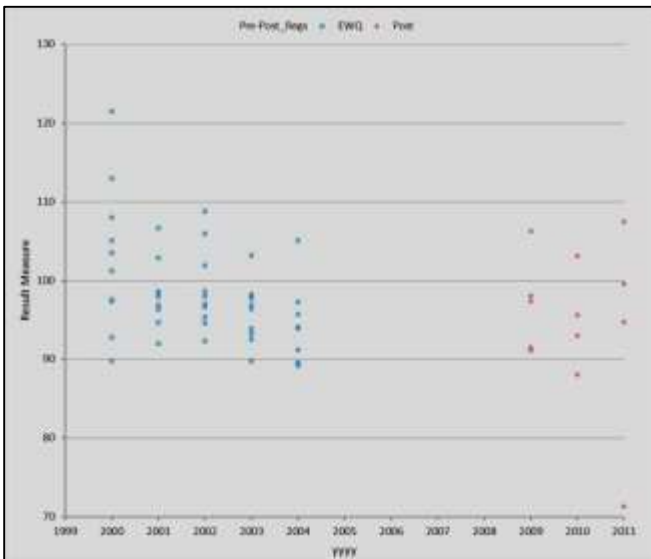
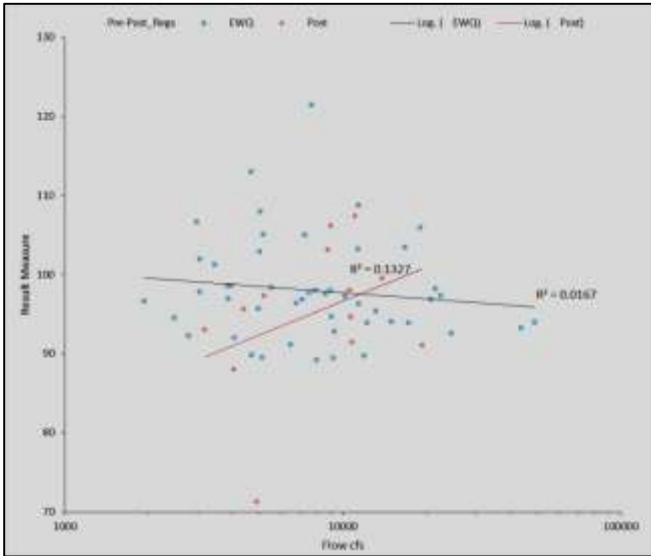
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2L):

Median 97%

Lower 95% Confidence Interval 95%

Upper 95% Confidence Interval 98%



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	49	33.5	0.68
1748 ICP DRRiegel Post	13	126.2	9.71

H statistic 0.49
 X² approximation 0.49
 DF 1
 p-value 0.4837¹
 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 here. DO Saturation is unrelated to flow, and apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals. There was one low saturation value of 71.3% found in August 2011 that possibly was a probe malfunction. However, USGS data contain multiple readings around 80%. This site historically had problems with an oxygen deficit due to uncontrolled upstream wastewater treatment. Such problems are no longer frequent. Biweekly instead of monthly sampling is recommended here.

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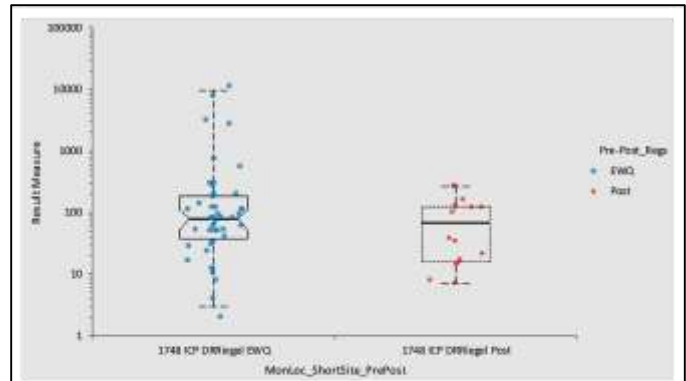
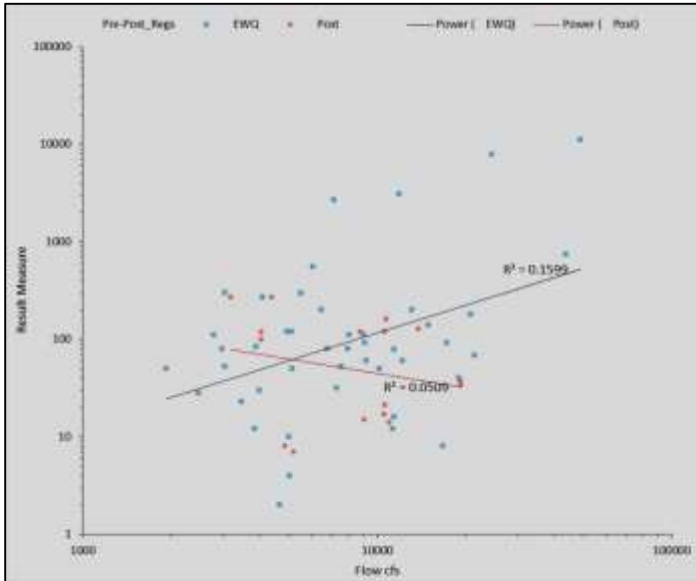
Enterococcus colonies/100 ml

Existing Water Quality (Table 2L):

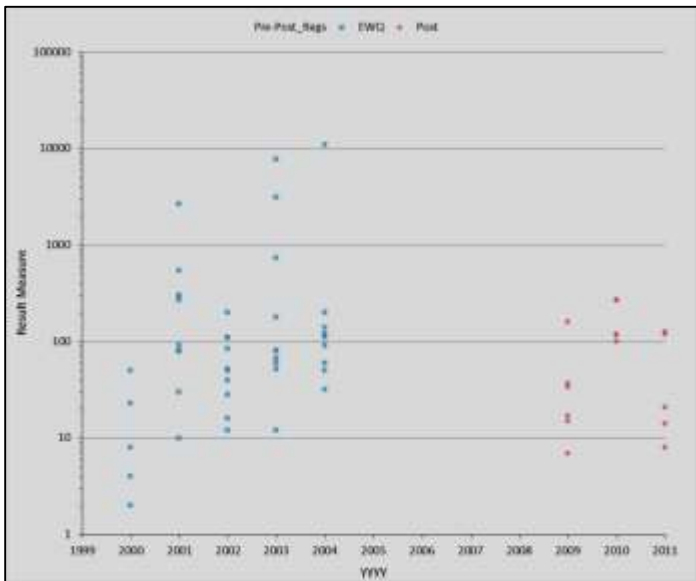
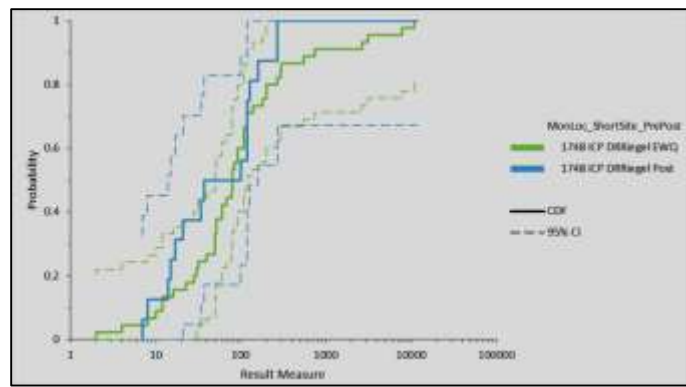
Median 80/100 ml

Lower 95% Confidence Interval 52/100 ml

Upper 95% Confidence Interval 110/100 ml



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	2	37	80	187	11000	149
1748 ICP DRRiegel Post	7	16	69	124	270	108



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	45	56.7	1.26
1748 ICP DRRiegel Post	16	159.4	9.96

H statistic	0.69
X² approximation	0.69
DF	1
p-value	0.4075 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 here. Enterococci apparently did not measurably change between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations and flows are plotted on a logarithmic scale, and the regression is a power relationship. Post-EWQ median enterococcus concentrations fell within the EWQ 95% confidence intervals.

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Escherichia coli colonies/100 ml

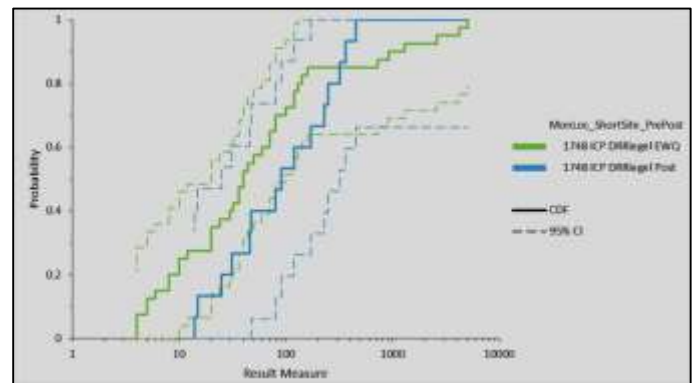
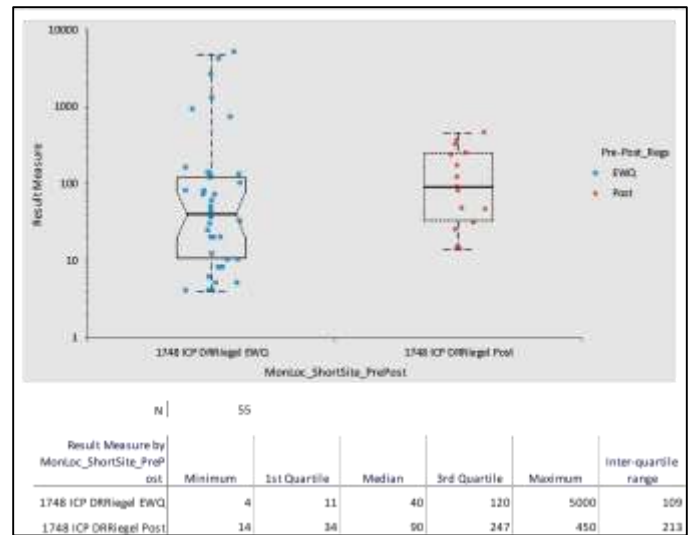
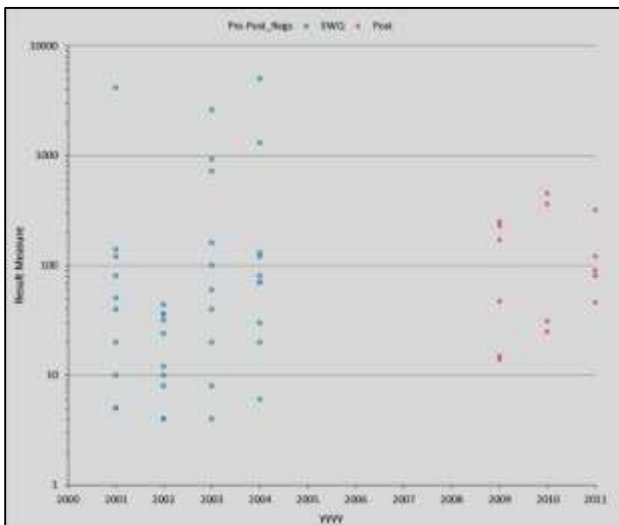
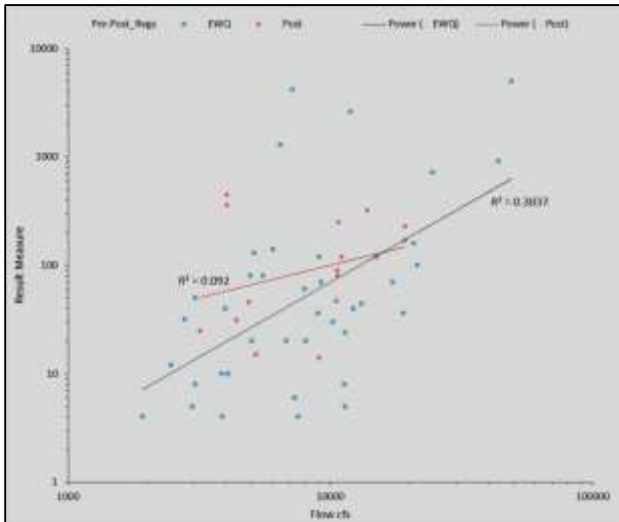
Existing Water Quality (Table 2L):

Median 40/100 ml

Lower 95% Confidence Interval 20/100 ml

Upper 95% Confidence Interval 80/100 ml

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	40	184.9	4.62
1748 ICP DRRiegel Post	15	493.1	32.87

H statistic 2.64
 X² approximation 2.64
 DF 1
 p-value 0.1040¹

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 here. Median E. coli concentrations increased but did not measurably change between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ median E. coli rose above the upper EWQ 95% confidence interval, but there were too few samples for statistical difference.

Concentrations and flows are plotted on a logarithmic scale. E. coli concentrations are related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – probably because of the narrower range of flow conditions sampled. New Jersey DEP and USGS data were available but too few in number to fully validate DRBC data.

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Fecal coliform colonies/100 ml

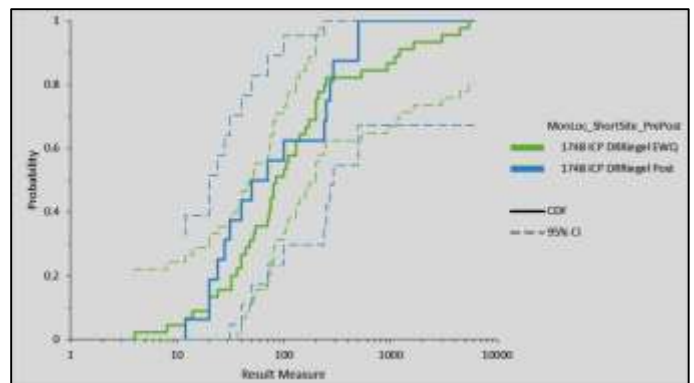
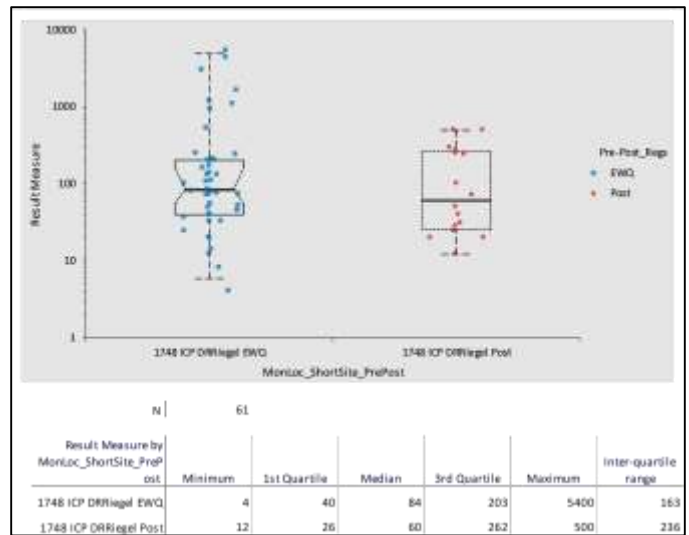
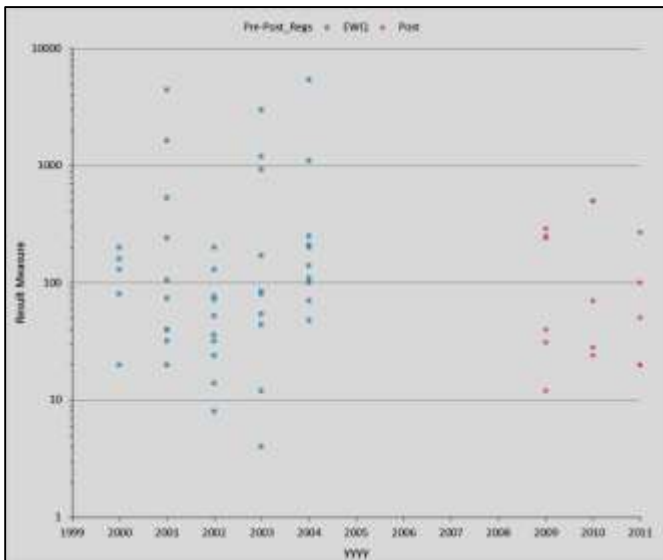
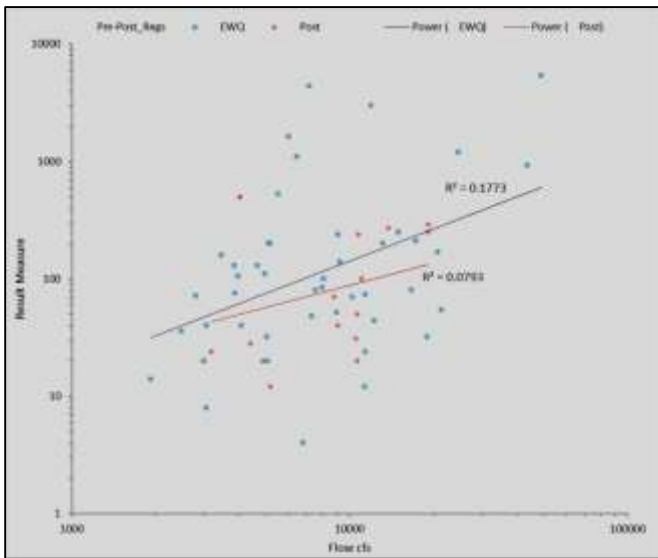
Existing Water Quality (Table 2L):

Median 84/100 ml

Lower 95% Confidence Interval 54/100 ml

Upper 95% Confidence Interval 160/100 ml

Defined in regulations as a flow-related parameter*



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	45	39.2	0.87
1748 ICP DRRiegel Post	16	110.3	6.89

H statistic 0.47
 χ^2 approximation 0.47
 DF 1
 p-value 0.4909¹

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 here. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ data contained fewer high results and were not fully representative of flow conditions. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. NJDEP and USGS data showed a statistically significant decline in concentrations, and validated DRBC results.

*Fecal coliform were erroneously identified in DRBC water quality regulations as flow-related. The relationship to flow does not hold true at Riegelsville, and the language should be removed from Table 2L.

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Hardness as CaCO₃, Total mg/l

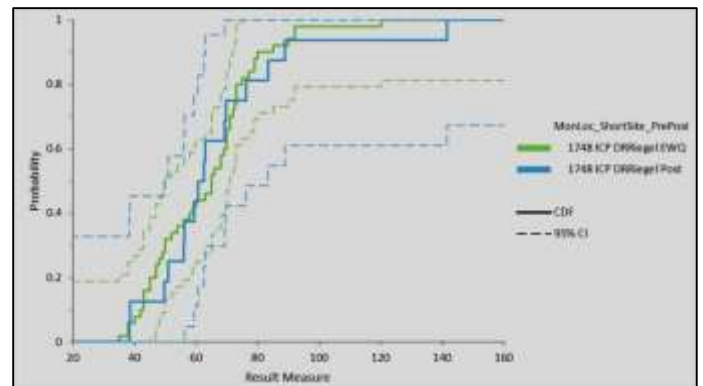
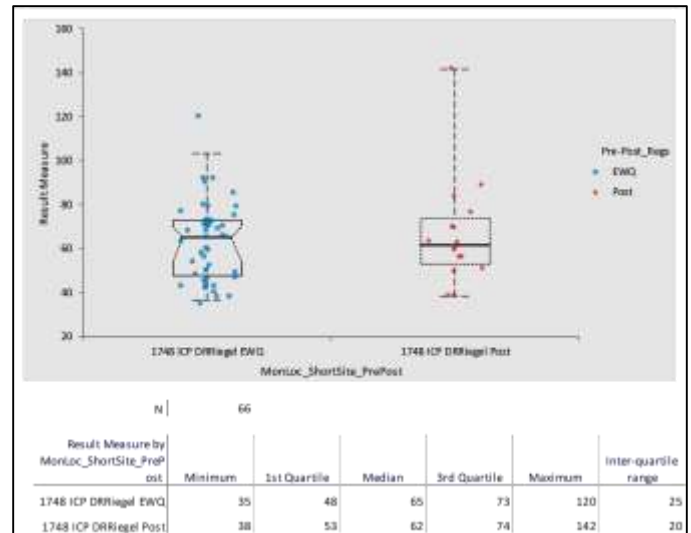
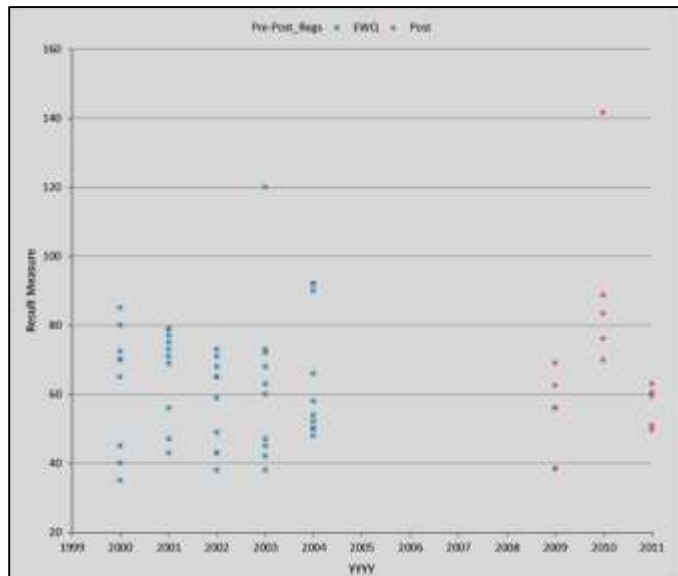
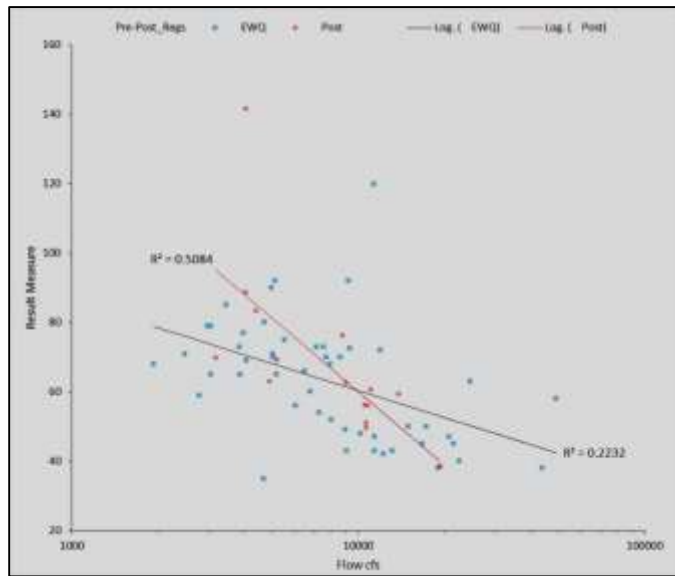
Existing Water Quality (Table 2L):

Median 65 mg/l

Lower 95% Confidence Interval 54 mg/l

Upper 95% Confidence Interval 70 mg/l

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	0.2	0.00
1748 ICP DRRiegel Post	16	0.6	0.04

H statistic | 0.00
 X² approximation | 0.00
 DF | 1
 p-value | 0.9642¹

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

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 here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Hardness is inversely related to flow in both data sets, though weakly so in the EWQ data. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. USGS data were available for comparison with DRBC results, and validated DRBC conclusions.

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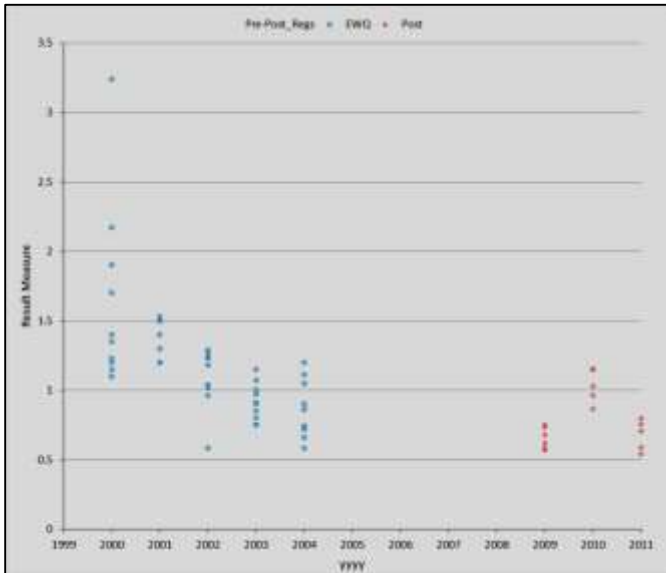
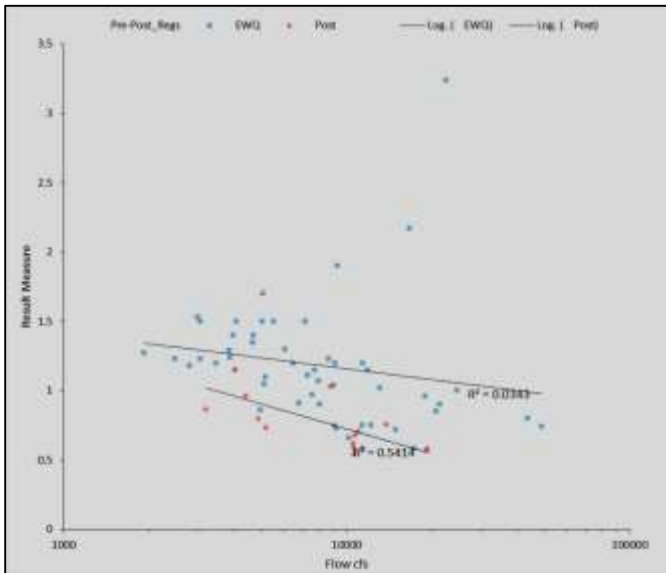
Nitrate + Nitrite as N, Total mg/l

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

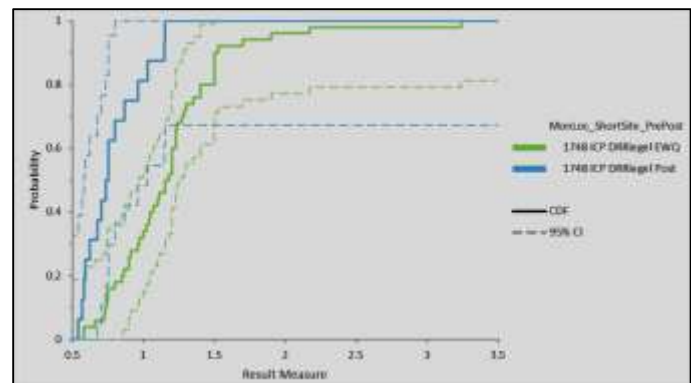
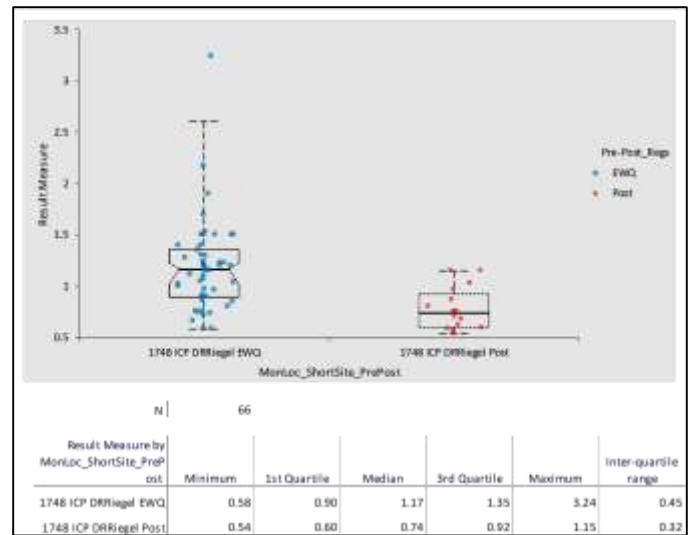
Median 1.17 mg/l

Lower 95% Confidence Interval 1.02 mg/l

Upper 95% Confidence Interval 1.23 mg/l



No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. Nitrate is unrelated to flow in the EWQ data and inversely related in the post-EWQ data.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	1425.8	28.52
1748 ICP DRRiegel Post	16	4455.6	278.47

H statistic	15.97
X ² approximation	15.97
DF	1
p-value	<0.0001 ¹

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

Post-EWQ nitrate concentrations fell below the lower EWP 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of DRBC data, as USGS measures dissolved nitrate while DRBC measures total nitrate. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high for the Delaware River at Riegelsville interpretive problems did not arise.

Chapter 15: 1748 ICP Delaware River at Riegelsville

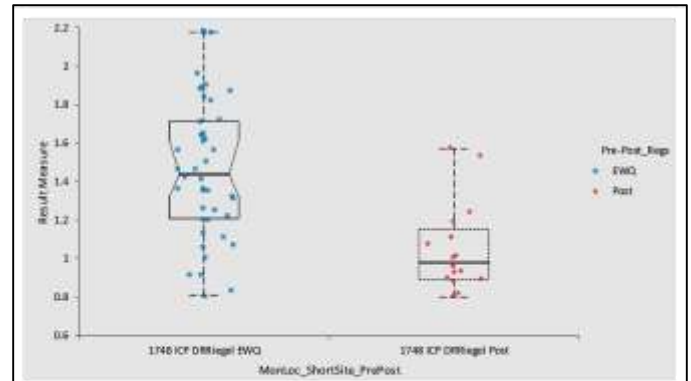
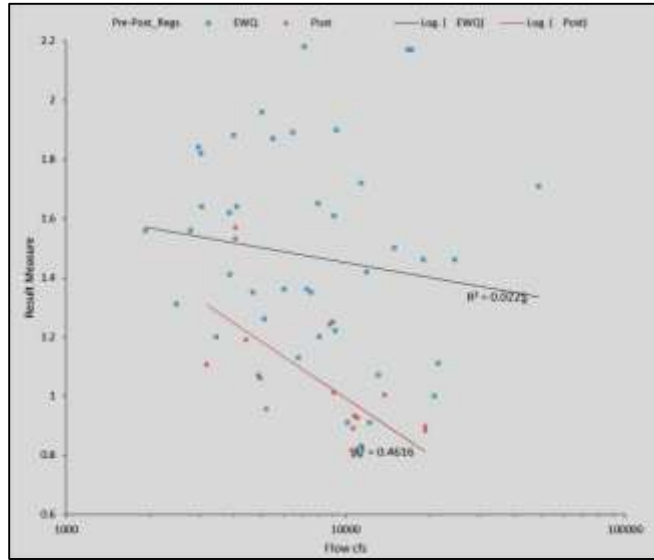
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2L):

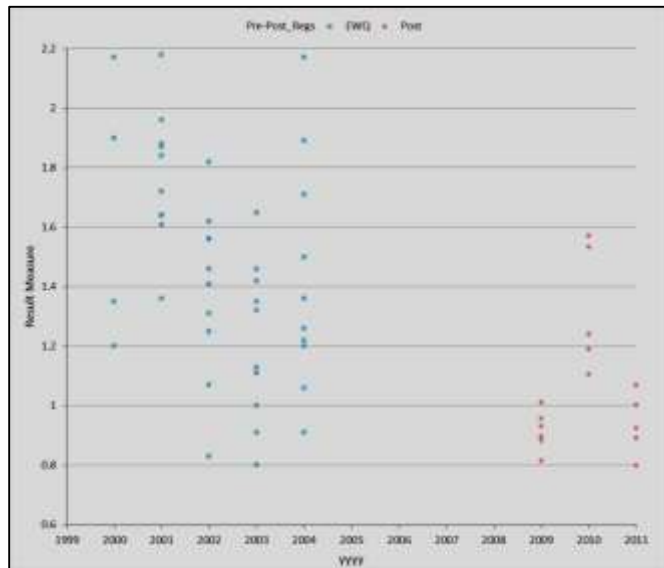
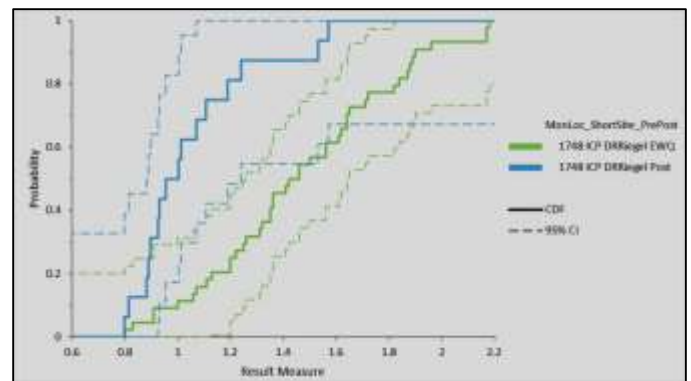
Median 1.44 mg/l

Lower 95% Confidence Interval 1.31 mg/l

Upper 95% Confidence Interval 1.62 mg/l



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.80	1.21	1.44	1.72	2.18	0.51
1748 ICP DRRiegel Post	0.80	0.89	0.98	1.15	1.57	0.26



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	44	1265.8	28.77
1748 ICP DRRiegel Post	16	3481.0	217.56

H statistic 15.57
 X² approximation 15.57
 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 here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. TN is unrelated to flow in the EWQ data, but inversely related to flow in the post-EWQ data. USGS data displayed a similar decline but were too few in number for statistical significance. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals.

Chapter 15: 1748 ICP Delaware River at Riegelsville

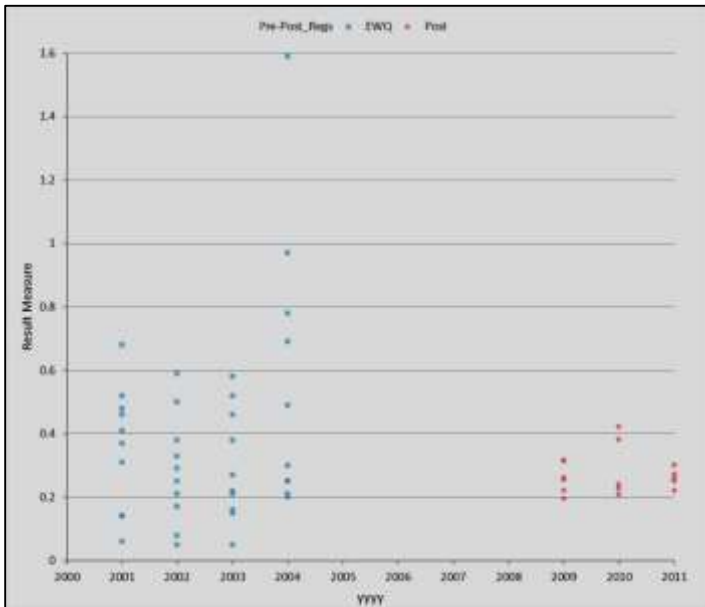
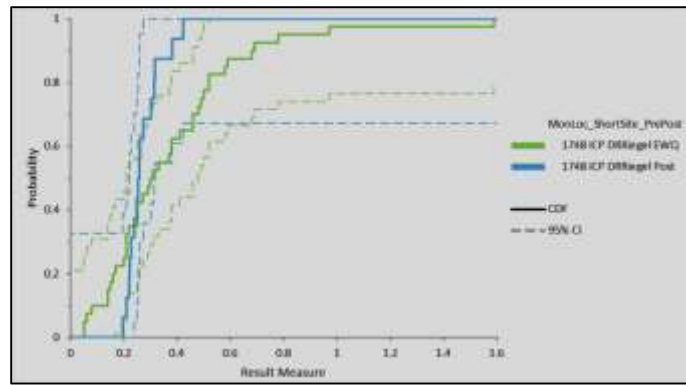
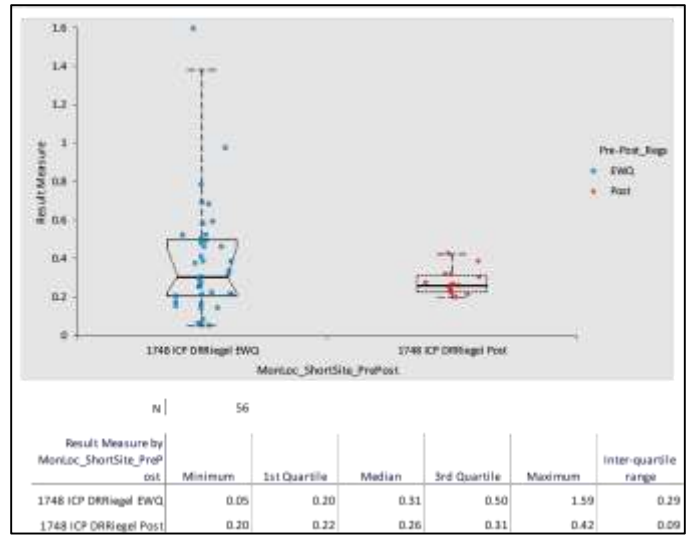
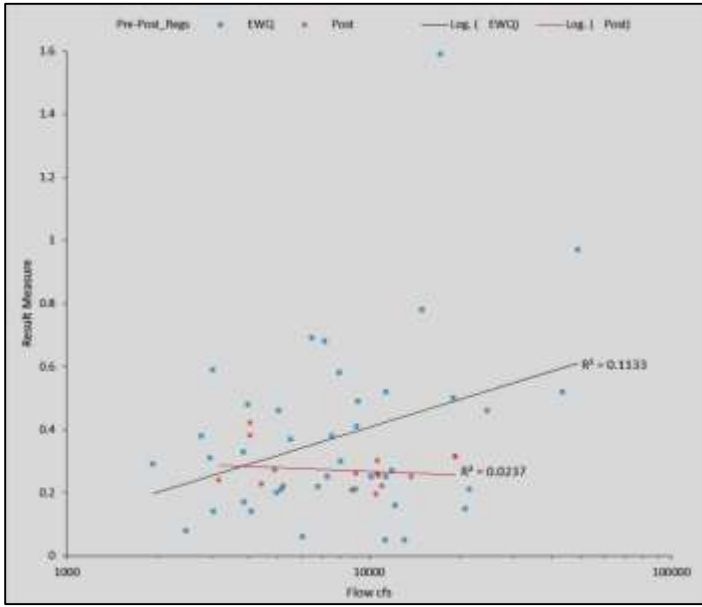
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2L):

Median 0.31 mg/l

Lower 95% Confidence Interval 0.22 mg/l

Upper 95% Confidence Interval 0.46 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	40	60.0	1.50
1748 ICP DRRiegel Post	16	150.1	9.38

H statistic: 0.79
 X² approximation: 0.79
 DF: 1
 p-value: 0.3741¹

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 here. TKN concentrations apparently did not measurably change between the EWQ and post-EWQ periods, though the post-EWQ range was far narrower and all concentrations were less than 0.5 mg/l. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell within the EWQ 95% confidence intervals. There were insufficient USGS data (n=4) to confirm DRBC results.

Chapter 15: 1748 ICP Delaware River at Riegelsville

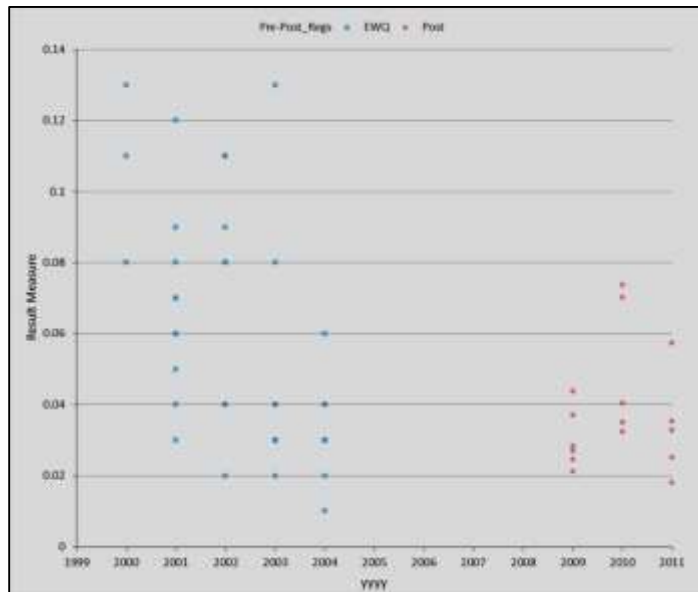
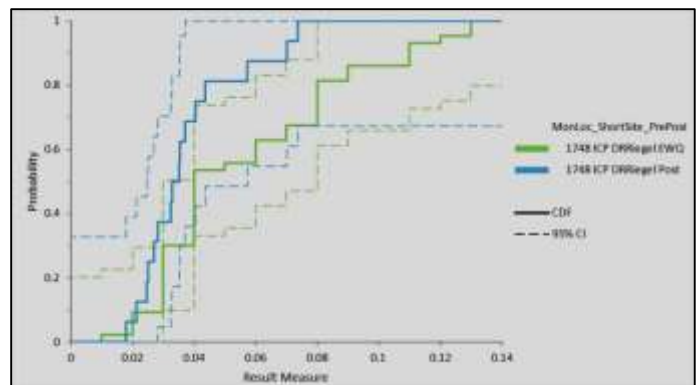
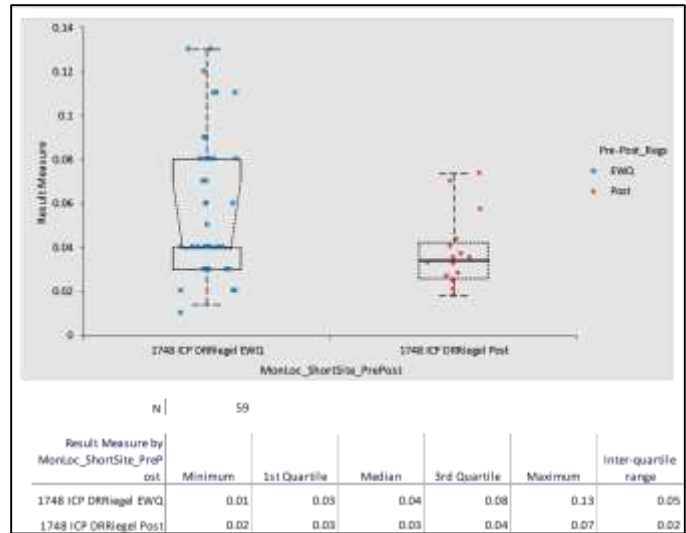
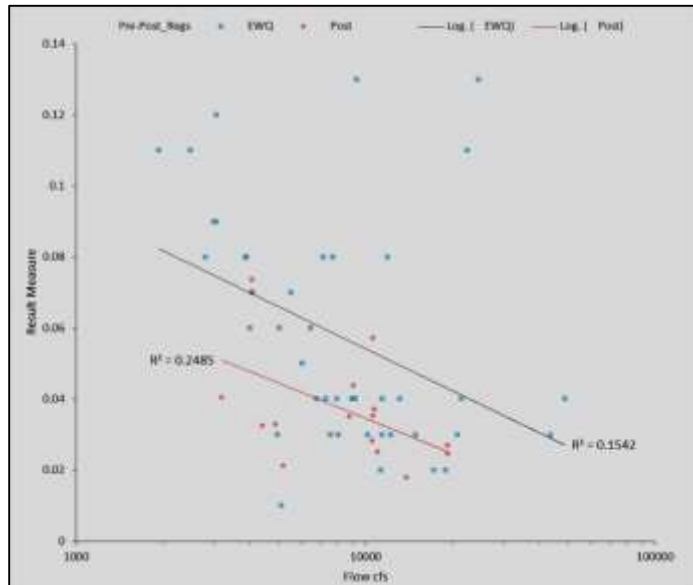
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2L):

Median 0.04 mg/l

Lower 95% Confidence Interval <0.04 mg/l

Upper 95% Confidence Interval 0.07 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	43	393.0	9.14
1748 ICP DRRiegel Post	16	1056.3	66.02

H statistic 4.96
 X² approximation 4.96
 DF 1
 p-value 0.0259¹

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 here. OP concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency.

OP is weakly related to flow in both data sets. Post-EWQ median OP fell to the EWQ lower 95% confidence interval and the upper quartile of data decreased significantly. This may be due to an improvement in detection limits, or may be a water quality improvement as there were no post-EWQ concentrations higher than 0.08 mg/l. Post-EWQ OP ranged much less widely than EWQ data. There were no independent data to confirm DRBC results.

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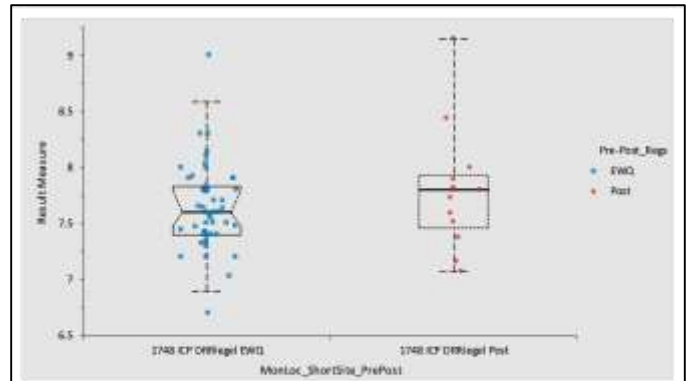
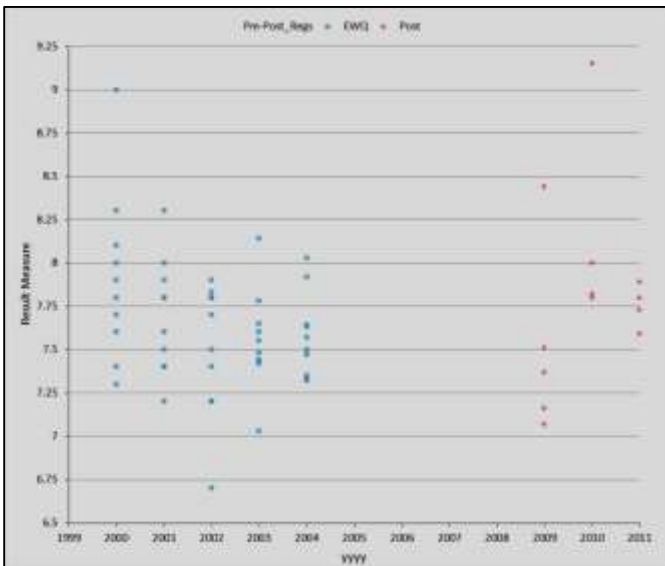
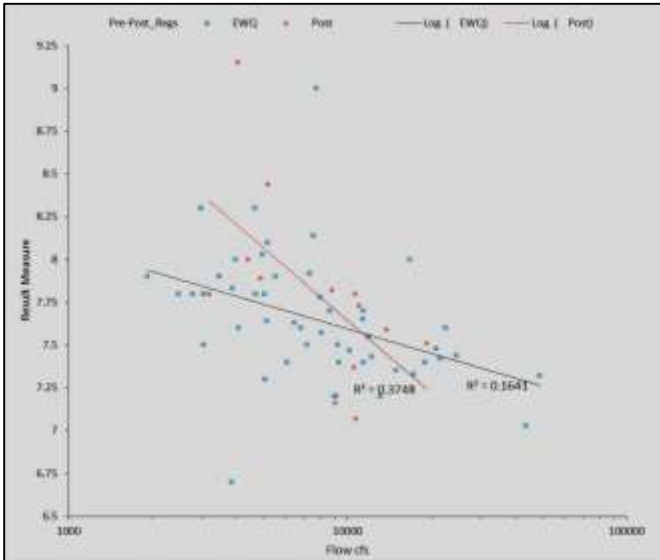
pH

Existing Water Quality (Table 2L):

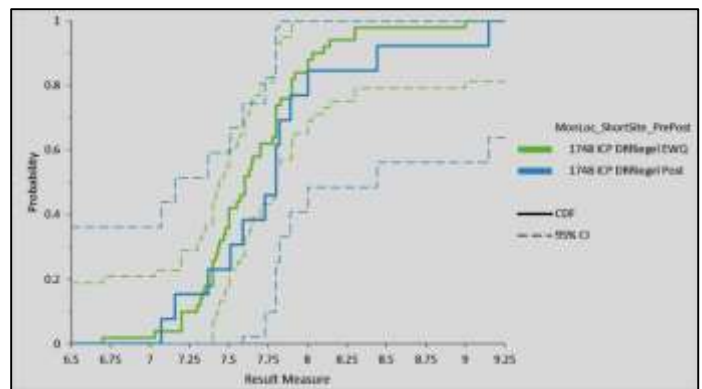
Median 7.60 standard units

Lower 95% Confidence Interval 7.48 standard units

Upper 95% Confidence Interval 7.80 standard units



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	6.70	7.40	7.60	7.84	9.00	0.44
1748 ICP DRRiegel Post	7.07	7.46	7.80	7.93	9.15	0.46



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	48.0	0.96
1748 ICP DRRiegel Post	13	184.7	14.21

H statistic: 0.69
 X² approximation: 0.69
 DF: 1
 p-value: 0.4048¹

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 here. pH did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. pH is weakly related to flow in both data sets, tending toward neutral at higher flow conditions. Post-EWQ median pH was at the upper EWQ 95% confidence interval, but the result was not statistically significant. In 2010 there was one spike above pH 9, indicating high algal productivity during that dry sampling period. USGS data confirm these results.

Chapter 15: 1748 ICP Delaware River at Riegelsville

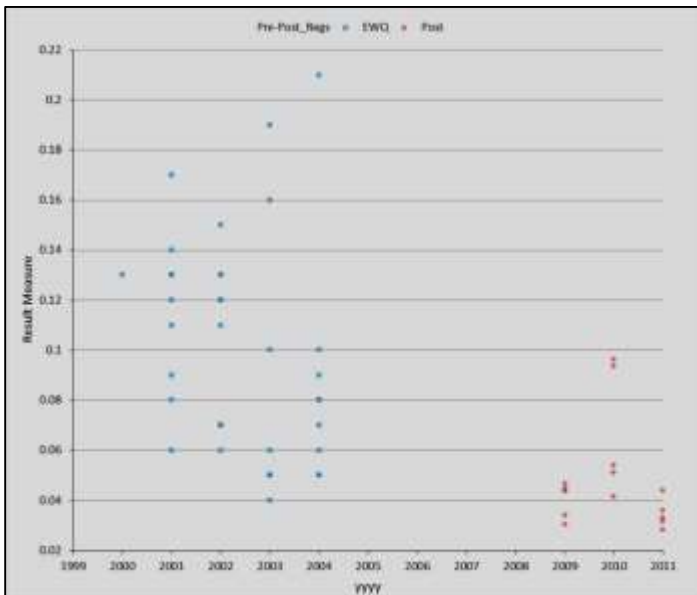
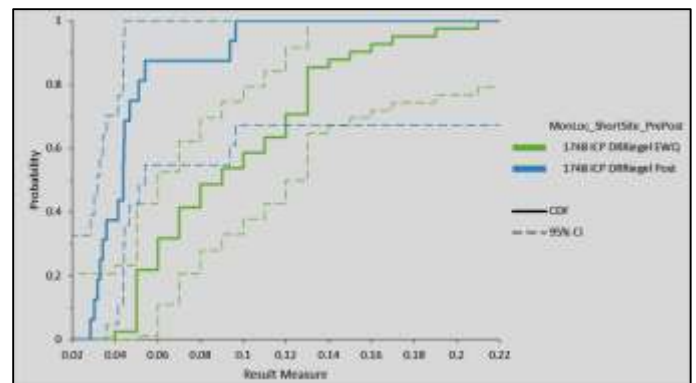
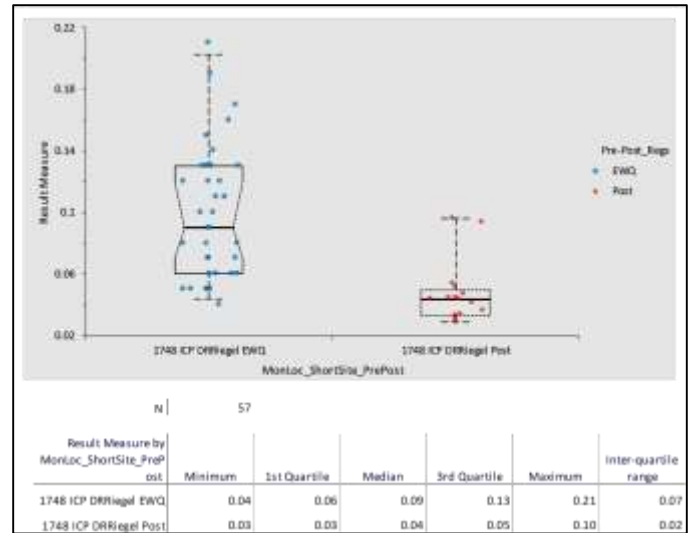
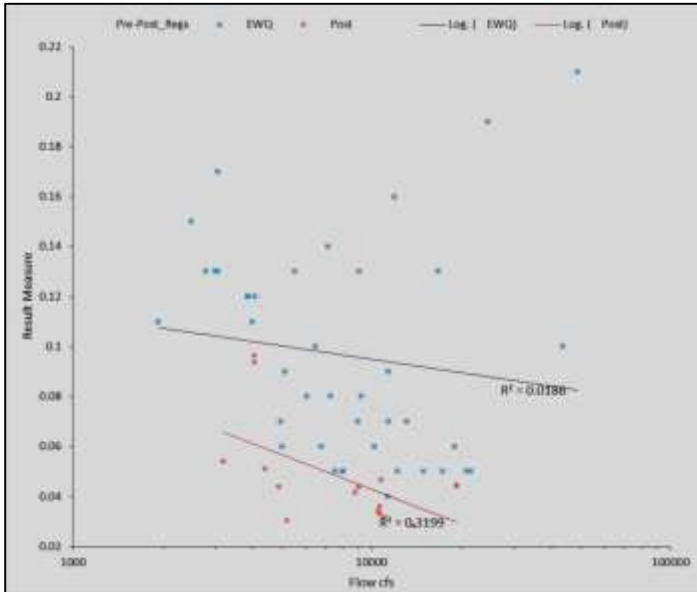
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2L):

Median 0.09 mg/l

Lower 95% Confidence Interval 0.07 mg/l

Upper 95% Confidence Interval 0.12 mg/l



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	41	1648.8	40.21
1748 ICP DRRiegel Post	16	4225.0	264.06

H statistic 21.42
 X² approximation 21.42
 DF 1
 p-value <0.0001¹

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.

No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. Post-EWQ median TP fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in the EWQ data, and weakly related in post-EWQ data. USGS data confirm DRBC results though not strongly. A decline in concentrations is shown in USGS data (n=19), but only DRBC post-EWQ data line up well with USGS results. DRBC EWQ results were more variable than USGS data.

Chapter 15: 1748 ICP Delaware River at Riegelsville

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

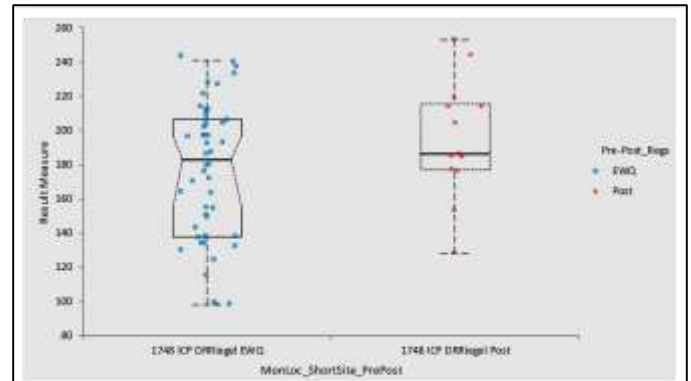
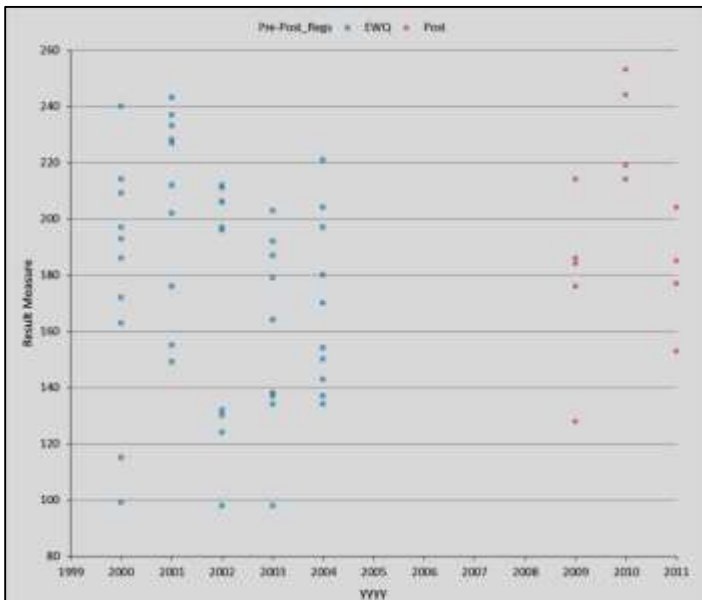
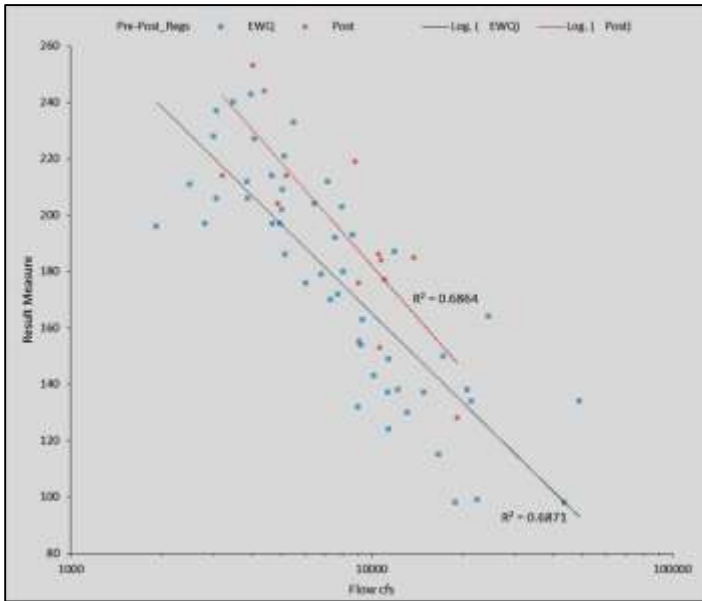
Existing Water Quality (Table 2L):

Median 183 $\mu\text{mho/cm}$

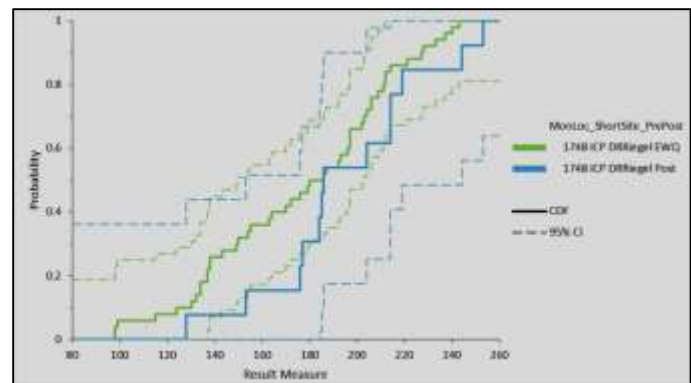
Lower 95% Confidence Interval 155 $\mu\text{mho/cm}$

Upper 95% Confidence Interval 197 $\mu\text{mho/cm}$

Defined in regulations as a flow-related parameter



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	98	138	183	206	243	68
1748 ICP DRRiegel Post	128	177	186	216	253	39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	129.6	2.59
1748 ICP DRRiegel Post	13	498.5	38.34

H statistic 1.87
 χ^2 approximation 1.87
 DF 1
 p-value 0.1715¹
 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 here. Specific conductance did not measurably change between the EWQ and post-EWQ period. Post-EWQ median specific conductance fell within the EWQ 95% confidence intervals. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance seen elsewhere is not apparent here; probably because the full flow regime is not well-represented in the post-EWQ data. USGS data (n=19) show a larger increase between the two periods, but there are insufficient data for statistical significance of the result. DRBC results compare well with USGS results.

Chapter 15: 1748 ICP Delaware River at Riegelsville

Total Dissolved Solids (TDS) mg/l

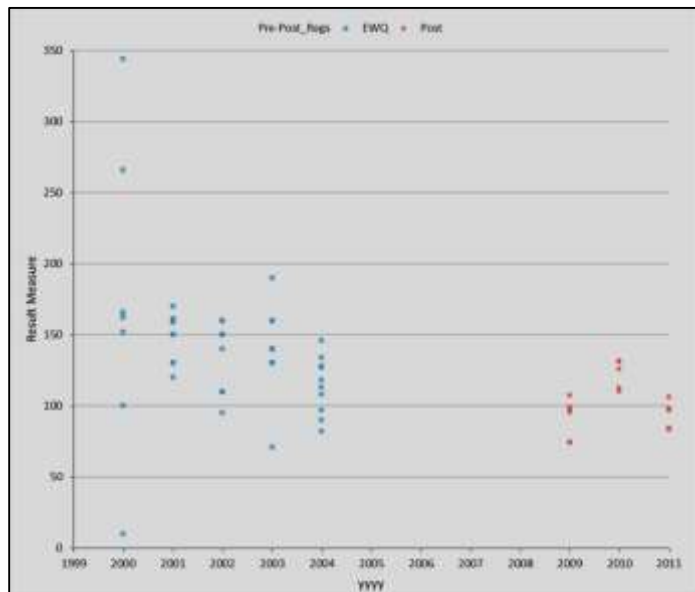
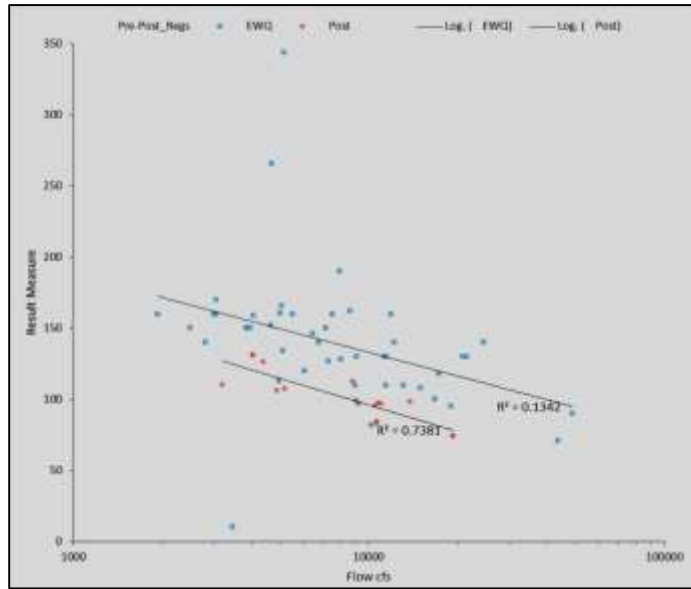
Existing Water Quality (Table 2L):

Median 140 mg/l

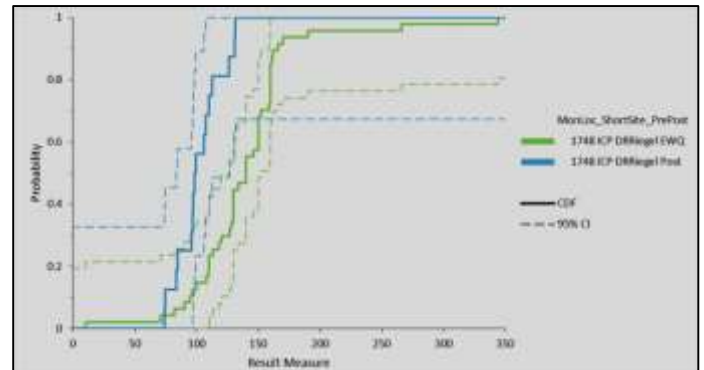
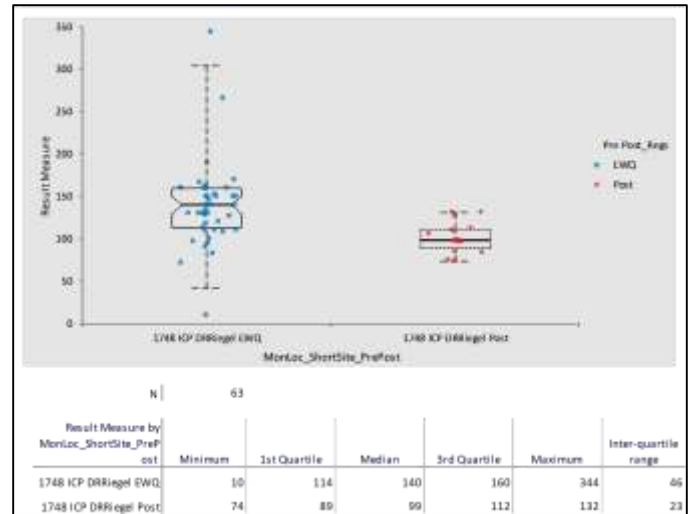
Lower 95% Confidence Interval 130 mg/l

Upper 95% Confidence Interval 150 mg/l

Defined in regulations as a flow-related parameter



No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency.



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	47	1287.6	27.40
1748 ICP DRRiegel Post	16	3782.3	236.39

H statistic	15.12
χ^2 approximation	15.12
DF	1
p-value	0.0001 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 Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

TDS is unrelated to flow in EWQ data, though TDS was designated in the rules as flow related and is inversely related to flow in post-EWQ data. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval and was much less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. USGS data were within the same range as DRBC data, but the TDS decline was not evident in USGS data. The USGS data displayed a slight increase in TDS, which is logical given the increases in chlorides and specific conductance. This supports the notion that there may be laboratory artifacts in DRBC's TDS data.

Chapter 15: 1748 ICP Delaware River at Riegelsville

Total Suspended Solids (TSS) mg/l

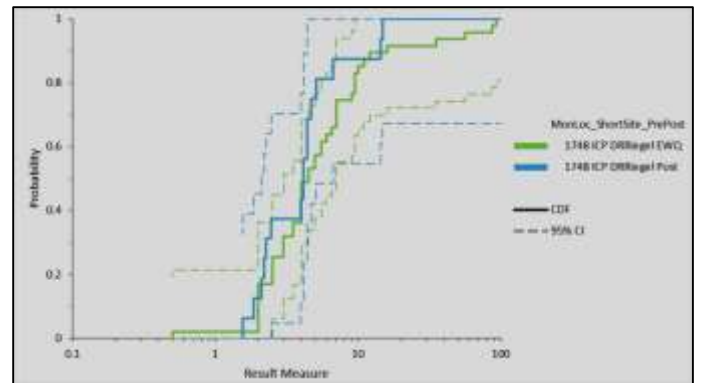
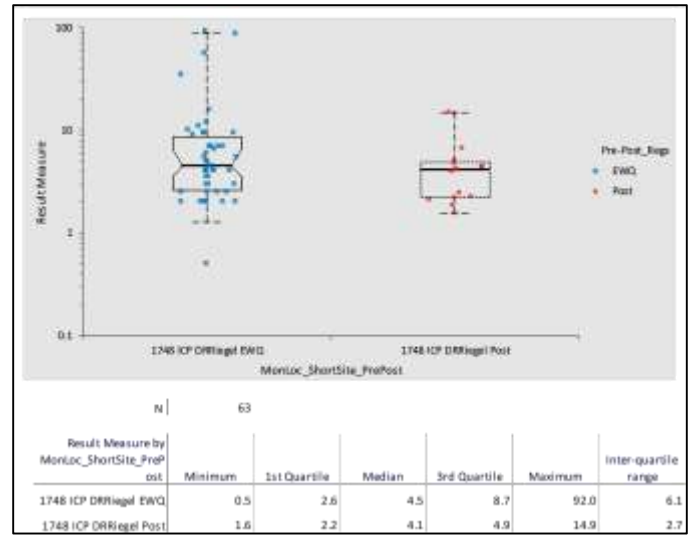
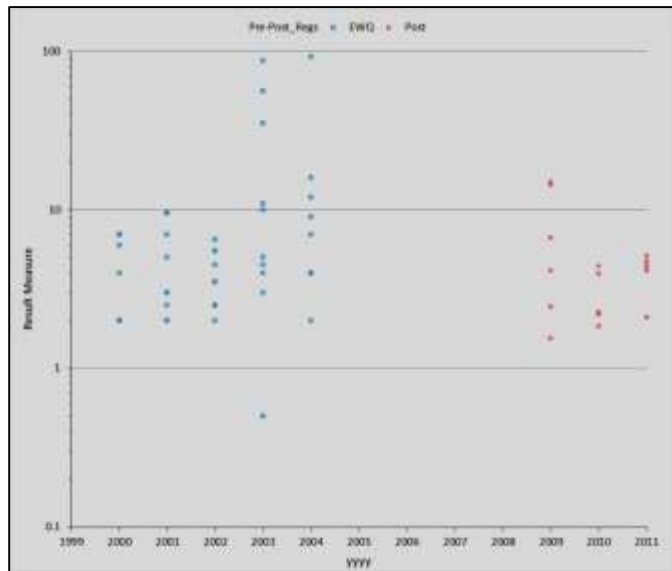
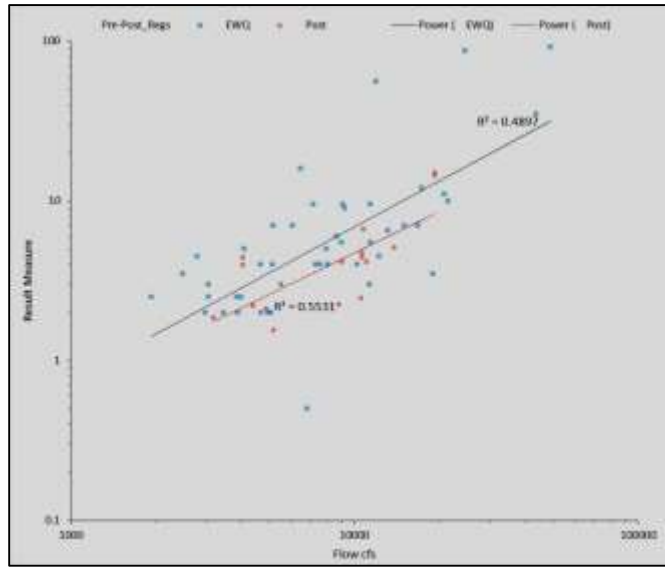
Existing Water Quality (Table 2L):

Median 4.5 mg/l

Lower 95% Confidence Interval 3.5 mg/l

Upper 95% Confidence Interval 6.5 mg/l

Defined in regulations as a flow-related parameter



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	47	92.7	1.97
1748 ICP DRRiegel Post	16	272.3	17.02

H statistic 1.09
 X² approximation 1.09
 DF 1
 p-value 0.2966¹

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 here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell within the EWQ 95% confidence intervals. Both flow and concentration are plotted on a logarithmic scale, and the regression is a power relationship. USGS data were too few for trend evaluation, but closely resembled DRBC results.

Chapter 15: 1748 ICP Delaware River at Riegelsville

Turbidity NTU

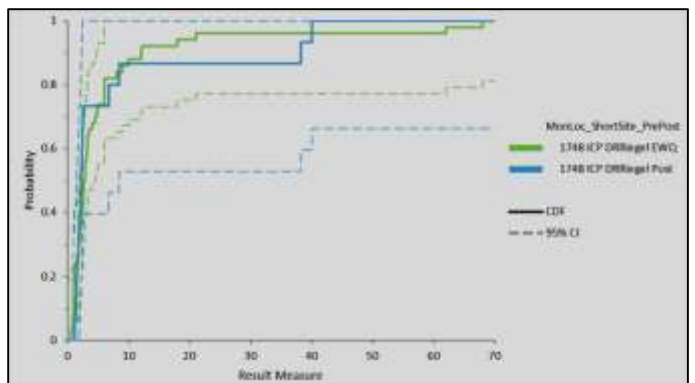
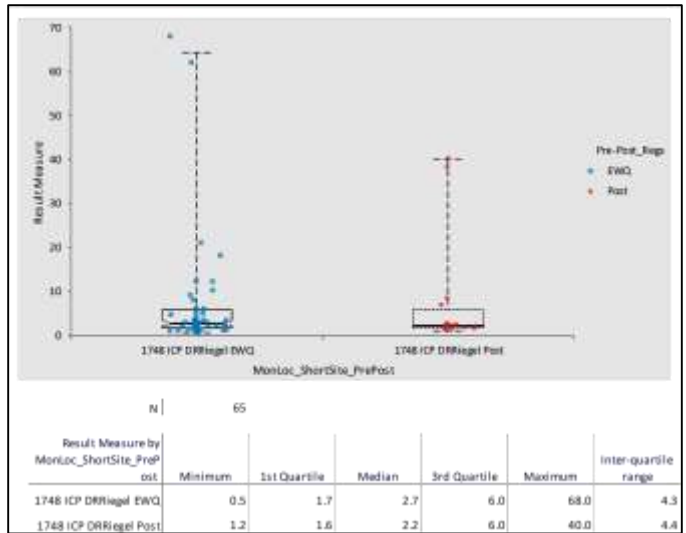
Existing Water Quality (Table 2L):

Median 2.7 NTU

Lower 95% Confidence Interval 2.1 NTU

Upper 95% Confidence Interval 3.5 NTU

Defined in regulations as a flow-related parameter



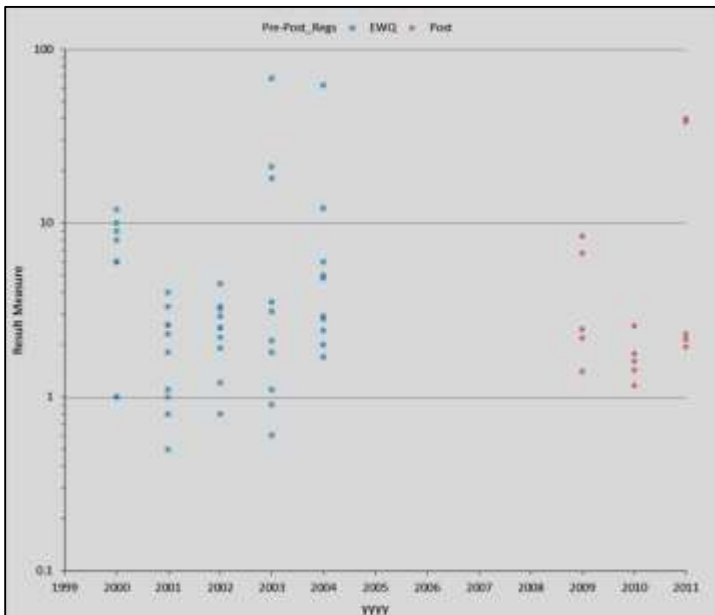
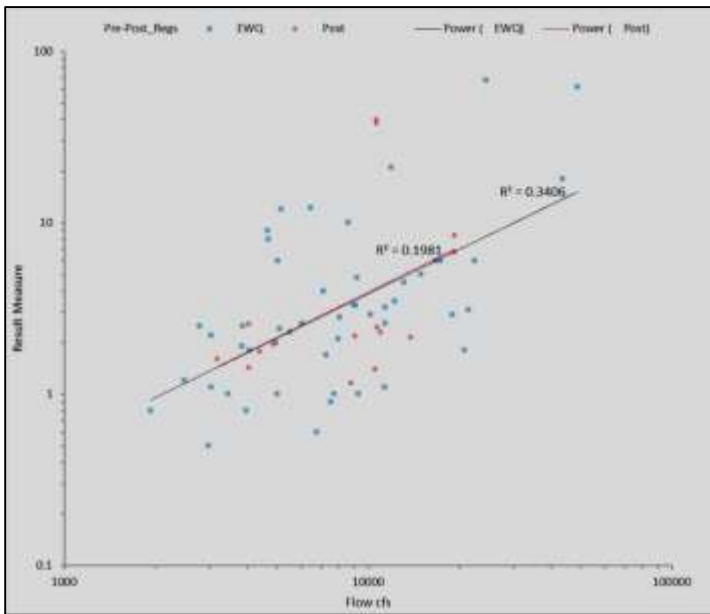
Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	8.4	0.17
1748 ICP DRRiegel Post	15	28.0	1.87

H statistic: 0.10
 X² approximation: 0.10
 DF: 1
 p-value: 0.7495¹

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.

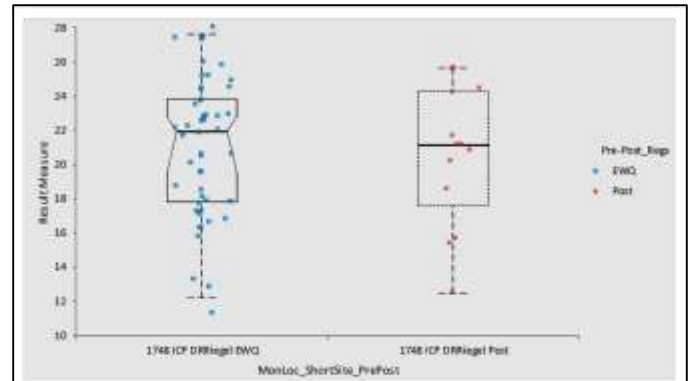
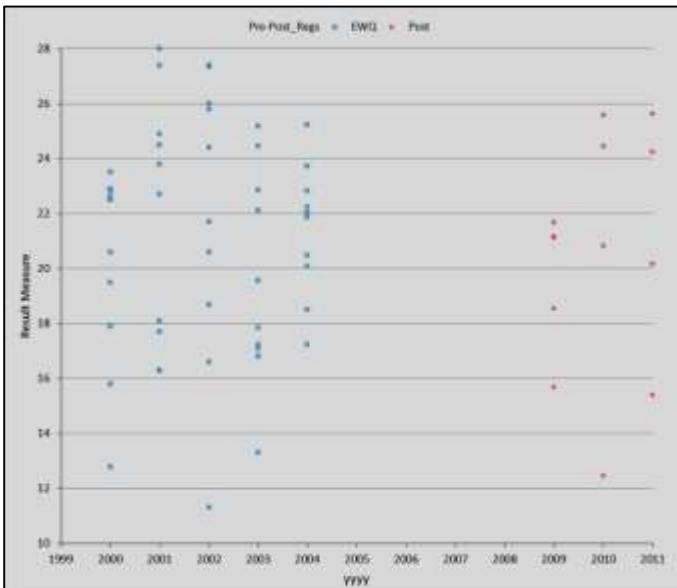
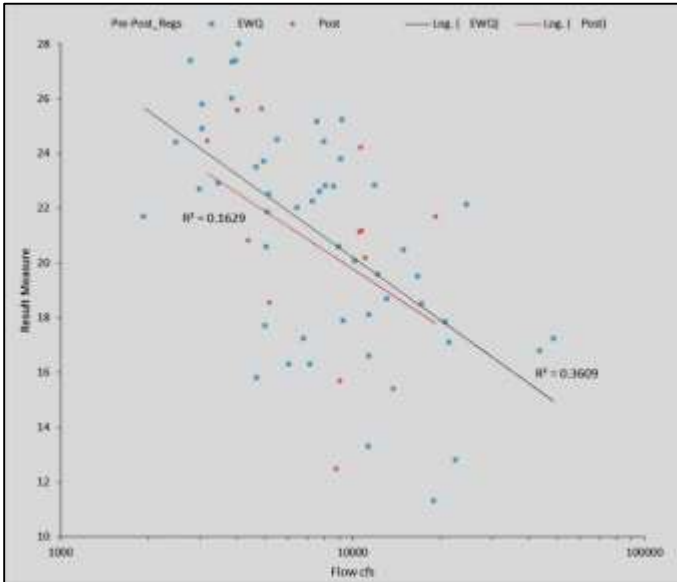
No water quality degradation is evident here. Turbidity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is positively related to flow in both data sets, and the power regression lines actually overlay one another. Concentration and flow are represented on logarithmic scales. There were very few USGS data available for comparison with DRBC results, but USGS and DRBC results were similar.



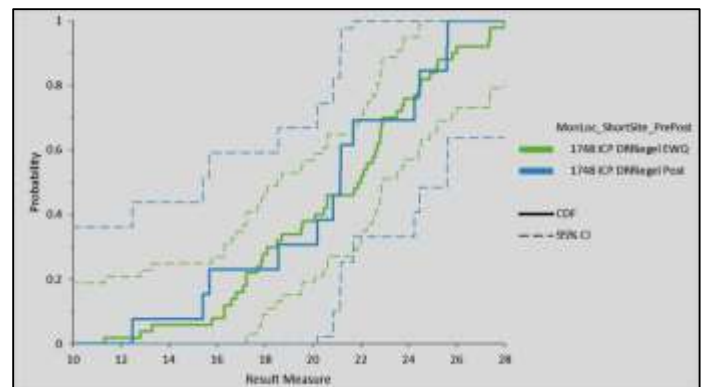
Chapter 15: 1748 ICP Delaware River at Riegelsville

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
1748 ICP DRRiegel EWQ	11.3	17.8	21.9	23.9	28.0	6.0
1748 ICP DRRiegel Post	12.5	17.6	21.1	24.3	25.6	6.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	11.5	0.23
1748 ICP DRRiegel Post	13	44.3	3.41

H statistic: 0.17
 χ^2 approximation: 0.17
 DF: 1
 p-value: 0.6835¹

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 here. Water temperature did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Water temperature is weakly and inversely related to flow in both data sets. Flow is plotted on a logarithmic scale. DRBC data closely resembled NJDEP and USGS results.