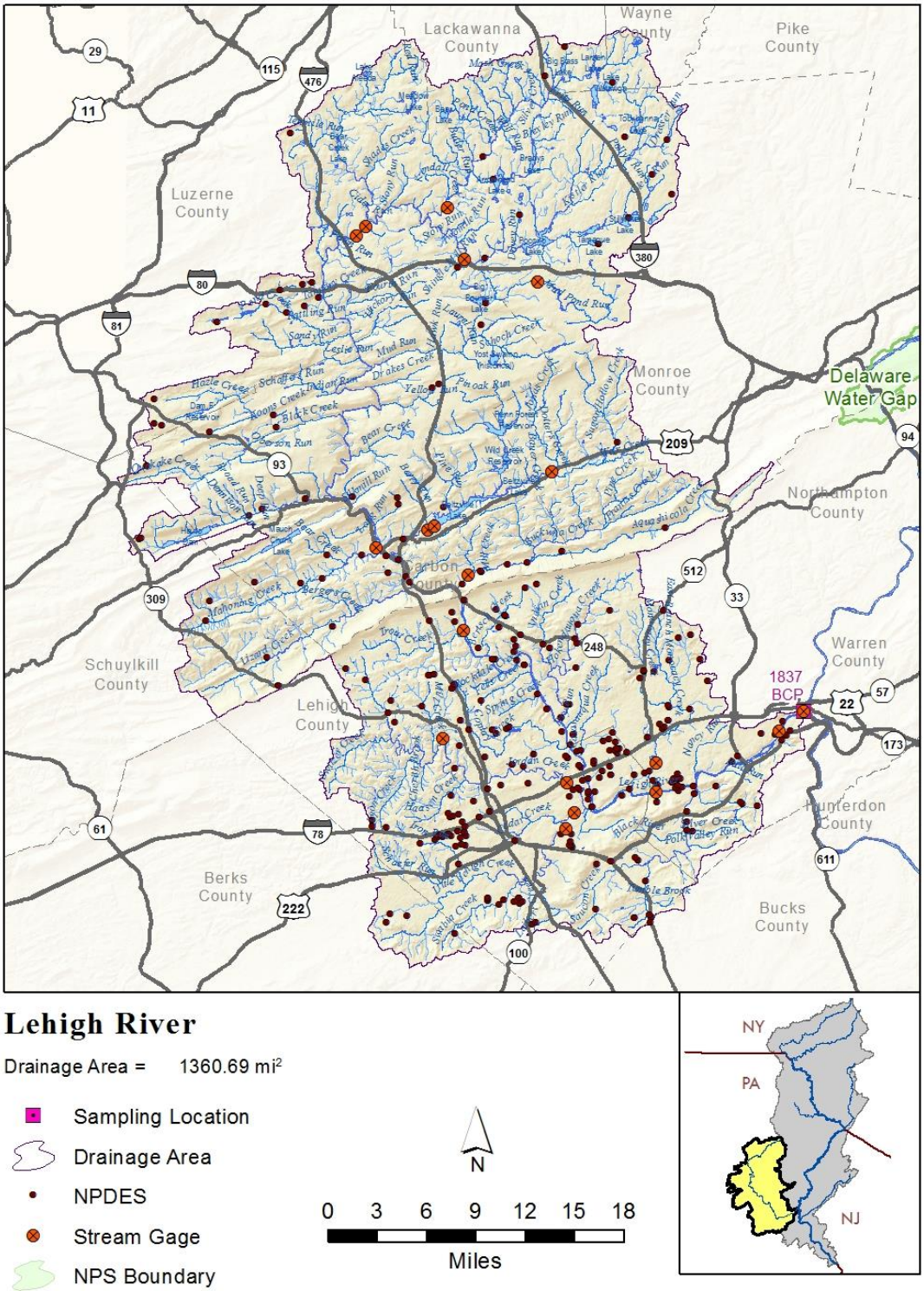
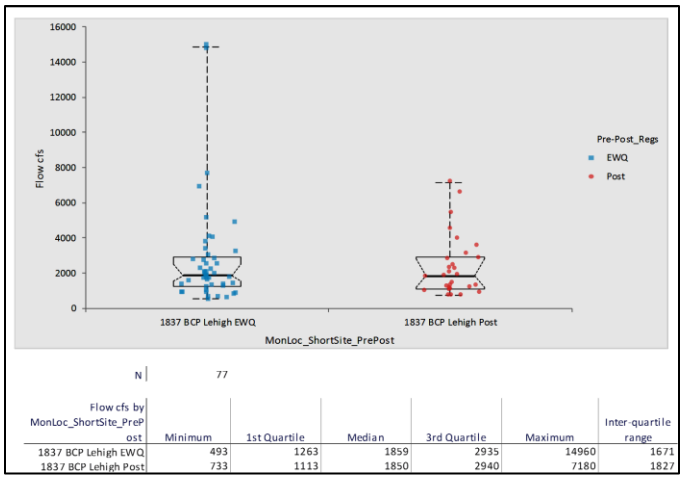
Chapter 17: 1837 BCP Lehigh River, Multiple Counties, PA



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



N	77					
Flow cfs by MonLoc_ShortSite_PreP ost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	493	1263	1859	2935	14960	1671
1837 BCP Lehigh Post	733	1113	1850	2940	7180	1827

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period. The range of flow conditions sampled was wider in the EWQ period, but not so much so that the water quality analyses were affected. In both periods there were sufficient samples to fully represent the Lehigh River flow regime.

Kruskal-Wallis test

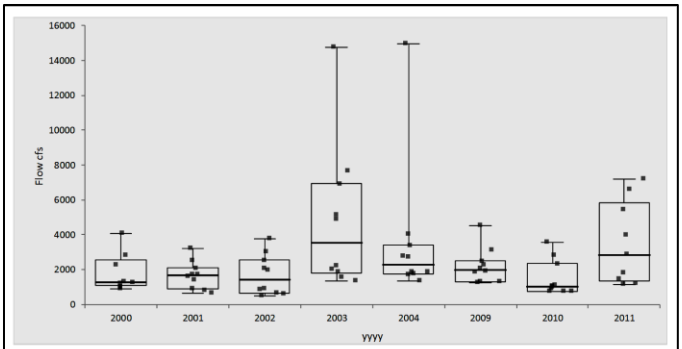
Flow cfs by MonLoc_ShortSite_PreP ost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	6.8	0.14
1837 BCP Lehigh Post	29	11.2	0.39

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8499

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

The Lehigh River is the largest and most populous tributary to the Lower Delaware River, so it affects water quality of the Delaware River the most of any tributary and masks the effects of other downstream tributaries. The 1361 square mile watershed is about 60% forested, contains 9.9% urban land cover, and about 16% of the watershed is underlain by carbonate bedrock. About 28% of the watershed was affected by glacial activity (USGS StreamStats retrieval, Feb. 2014).

Numerous new and renewed discharge permits have been issued here under the DRBC Special Protection Waters rules. DRBC has a water quality model of the Lehigh River and uses it to implement discharge permits under Special Protection Waters rules.



N	77					
Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	909	1098	1266	2577	4077	1479
2001	665	893	1671	2120	3202	1227
2002	493	657	1415	2560	3773	1903
2003	1350	1819	3533	6962	14777	5142
2004	1340	1735	2284	3403	14960	1668
2009	1270	1318	1965	2524	4520	1207
2010	733	764	1024	2372	3570	1608
2011	1130	1357	2850	5823	7180	4467

Pennsylvania DEP maintains a long term water quality monitoring (WQN) station nearby, so there are independent data available to compare with DRBC results. DRBC collects samples from the Route 611 Bridge near the Lehigh River confluence with the Delaware River.

Annual May to September flow statistics associated with water quality measurements are plotted above. These are measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 2520 cfs; and harmonic mean flow is about 1250 cfs (USGS Stream Stats retrieval, Feb. 2014) 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 estimated using instantaneous readings at the USGS gage 01454720 on the Lehigh River at Glendon, PA. Those reading are adjusted to account for the slight drainage area difference between the gage and the sampling site.

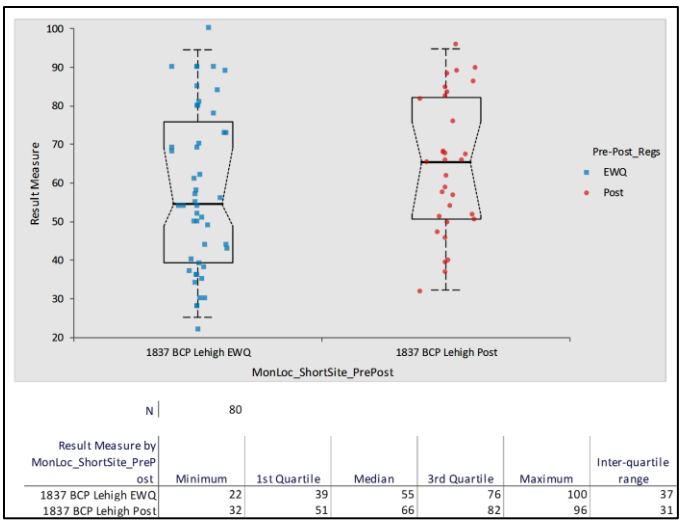
Upstream ICP: Delaware River at Easton 1838 ICP
Downstream ICP: Del. River at Riegelsville 1748 ICP

Chapter 17: 1837 BCP Lehigh River, PA

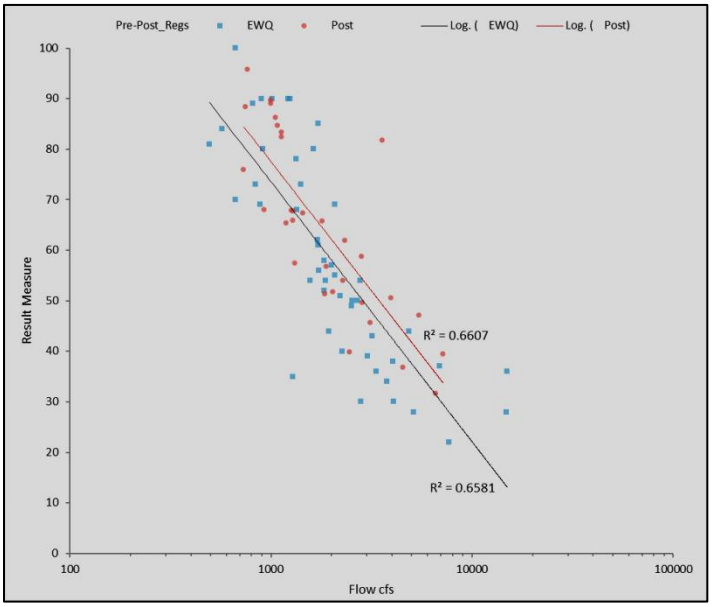
Alkalinity as CaCO3, Total mg/l

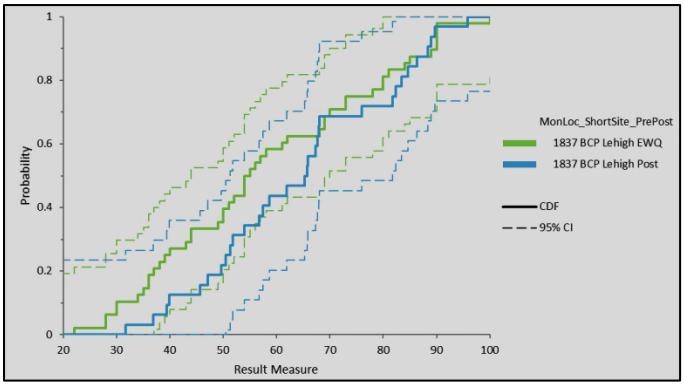
Existing Water Quality (Table 2J):

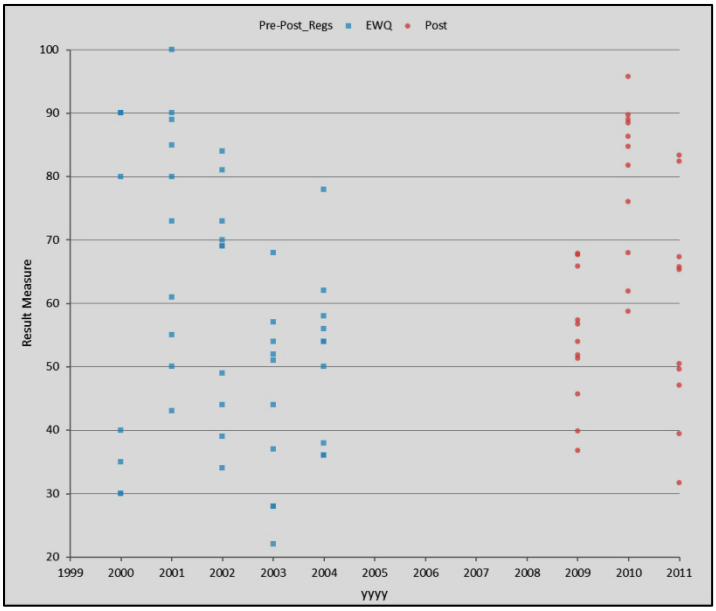
Median 55 mg/l
Lower 95% Confidence Interval 49 mg/l
Upper 95% Confidence Interval 69 mg/l
Defined in regulations as a flow-related parameter



N	80					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	22	39	55	76	100	37
1837 BCP Lehigh Post	32	51	66	82	96	31







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	376.9	7.85
1837 BCP Lehigh Post	32	565.3	17.67

H statistic	1.75
X² approximation	1.75
DF	1
p-value	0.1865 [1]

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

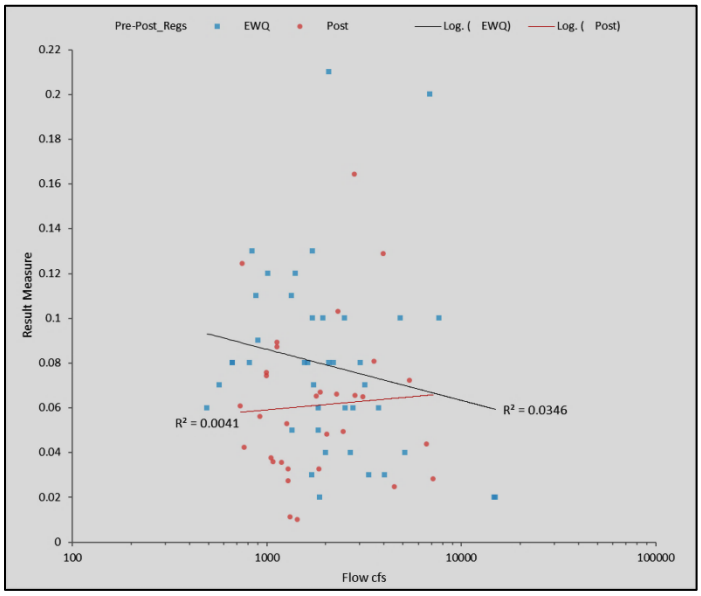
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. PADEP samples compared well with DRBC data, though there were only 11 WQN results which were insufficient data for statistical comparisons.

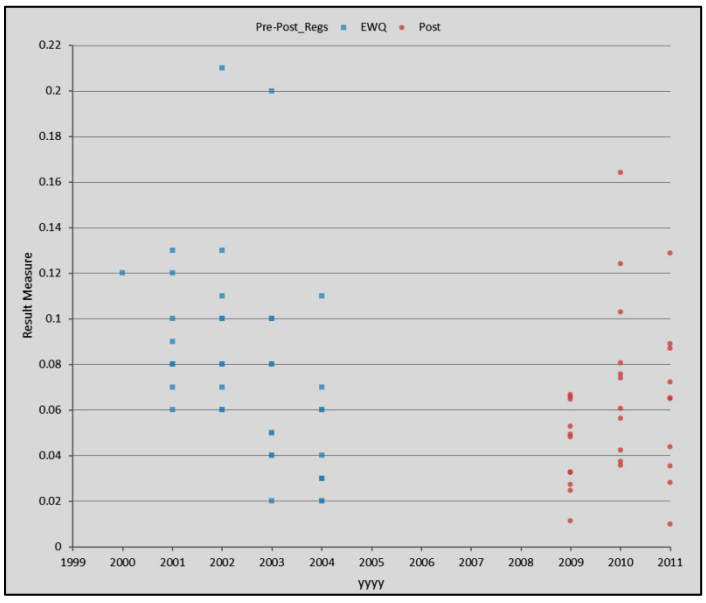
Chapter 17: 1837 BCP Lehigh River, PA

Ammonia Nitrogen as N, Total mg/l

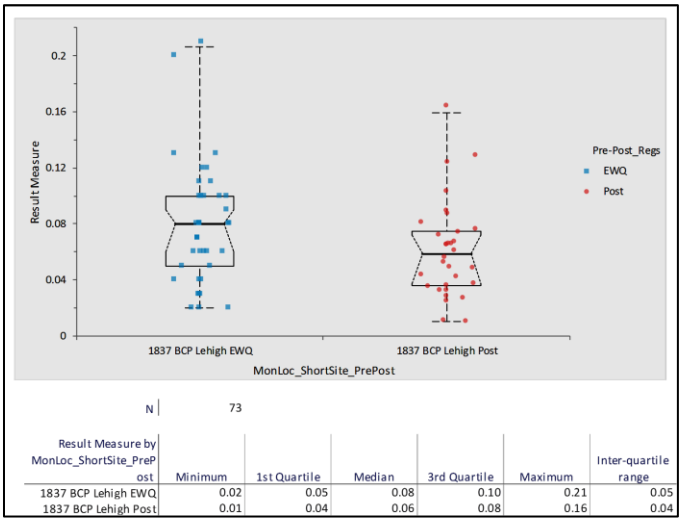
Existing Water Quality (Table 2J):

Median 0.08 mg/l
Lower 95% Confidence Interval 0.06 mg/l
Upper 95% Confidence Interval 0.09 mg/l

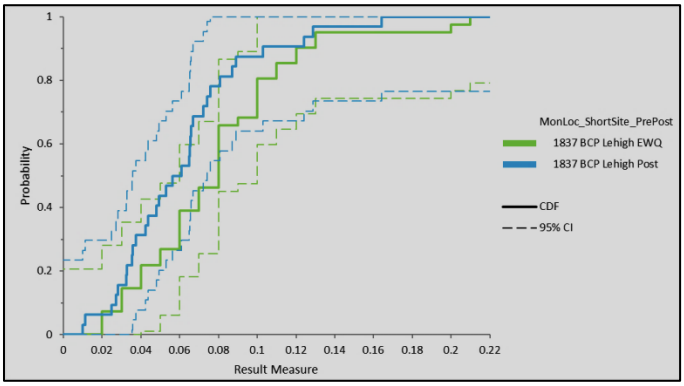




No water quality degradation is evident here. Ammonia concentrations apparently declined slightly. Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median ammonia concentration was just below the EWQ lower 95% confidence interval.



	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
Result Measure by MonLoc_ShortSite_PrePost	73						
1837 BCP Lehigh EWQ		0.02	0.05	0.08	0.10	0.21	0.05
1837 BCP Lehigh Post		0.01	0.04	0.06	0.08	0.16	0.04



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	41	781.5	19.06
1837 BCP Lehigh Post	32	1001.3	31.29

H statistic	3.97
X^2 approximation	3.97
DF	1
p-value	0.0463 [1]

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.

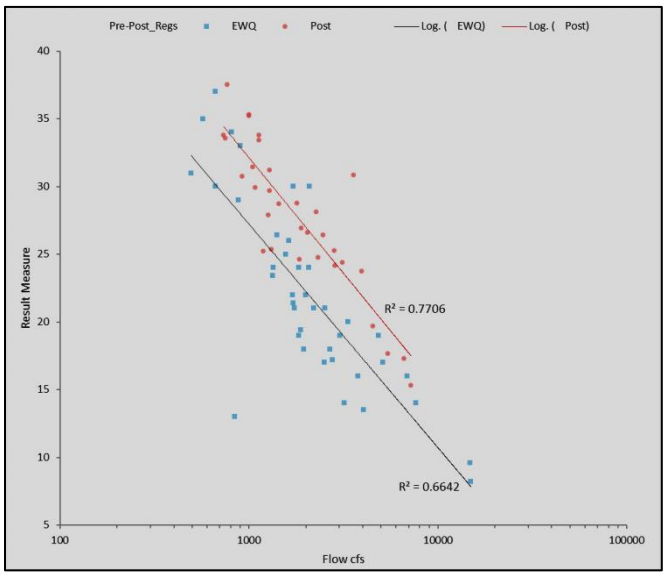
There were no post-EWQ PADEP data available for comparison with DRBC data. Ammonia is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. DRBC's post-EWQ detection limit (0.004-0.006 mg/l) was much lower than during the EWQ period (0.02-0.05 mg/l). EWQ data possessed 8/41 undetected results, so EWQ estimation of the median concentration was unaffected. In the post-EWQ data there were no undetected results. Thus the result found by DRBC may be a decline in ambient concentrations unless laboratory artifacts interfered. However, ammonia concentrations are still high in the Lehigh River.

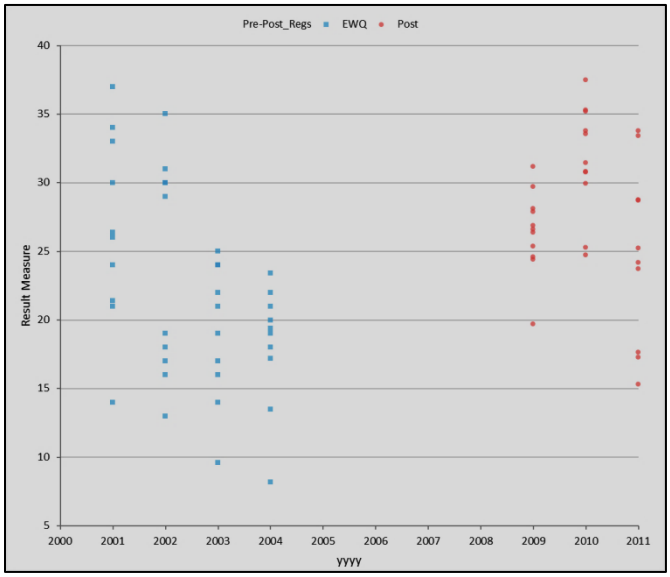
Chapter 17: 1837 BCP Lehigh River, PA

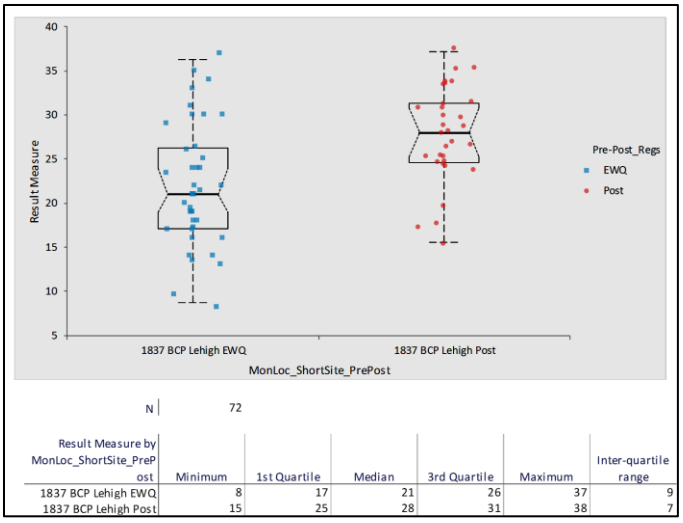
Chloride, Total mg/l

Existing Water Quality (Table 2J):

Median 21 mg/l
Lower 95% Confidence Interval 19 mg/l
Upper 95% Confidence Interval 24 mg/l
Defined in regulations as a flow-related parameter

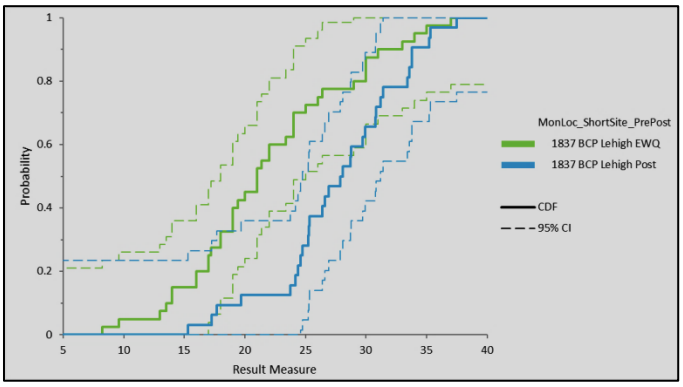






N	72

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	8	17	21	26	37	9
1837 BCP Lehigh Post	15	25	28	31	38	7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	40	2520.2	63.00
1837 BCP Lehigh Post	32	3150.2	98.44

H statistic	12.95
X^2 approximation	12.95
DF	1
p-value	0.0003 [1]

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.

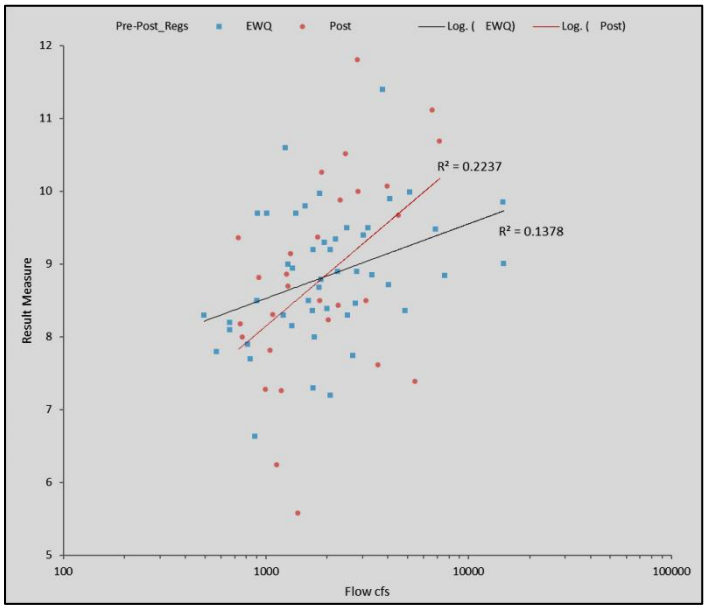
Water quality degradation is evident here. Chloride concentrations apparently rose by about 7 mg/l between the two periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is inversely related to flow in both data sets. Flow is plotted on a logarithmic scale. Only 3 PADEP samples were available to validate this conclusion, and all were 2009 samples that matched the higher concentration range of the post-EWQ period.

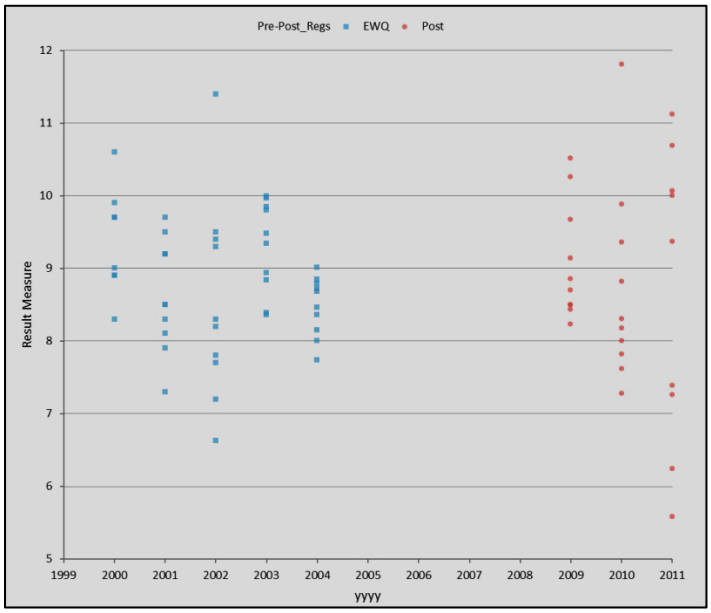
Chapter 17: 1837 BCP Lehigh River, PA

Dissolved Oxygen (DO) mg/l

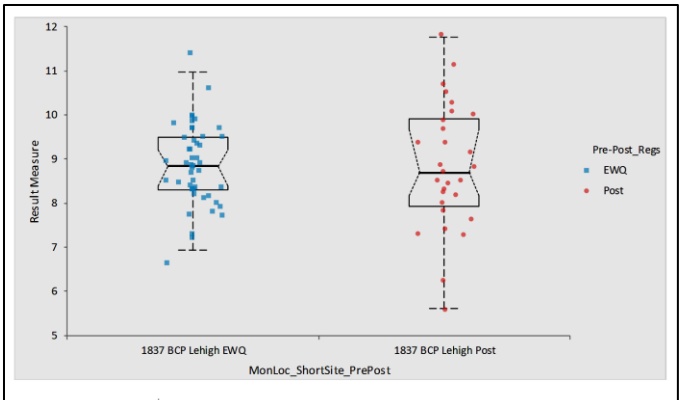
Existing Water Quality (Table 2J):

Median 8.85 mg/l
Lower 95% Confidence Interval 8.39 mg/l
Upper 95% Confidence Interval 9.20 mg/l



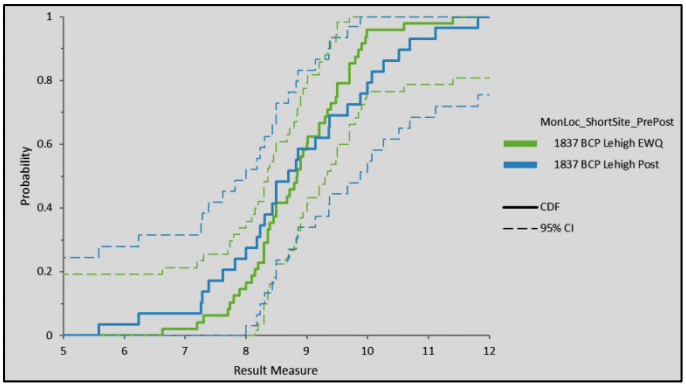


No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. There was no known uncertainty introduced by uncontrolled variables.



N 77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	6.63	8.30	8.85	9.49	11.40	1.19
1837 BCP Lehigh Post	5.58	7.94	8.70	9.92	11.81	1.98



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	1.5	0.03
1837 BCP Lehigh Post	29	2.5	0.09

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9288 [1]

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

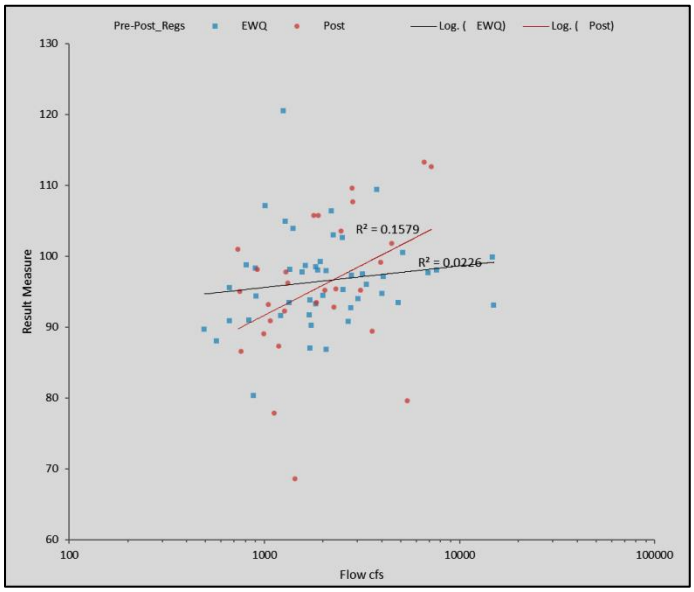
Post-EWQ median DO was within the EWQ 95% confidence intervals, though it ranged more widely. DO concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. There were two results of 6 mg/l or below in the post-EWQ data – these were taken at a time of day when DO concentrations should be near maximum. Thus there may be instances of uncontrolled sewage or other oxygen-reducing materials in the Lehigh. Both samples were taken in July 2011 under low/normal flow conditions. PADEP data generally match DRBC results, though no data were available in the July 2011 period for comparison.

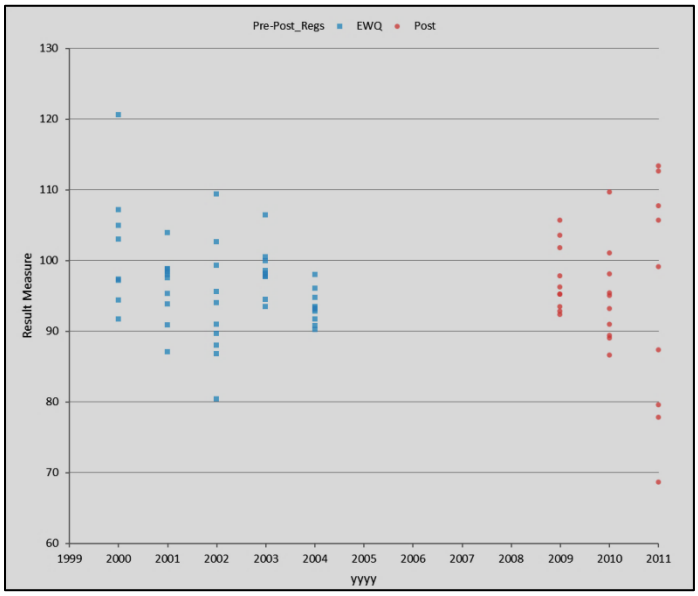
Chapter 17: 1837 BCP Lehigh River, PA

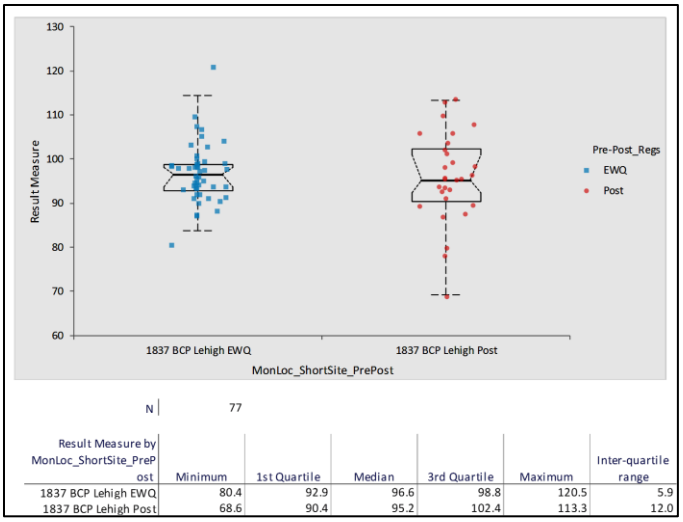
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2J):

Median 97%
Lower 95% Confidence Interval 94%
Upper 95% Confidence Interval 98%

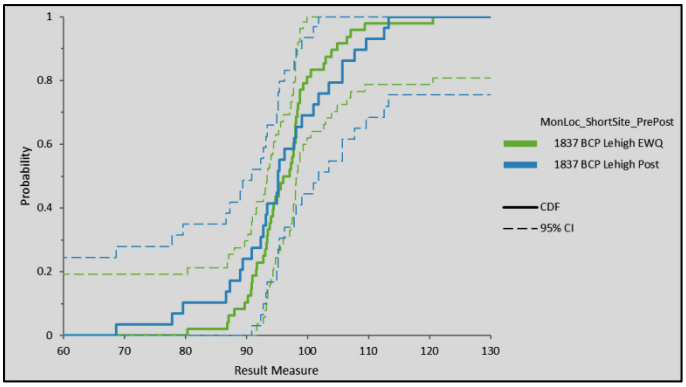






N	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	80.4	92.9	96.6	98.8	120.5	5.9
1837 BCP Lehigh Post	68.6	90.4	95.2	102.4	113.3	12.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	10.1	0.21
1837 BCP Lehigh Post	29	16.7	0.58

H statistic	0.05
X^2 approximation	0.05
DF	1
p-value	0.8171 [1]

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

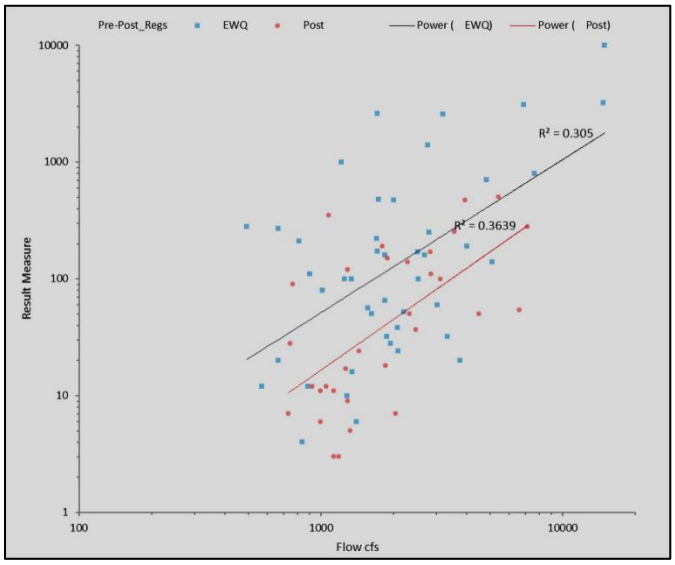
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. No known analytical uncertainty was introduced by uncontrolled variables. Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. Three measurements fell below 80% saturation, indicating an excess of oxygen-reducing material at certain times. As a rule of thumb, 80-120% is considered "normal"; in that range a balance exists between oxygen demand and supply. No PADEP data were readily available to confirm DRBC results.

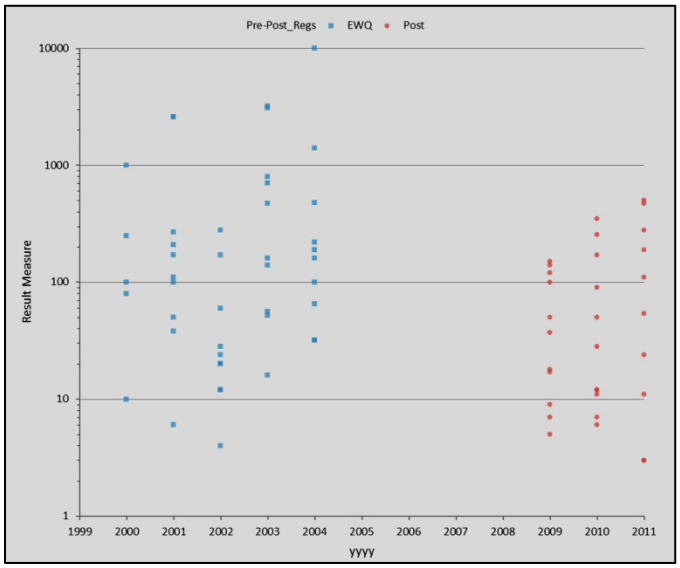
Chapter 17: 1837 BCP Lehigh River, PA

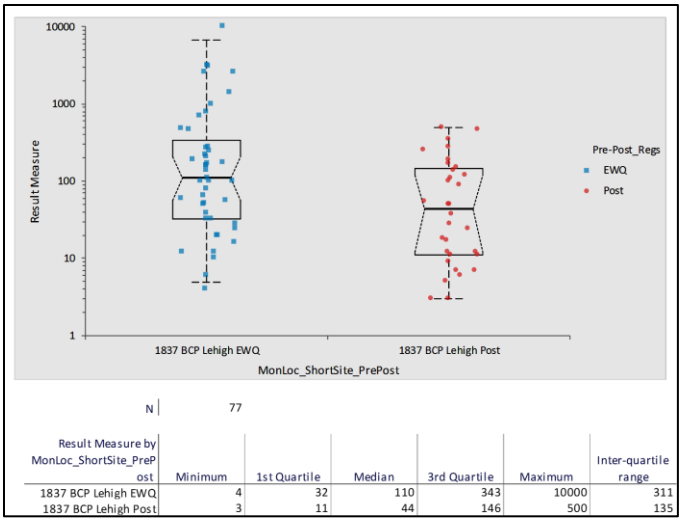
Enterococcus colonies/100 ml

Existing Water Quality (Table 2J):

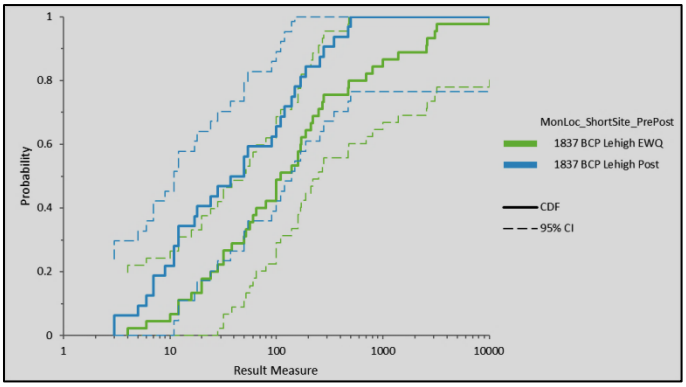
Median 110/100 ml
Lower 95% Confidence Interval 56/100 ml
Upper 95% Confidence Interval 210/100 ml







N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	4	32	110	343	10000	311
1837 BCP Lehigh Post	3	11	44	146	500	135



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	45	1456.4	32.36
1837 BCP Lehigh Post	32	2048.0	64.00

H statistic	7.01
X^2 approximation	7.01
DF	1
p-value	0.0081 [1]

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.

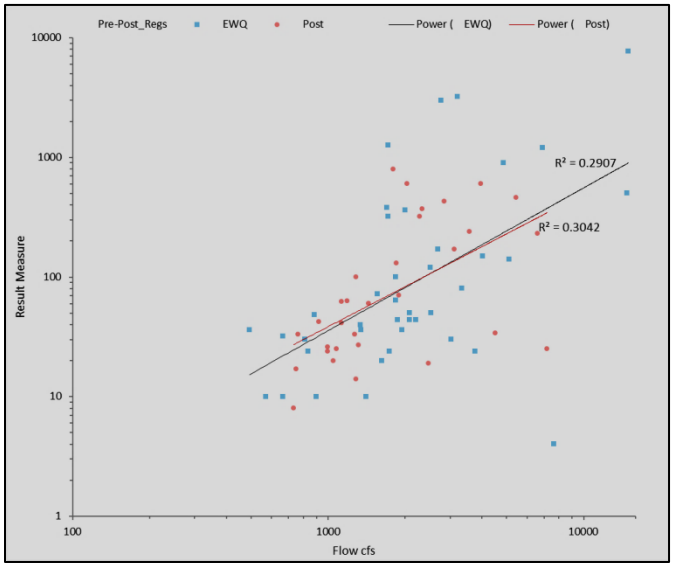
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Enterococcus concentrations are weakly related to flow in both data sets. Concentrations and flows are plotted on a logarithmic scale, and the regression is a power relationship. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval, indicating either a water quality improvement or potential laboratory artifacts.

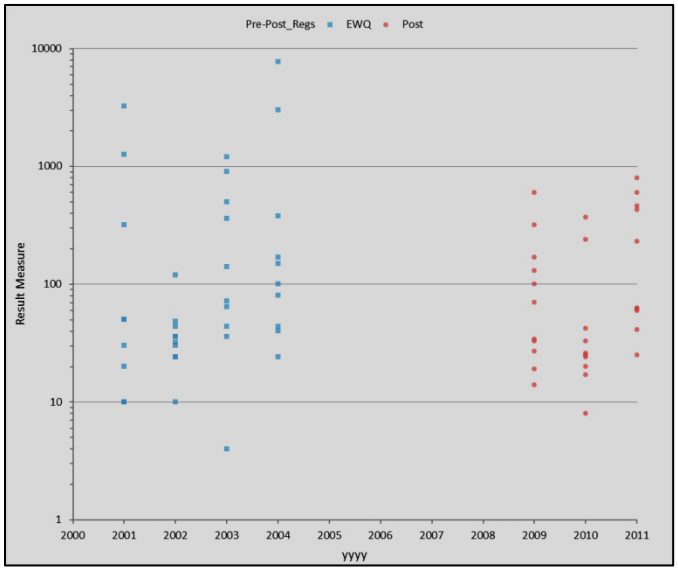
Chapter 17: 1837 BCP Lehigh River, PA

Escherichia coli colonies/100 ml

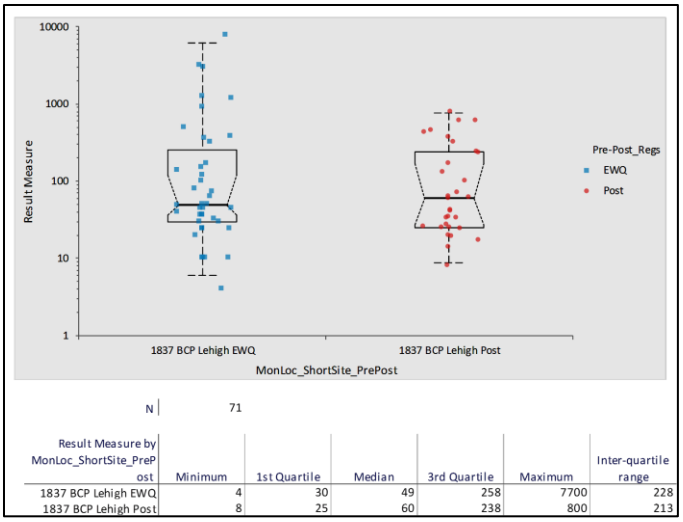
Existing Water Quality (Table 2J):

Median 49/100 ml
Lower 95% Confidence Interval 36/100 ml
Upper 95% Confidence Interval 120/100 ml
Designated in DRBC rules as flow-related

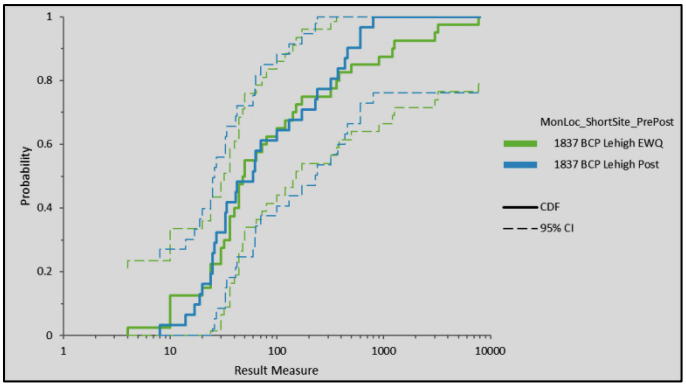




No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts.



N	71					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	4	30	49	258	7700	228
1837 BCP Lehigh Post	8	25	60	238	800	213



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	40	16.3	0.41
1837 BCP Lehigh Post	31	21.0	0.68

H statistic	0.09
X^2 approximation	0.09
DF	1
p-value	0.7674 [1]

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

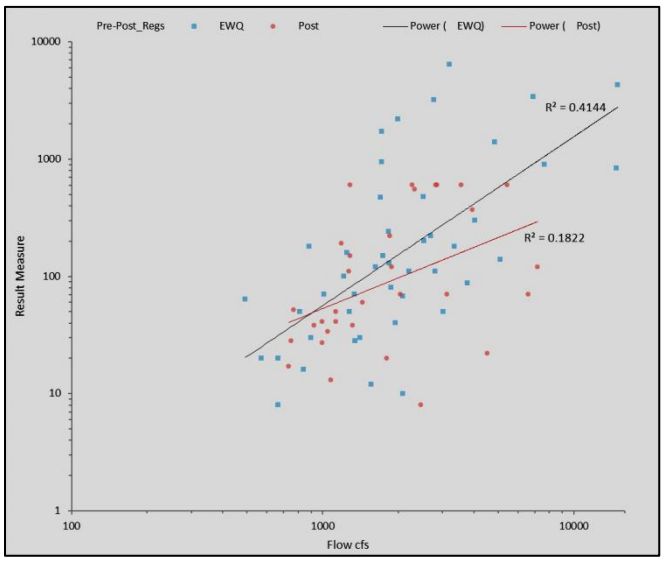
Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on a logarithmic scale, and regressions are power relationships. E. coli concentrations are weakly related to flow in both data sets. Pennsylvania DEP or USGS data were not available to validate DRBC results.

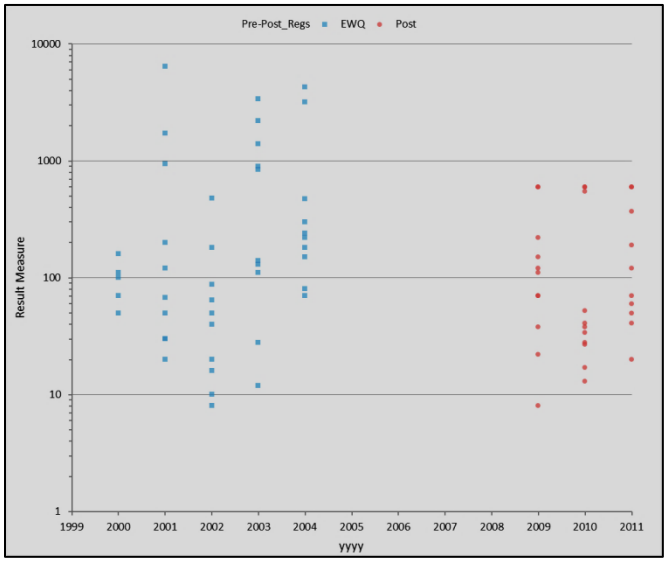
Chapter 17: 1837 BCP Lehigh River, PA

Fecal coliform colonies/100 ml

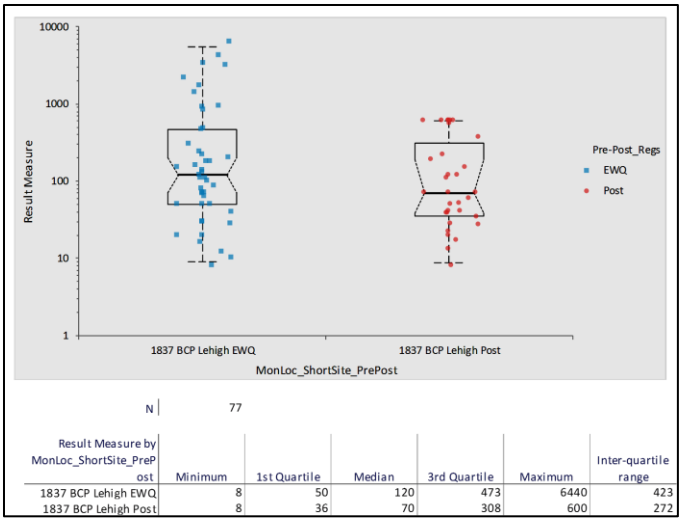
Existing Water Quality (Table 2J):

Median 120/100 ml
Lower 95% Confidence Interval 70/100 ml
Upper 95% Confidence Interval 200/100 ml
Designated in DRBC rules as flow-related



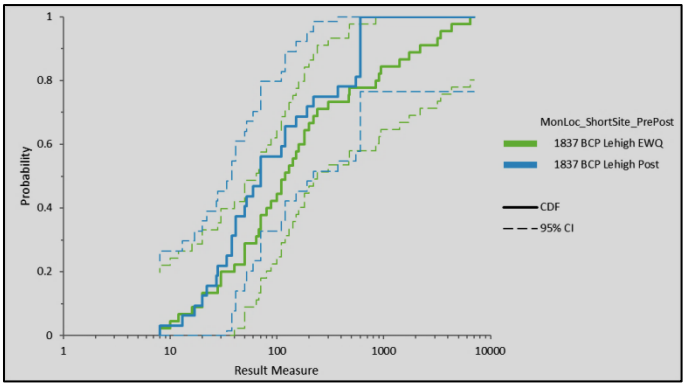


No water quality degradation is evident here. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. There were fewer high results in the post-EWQ data set due to 3 truncated laboratory upper quantitation limits, though these did not affect comparisons.



N	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	8	50	120	473	6440	423
1837 BCP Lehigh Post	8	36	70	308	600	272



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	45	361.3	8.03
1837 BCP Lehigh Post	32	508.0	15.88

H statistic	1.74
X^2 approximation	1.74
DF	1
p-value	0.1873 [1]

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

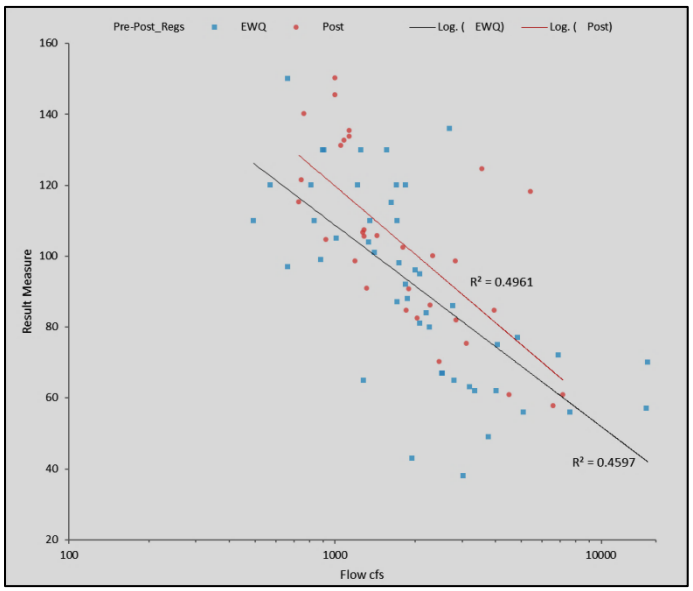
Uncertainty is introduced into analyses by potential laboratory artifacts. Fecal coliform concentrations are weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations and flows are plotted on a logarithmic scale, and regressions are power relationships. There were insufficient PADEP data for comparison with DRBC results.

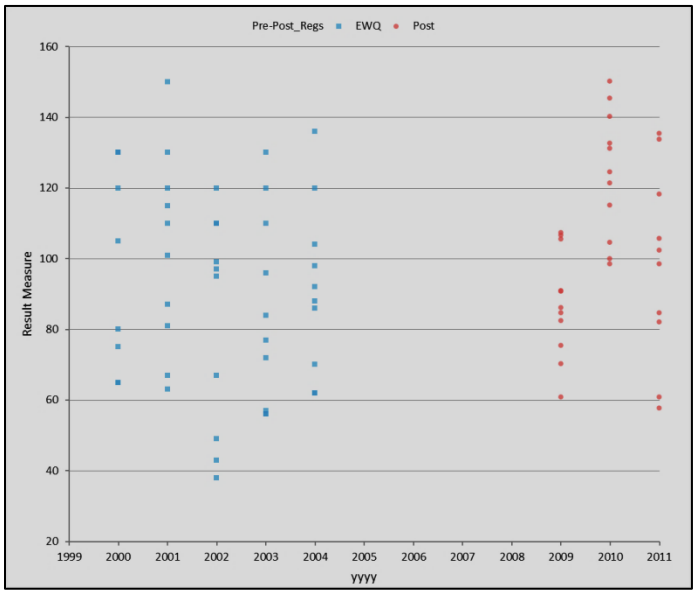
Chapter 17: 1837 BCP Lehigh River, PA

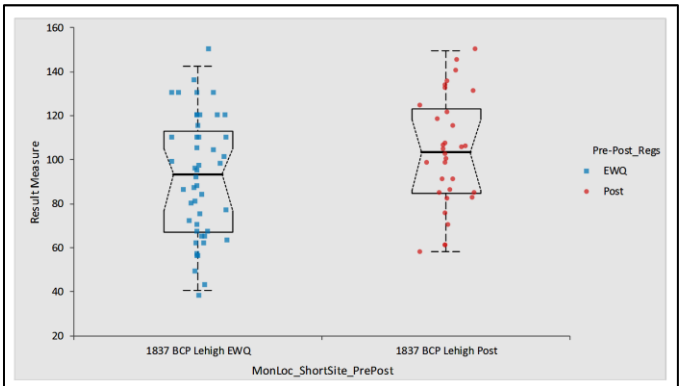
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2J):

Median 94 mg/l
Lower 95% Confidence Interval 77 mg/l
Upper 95% Confidence Interval 105 mg/l
Defined in regulations as a flow-related parameter

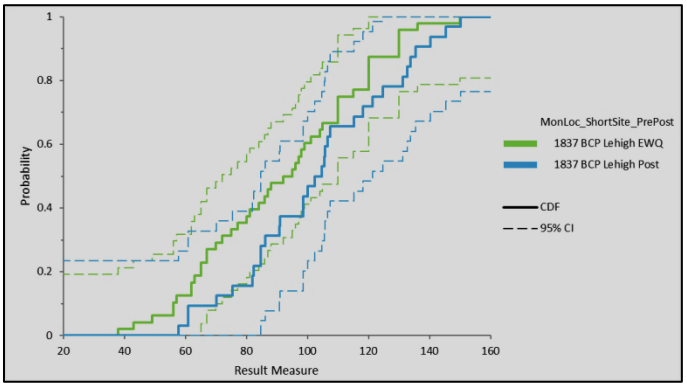






N	80

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	38	67	94	113	150	46
1837 BCP Lehigh Post	58	85	104	123	150	39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	697.7	14.54
1837 BCP Lehigh Post	32	1046.5	32.70

H statistic	3.23
X^2 approximation	3.23
DF	1
p-value	0.0722 [1]

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

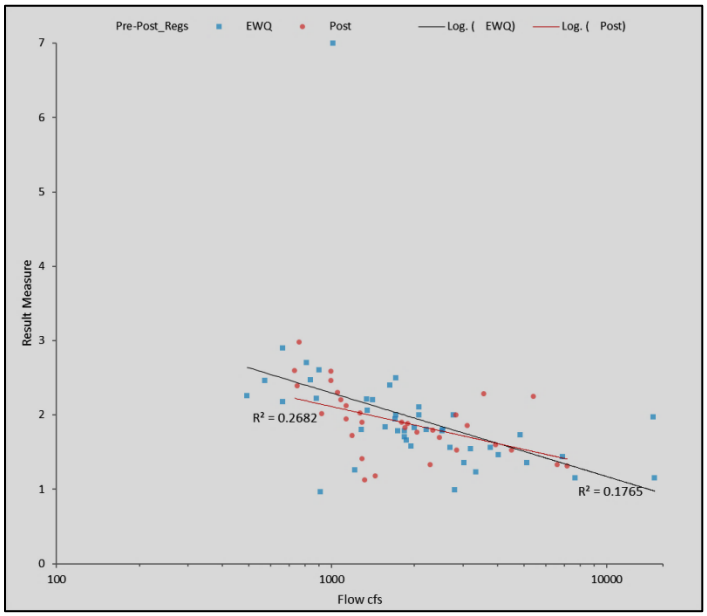
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. PADEP data were similar to DRBC results.

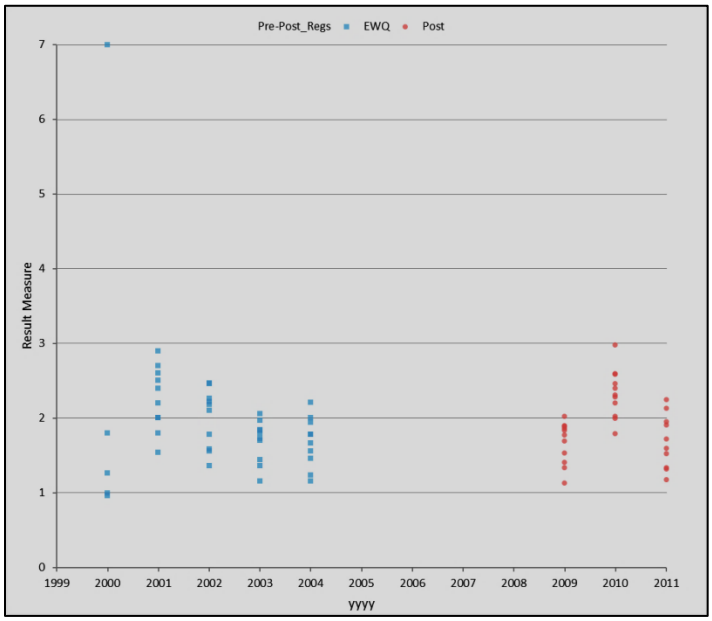
Chapter 17: 1837 BCP Lehigh River, PA

Nitrate + Nitrite as N, Total mg/l

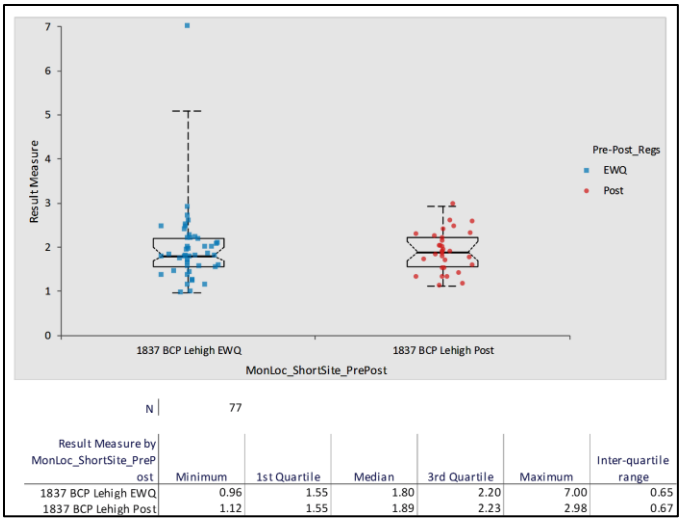
Existing Water Quality (Table 2J, as Nitrate only):

Median 1.80 mg/l
Lower 95% Confidence Interval 1.70 mg/l
Upper 95% Confidence Interval 2.00 mg/l

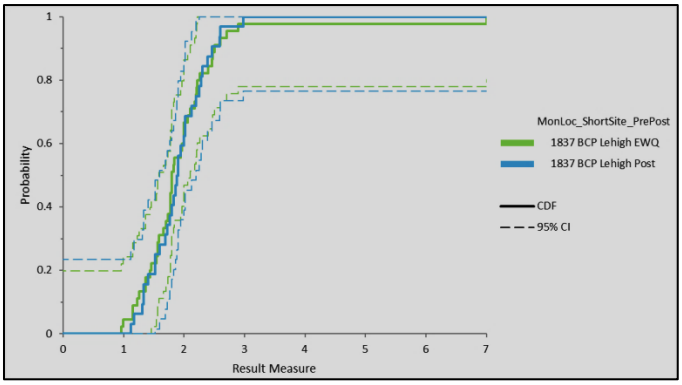




No water quality degradation is evident here. Nitrate concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Nitrate is unrelated to flow in both data sets.



N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.96	1.55	1.80	2.20	7.00	0.65
1837 BCP Lehigh Post	1.12	1.55	1.89	2.23	2.98	0.67



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	45	17.4	0.39
1837 BCP Lehigh Post	32	24.5	0.77

H statistic	0.08
X^2 approximation	0.08
DF	1
p-value	0.7722 [1]

H0: $\theta_i = \theta_2 = \theta...$
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] Do not reject the null hypothesis at the 5% significance level.

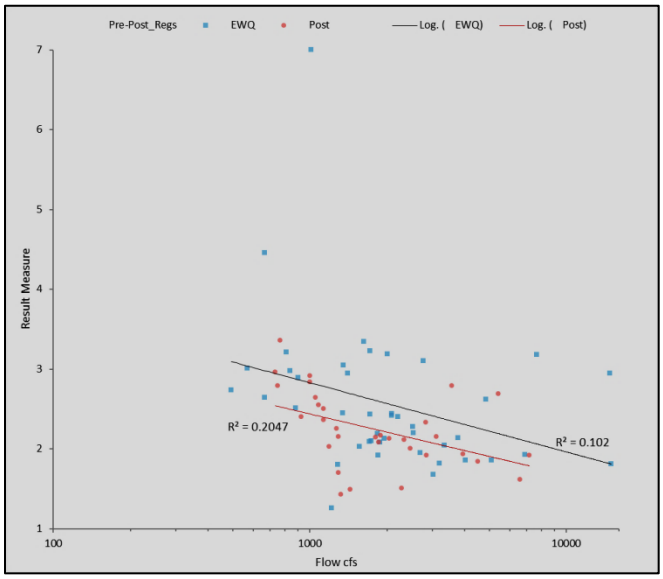
Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. PADEP results validated DRBC data. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in the Lehigh River that no such interpretive problems arose.

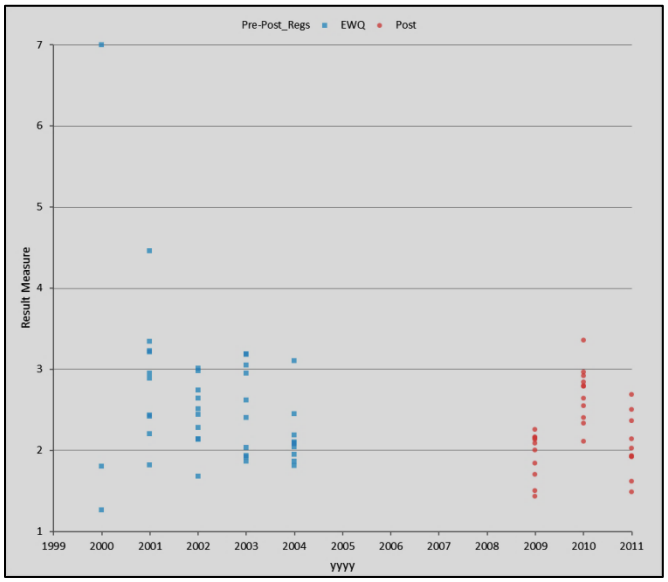
Chapter 17: 1837 BCP Lehigh River, PA

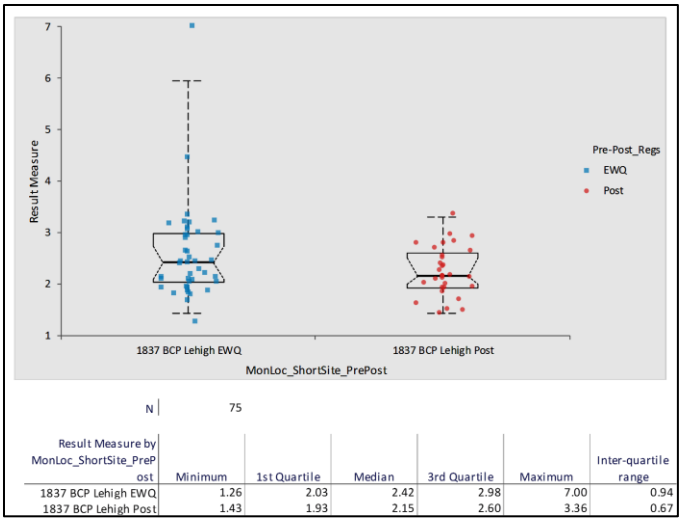
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2J):

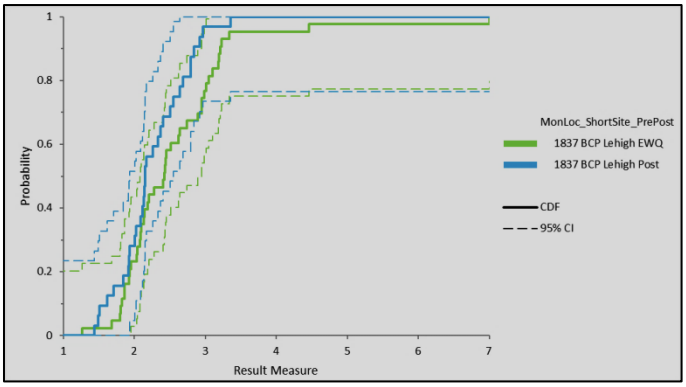
Median 2.43 mg/l
Lower 95% Confidence Interval 2.13 mg/l
Upper 95% Confidence Interval 2.74 mg/l







N	75					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	1.26	2.03	2.42	2.98	7.00	0.94
1837 BCP Lehigh Post	1.43	1.93	2.15	2.60	3.36	0.67



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	43	489.0	11.37
1837 BCP Lehigh Post	32	657.0	20.53

H statistic	2.41
X^2 approximation	2.41
DF	1
p-value	0.1204 [1]

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

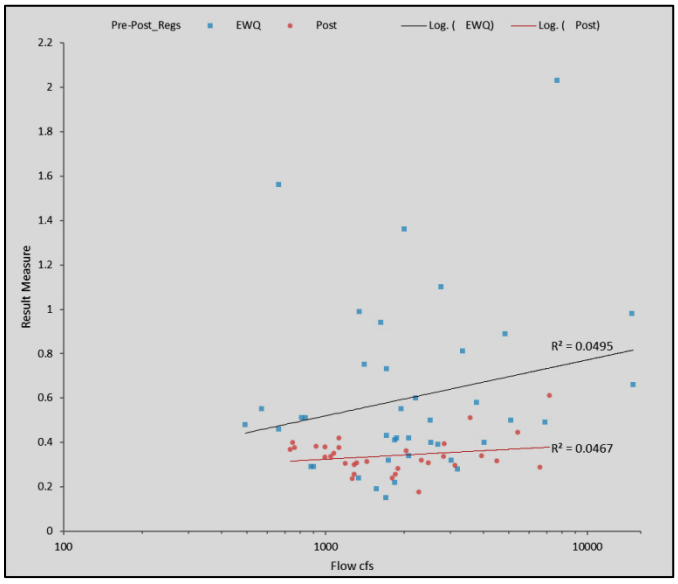
No water quality degradation is evident here. Total Nitrogen concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. TN is unrelated to flow in both data sets. Post-EWQ PADEP data were comparable to DRBC results, though there were insufficient PADEP data from the EWQ period for comparison with DRBC data. Post-EWQ median TN concentration fell within the EWQ 95% confidence intervals.

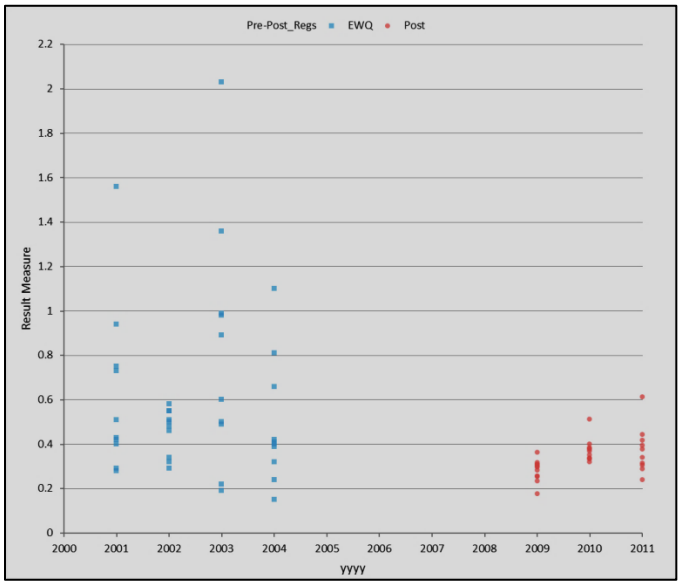
Chapter 17: 1837 BCP Lehigh River, PA

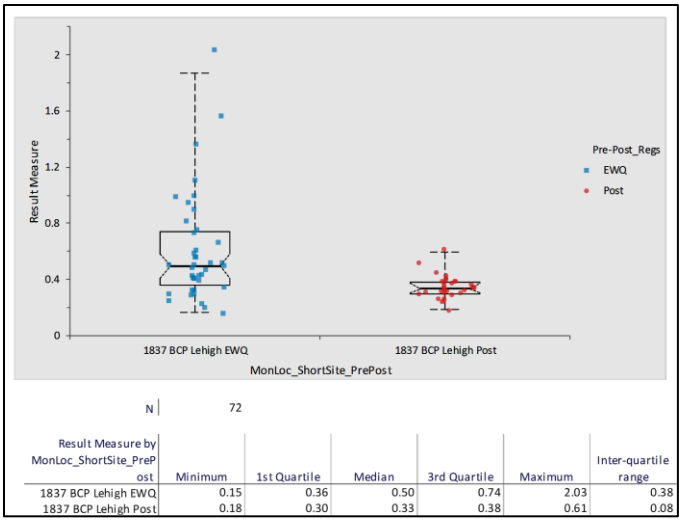
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2J):

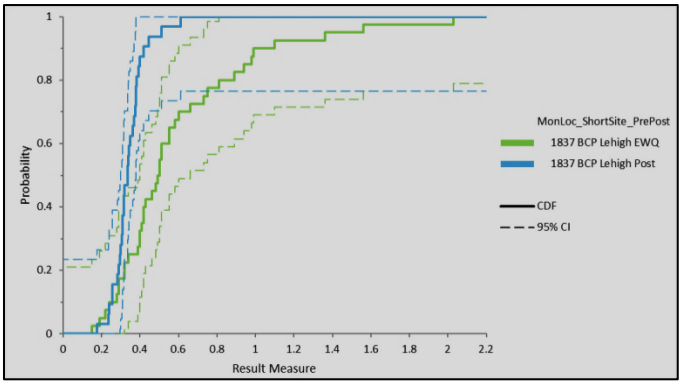
Median 0.50 mg/l
Lower 95% Confidence Interval 0.41 mg/l
Upper 95% Confidence Interval 0.58 mg/l







N	72					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.15	0.36	0.50	0.74	2.03	0.38
1837 BCP Lehigh Post	0.18	0.30	0.33	0.38	0.61	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	40	3010.2	75.26
1837 BCP Lehigh Post	32	3762.8	117.59

H statistic	15.47
X^2 approximation	15.47
DF	1
p-value	<0.0001 [1]

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.

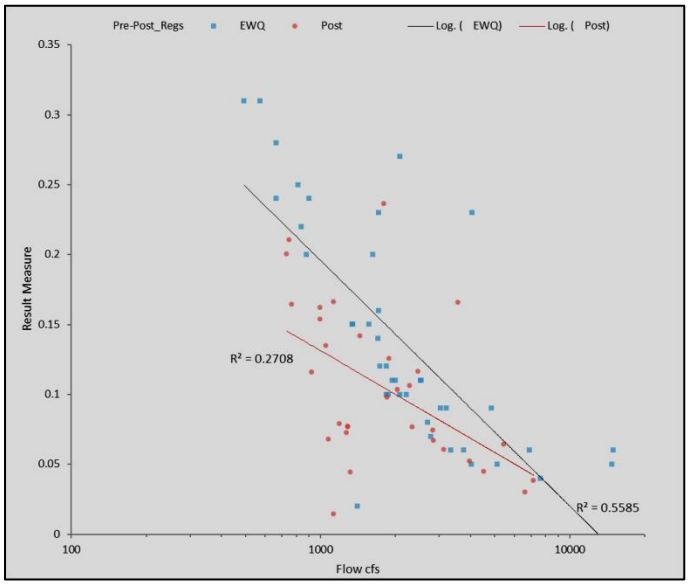
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. The post-EWQ range was far narrower and all concentrations were less than 0.6 mg/l. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval. The TKN decline was enough to offset the slight rise in nitrate, thus the slight improvement in total nitrogen concentrations. There were no additional data to confirm DRBC results.

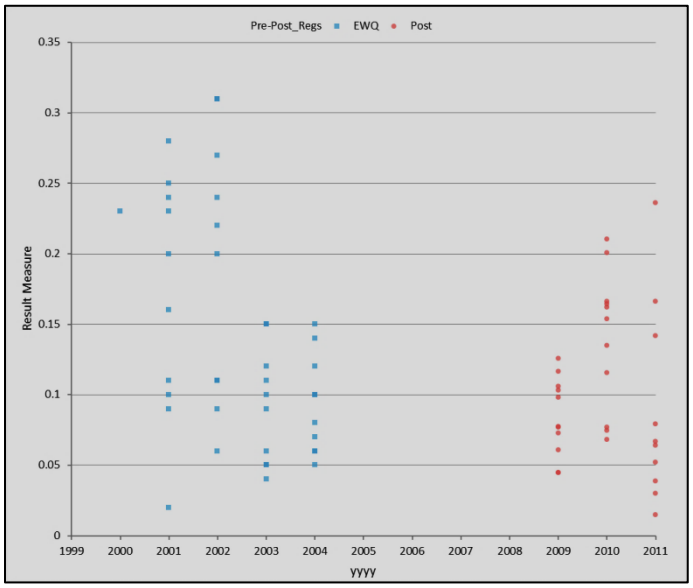
Chapter 17: 1837 BCP Lehigh River, PA

Orthophosphate as P, Total mg/l (OP)

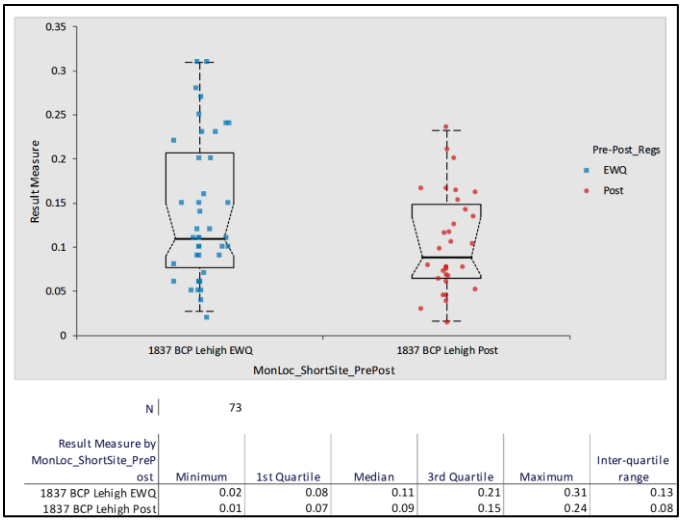
Existing Water Quality (Table 2J):

Median 0.11 mg/l
Lower 95% Confidence Interval 0.09 mg/l
Upper 95% Confidence Interval 0.15 mg/l



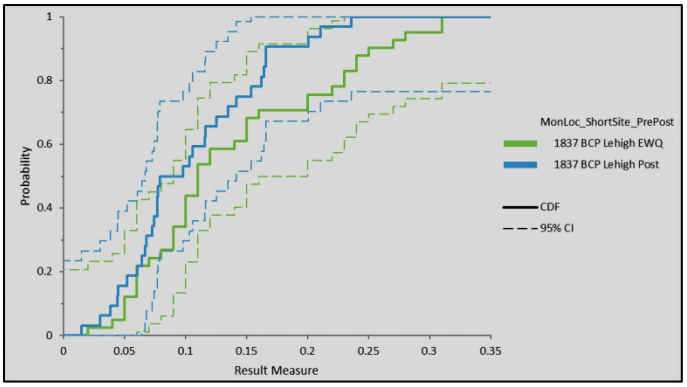


No water quality degradation is evident here. Orthophosphate concentrations did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts.



N	73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.02	0.08	0.11	0.21	0.31	0.13
1837 BCP Lehigh Post	0.01	0.07	0.09	0.15	0.24	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	41	491.8	12.00
1837 BCP Lehigh Post	32	630.1	19.69

H statistic	2.49
X^2 approximation	2.49
DF	1
p-value	0.1143 [1]

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

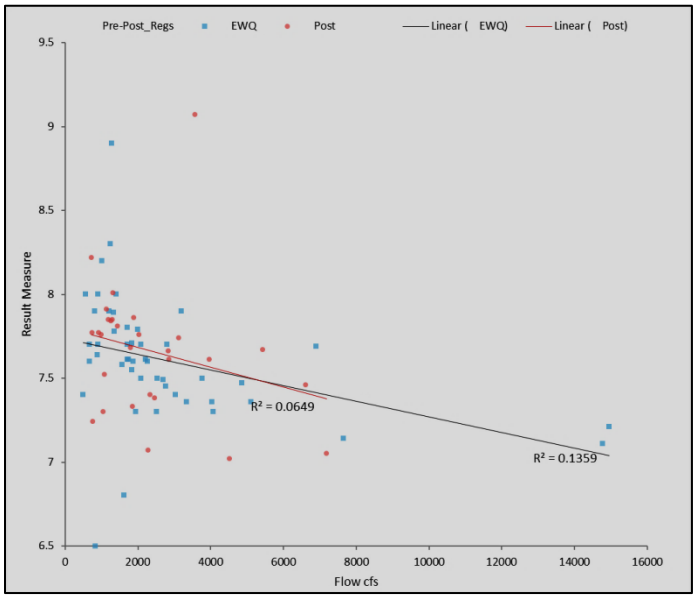
Orthophosphate is inversely related to flow in both data sets, though the relationship is weak in the post-EWQ data. Post-EWQ median orthophosphate fell within the EWQ 95% confidence intervals. Unlike in other watersheds, there were no undetected results in the EWQ or post-EWQ data, so this analysis contained no interference by differences between detection limits. PADEP data were comparable but inconsistent with DRBC results. The PADEP data indicated an increase in orthophosphate concentrations, though there were too few data for statistical significance.

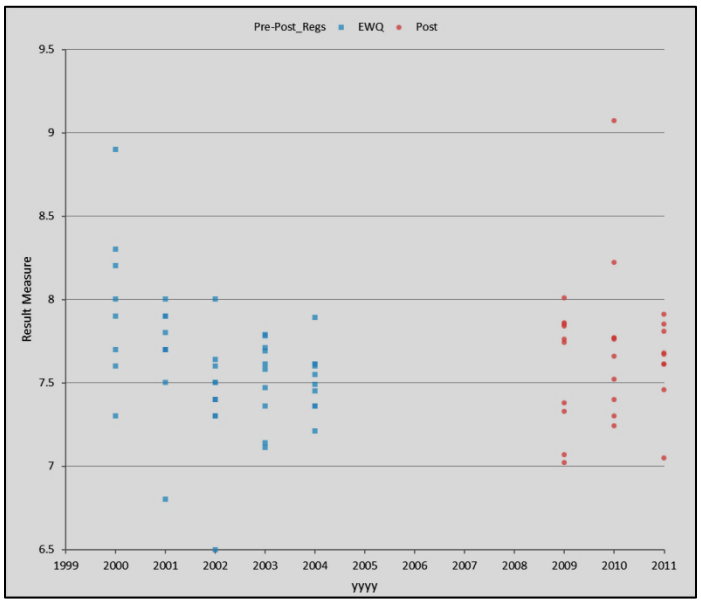
Chapter 17: 1837 BCP Lehigh River, PA

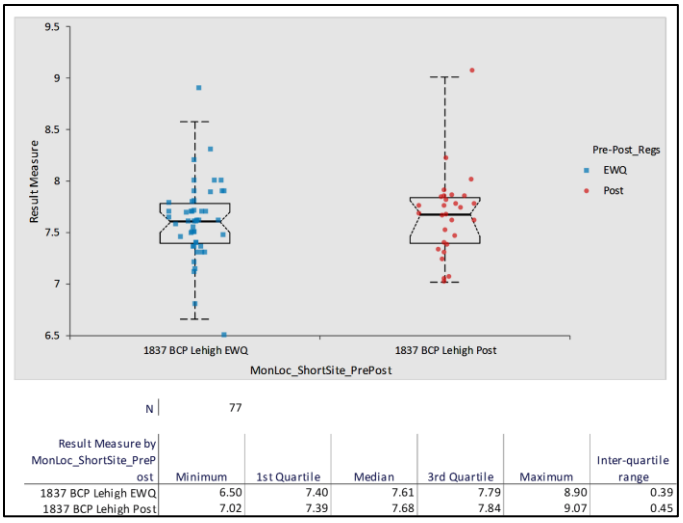
pH

Existing Water Quality (Table 2J):

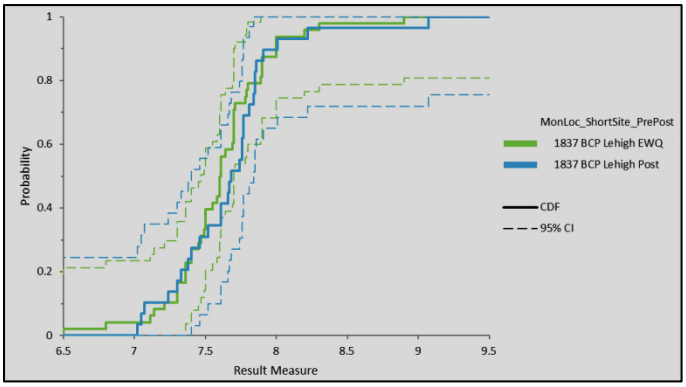
Median 7.61 standard units
Lower 95% Confidence Interval 7.50 standard units
Upper 95% Confidence Interval 7.70 standard units







N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	6.50	7.40	7.61	7.79	8.90	0.39
1837 BCP Lehigh Post	7.02	7.39	7.68	7.84	9.07	0.45



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	92.1	1.92
1837 BCP Lehigh Post	29	152.5	5.26

H statistic	0.49
X^2 approximation	0.49
DF	1
p-value	0.4843 [1]

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

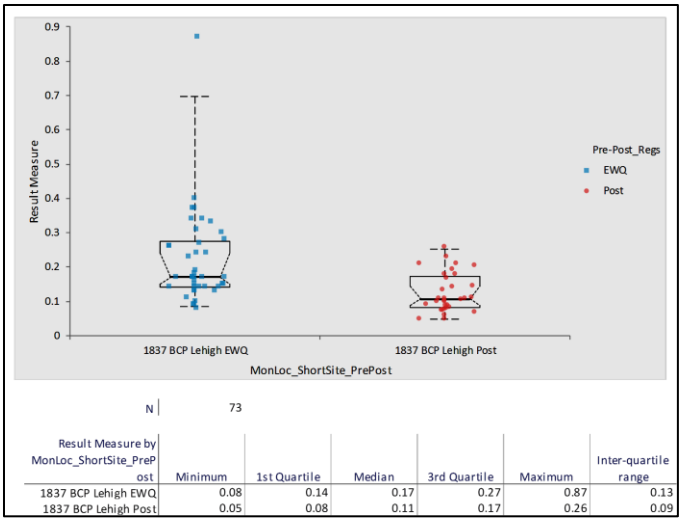
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. There were no known uncontrolled variables in these data, and so minimal uncertainty about results. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. In July 2010 there was one spike above pH 9, indicating high algal productivity during that sampling period. PADEP and USGS data confirmed DRBC results.

Chapter 17: 1837 BCP Lehigh River, PA

Phosphorus as P, Total (TP) mg/l

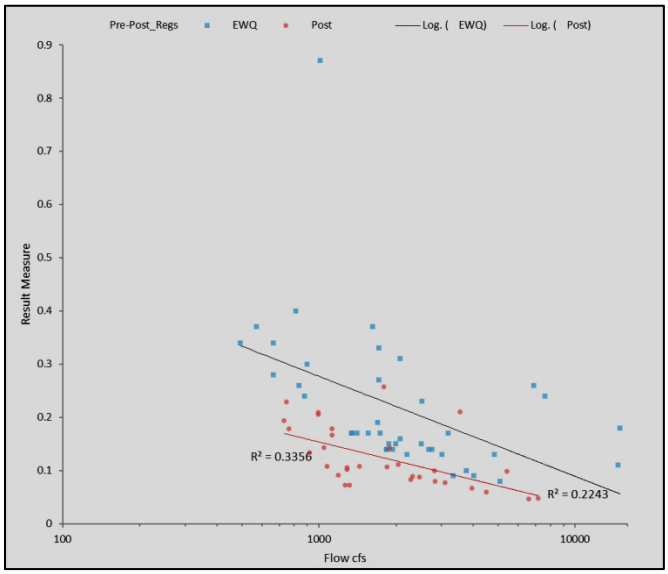
Existing Water Quality (Table 2J):

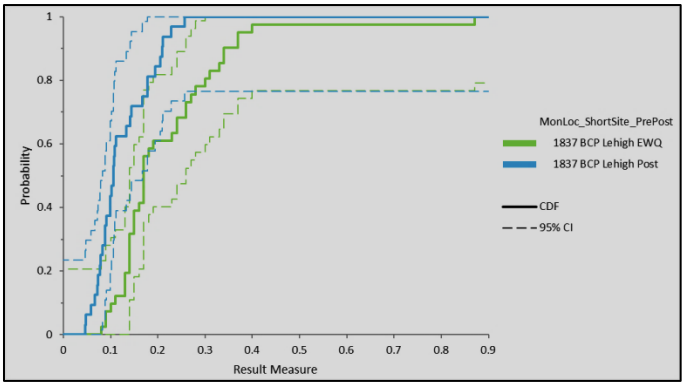
Median 0.17 mg/l
Lower 95% Confidence Interval 0.15 mg/l
Upper 95% Confidence Interval 0.24 mg/l

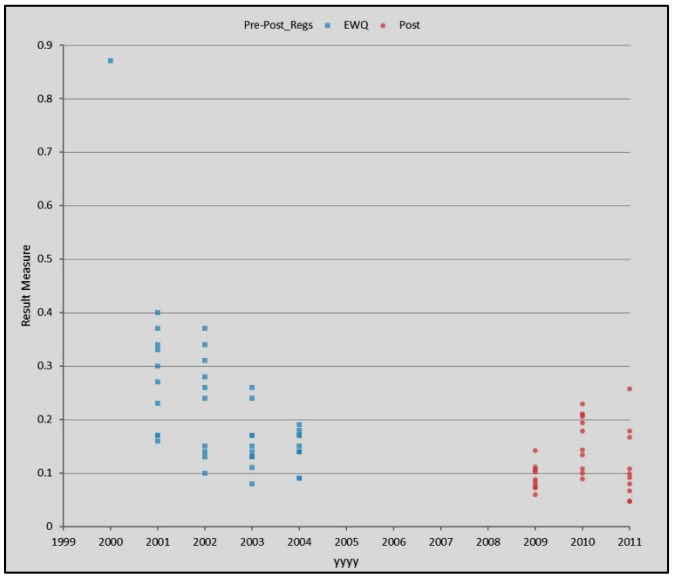


N	73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.08	0.14	0.17	0.27	0.87	0.13
1837 BCP Lehigh Post	0.05	0.08	0.11	0.17	0.26	0.09







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	41	3321.0	81.00
1837 BCP Lehigh Post	32	4255.0	132.97

H statistic	16.85
X^2 approximation	16.85
DF	1
p-value	<0.0001 [1]

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.

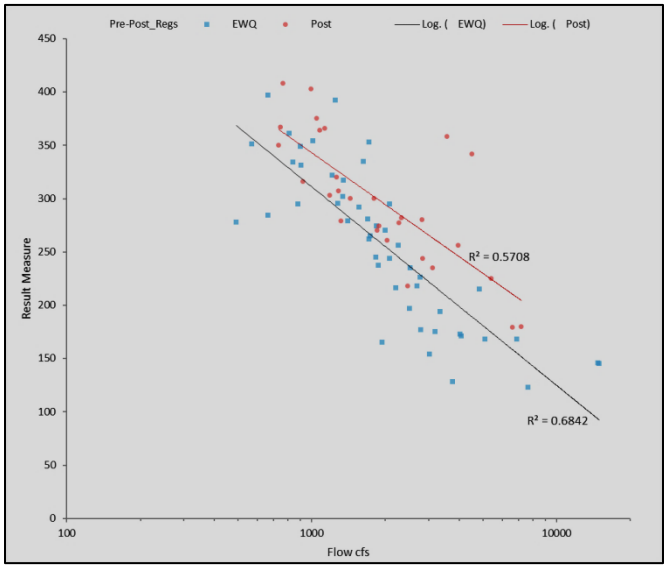
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. No additional data were available to confirm DRBC results. EWQ results were more variable than post-EWQ data, which contained no concentrations higher than 0.25 mg/l. This may constitute a water quality improvement; or may be reflective of laboratory artifacts.

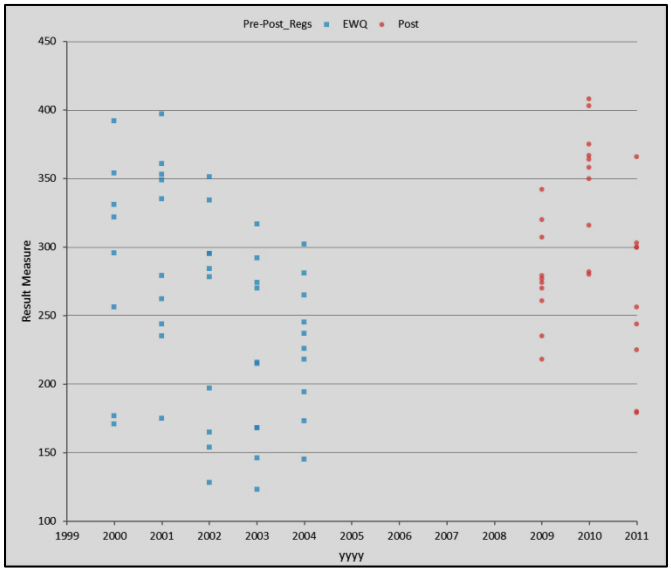
Chapter 17: 1837 BCP Lehigh River, PA

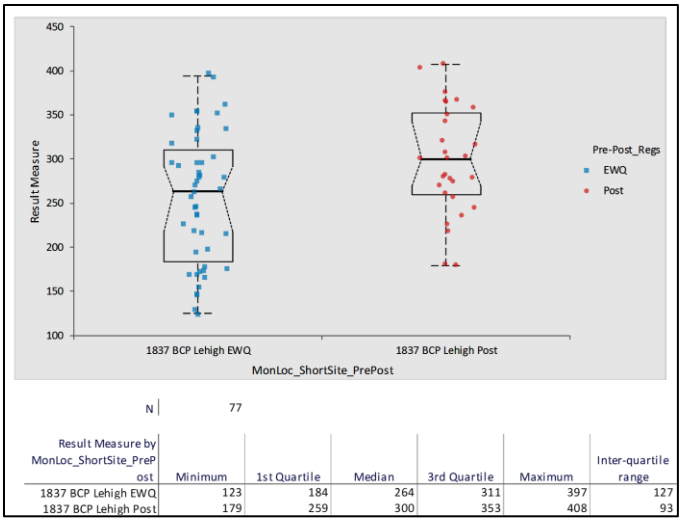
Specific Conductance µmho/cm

Existing Water Quality (Table 2J):

Median 264 µmho/cm
Lower 95% Confidence Interval 218 µmho/cm
Upper 95% Confidence Interval 292 µmho/cm
Defined in regulations as a flow-related parameter

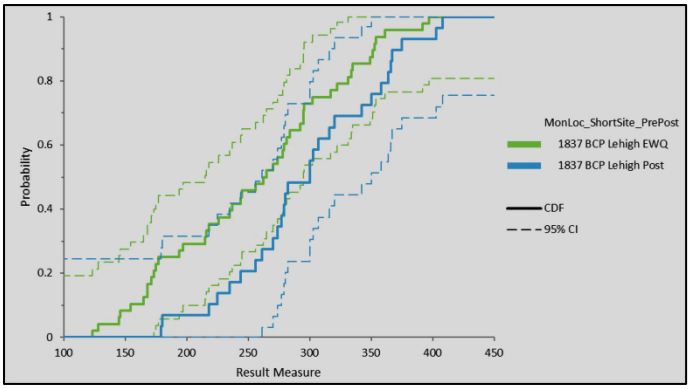






N	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	123	184	264	311	397	127
1837 BCP Lehigh Post	179	259	300	353	408	93



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	1155.4	24.07
1837 BCP Lehigh Post	29	1912.4	65.95

H statistic	6.13
X^2 approximation	6.13
DF	1
p-value	0.0133[1]

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.

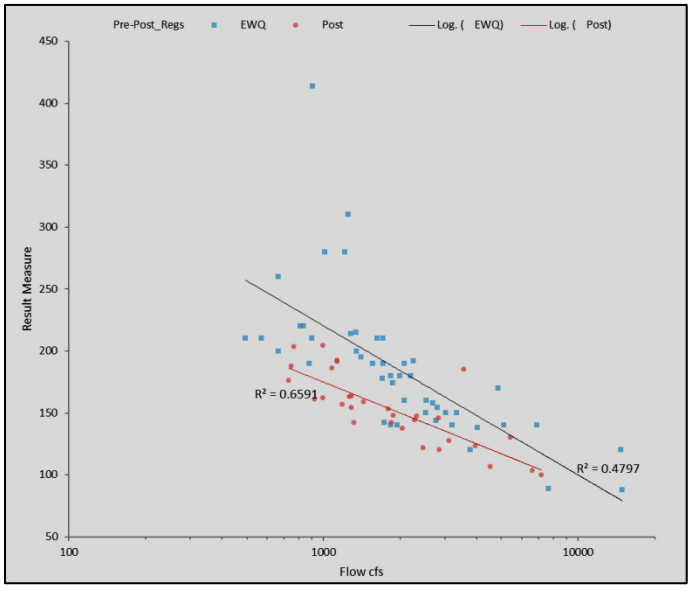
Water quality degradation is evident here. Specific conductance increased 36 µmho/cm; rising above the EWQ upper 95% confidence interval. There were no known uncontrolled variables and thus minimal analytical uncertainty in these data. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 264 to 300 µmho/cm; a 14% increase in a few years' time. Further investigation is underway. PADEP and USGS data confirmed DRBC results.

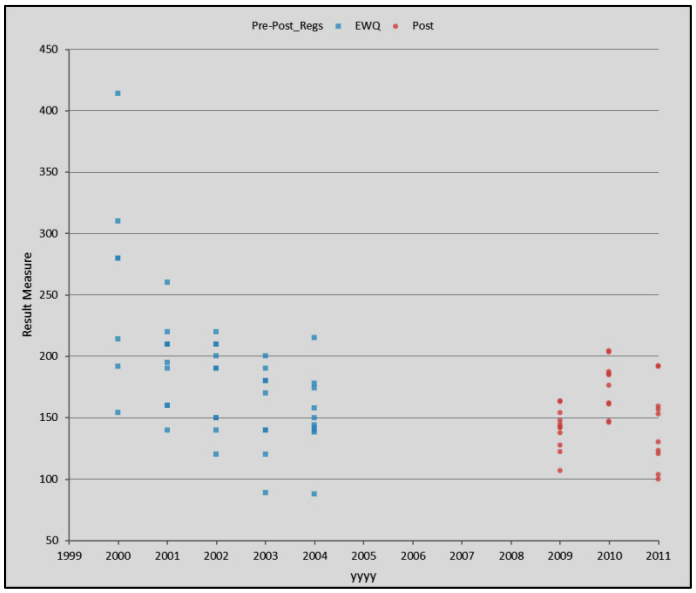
Chapter 17: 1837 BCP Lehigh River, PA

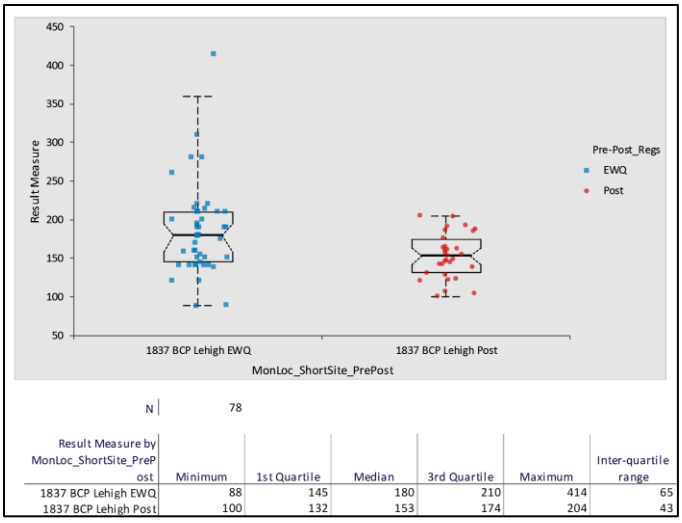
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2J):

Median 180 mg/l
Lower 95% Confidence Interval 158 mg/l
Upper 95% Confidence Interval 195 mg/l
Defined in regulations as a flow-related parameter

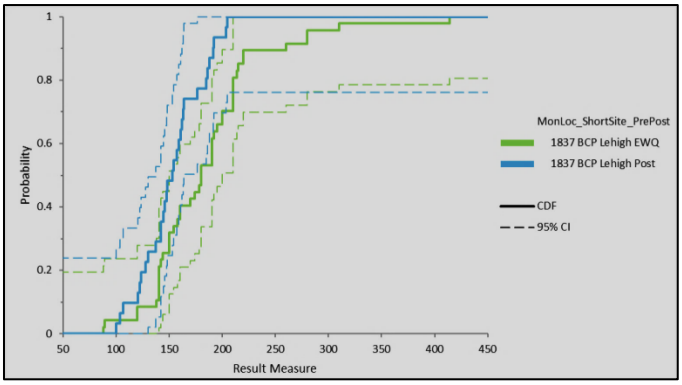






N	78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	88	145	180	210	414	65
1837 BCP Lehigh Post	100	132	153	174	204	43



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	47	1522.5	32.39
1837 BCP Lehigh Post	31	2308.3	74.46

H statistic	7.47
X^2 approximation	7.47
DF	1
p-value	0.0063 [1]

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.

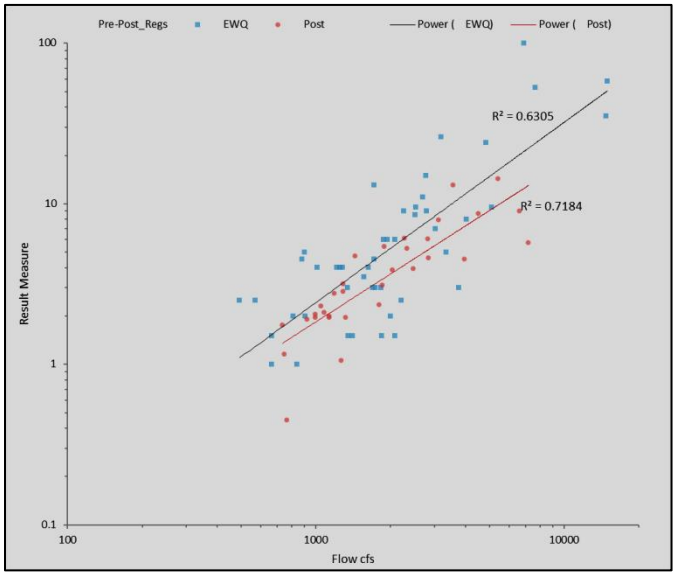
No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was 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. PADEP data showed an increase between the two periods – results were comparable with DRBC data in the post-EWQ period, but DRBC EWQ data were more variable, especially in the 2000 data set.

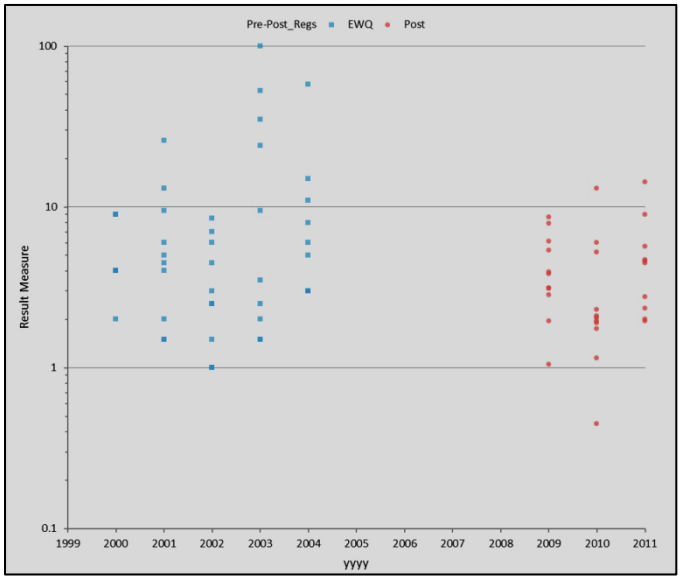
Chapter 17: 1837 BCP Lehigh River, PA

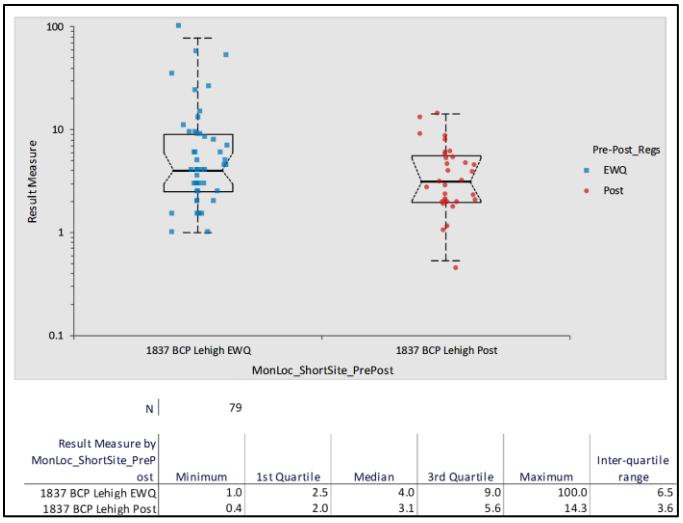
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2J):

Median 4.0 mg/l
Lower 95% Confidence Interval 3.0 mg/l
Upper 95% Confidence Interval 6.0 mg/l
<u>Should have been designated in rules as flow-related</u>

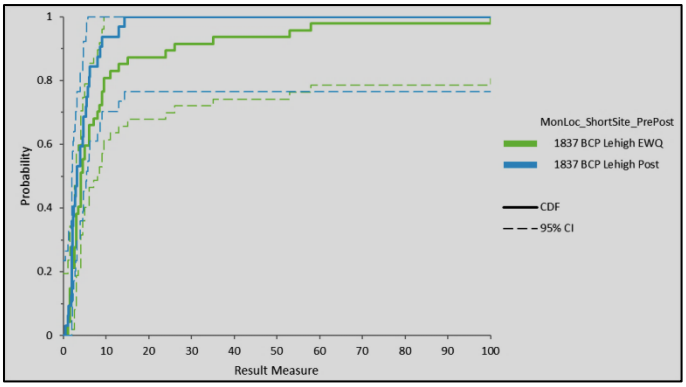






N	79

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	1.0	2.5	4.0	9.0	100.0	6.5
1837 BCP Lehigh Post	0.4	2.0	3.1	5.6	14.3	3.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	47	531.1	11.30
1837 BCP Lehigh Post	32	780.1	24.38

H statistic	2.49
X^2 approximation	2.49
DF	1
p-value	0.1144 [1]

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

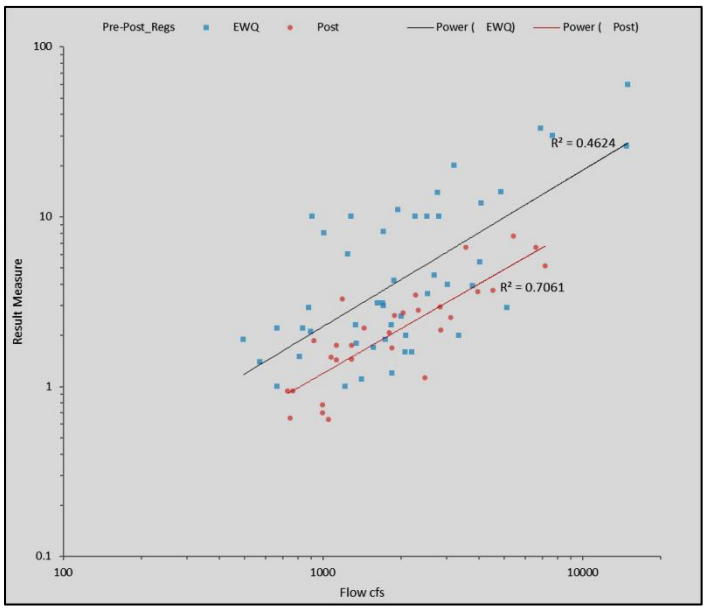
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell near the EWQ lower 95% confidence interval. Flows and concentrations are plotted on a logarithmic scale, and regressions are power relationships. There were insufficient PADEP data available to confirm DRBC results.

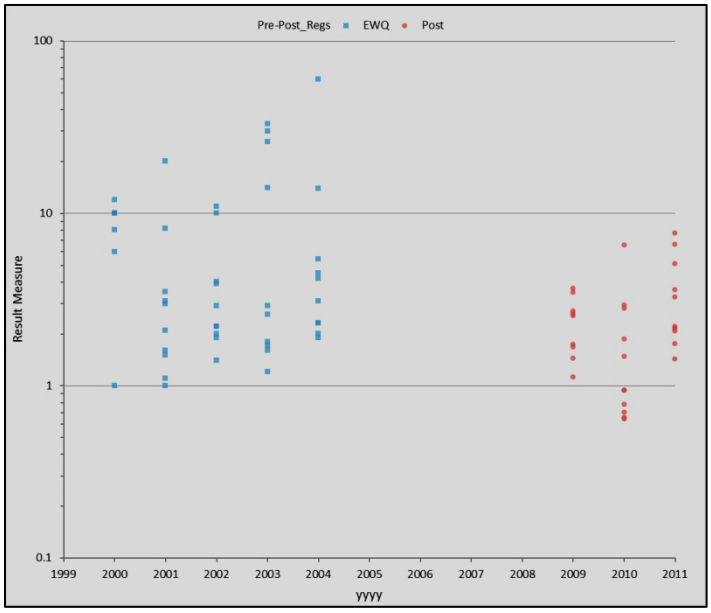
Chapter 17: 1837 BCP Lehigh River, PA

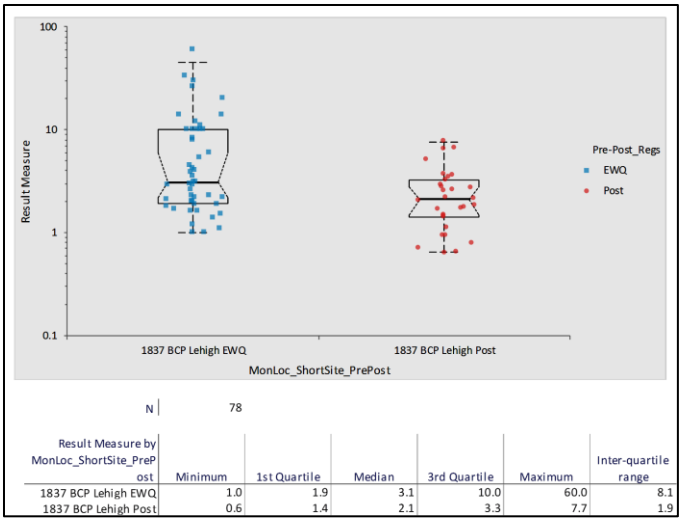
Turbidity NTU

Existing Water Quality (Table 2J):

Median 3.1 NTU
Lower 95% Confidence Interval 2.2 NTU
Upper 95% Confidence Interval 6.0 NTU
Defined in regulations as a flow-related parameter

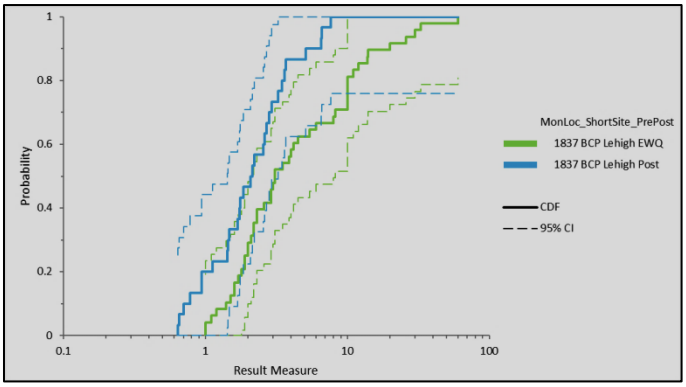






N	78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	1.0	1.9	3.1	10.0	60.0	8.1
1837 BCP Lehigh Post	0.6	1.4	2.1	3.3	7.7	1.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	1764.2	36.75
1837 BCP Lehigh Post	30	2822.7	94.09

H statistic	8.94
X^2 approximation	8.94
DF	1
p-value	0.0028 [1]

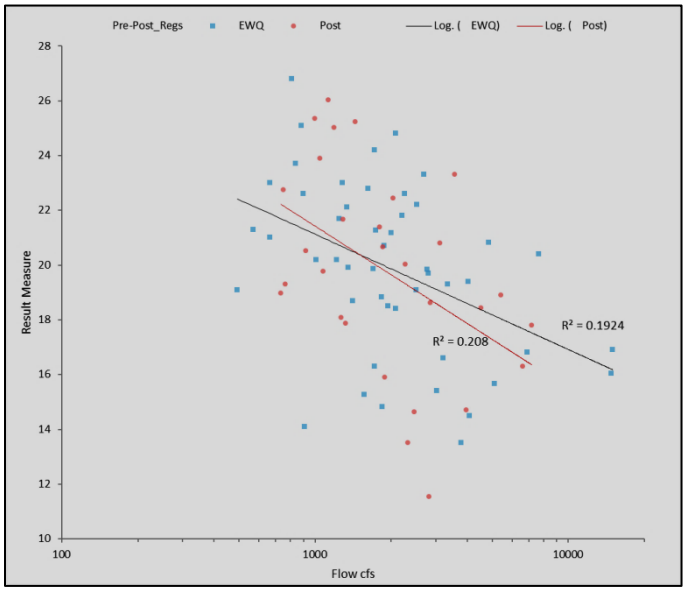
H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

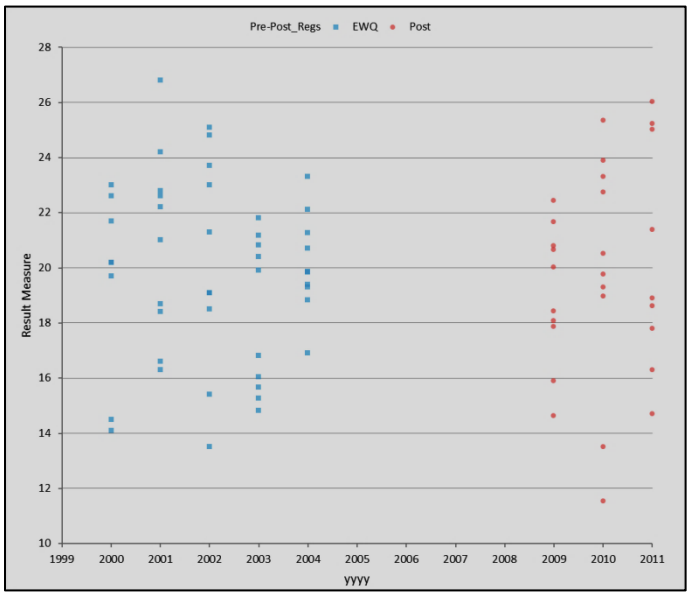
No water quality degradation is evident here. Turbidity measurably declined between the EWQ and post-EWQ periods. Uncertainty in this conclusion was introduced by relatively fewer post-EWQ high-flow samples. The post-EWQ median turbidity fell below the lower EWQ 95% confidence interval. Turbidity is positively related to flow in both data sets. Concentrations and flows are represented on logarithmic scale, and regressions are power relationships. There were no additional data available for comparison with DRBC results. High-flow conditions were under-represented in the post-EWQ sample set, so the apparent decline in turbidity may be because fewer high-flow samples were taken.

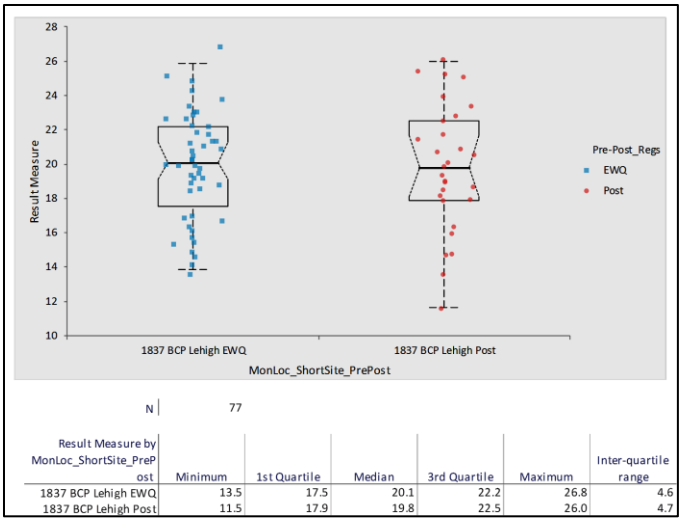
Chapter 17: 1837 BCP Lehigh River, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

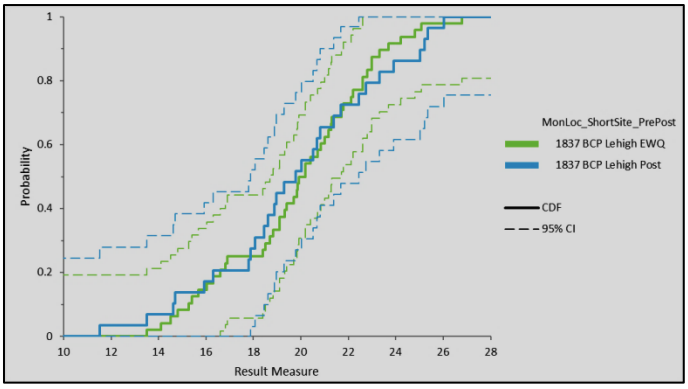






N	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	13.5	17.5	20.1	22.2	26.8	4.6
1837 BCP Lehigh Post	11.5	17.9	19.8	22.5	26.0	4.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	7.1	0.15
1837 BCP Lehigh Post	29	11.8	0.41

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8458[1]

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] 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. There were no known uncontrolled variables in these data, so there is minimal analytical uncertainty. Water temperature is weakly related to flow in both data sets. Flow is plotted on a logarithmic scale. PADEP and USGS data were available and confirmed DRBC results.