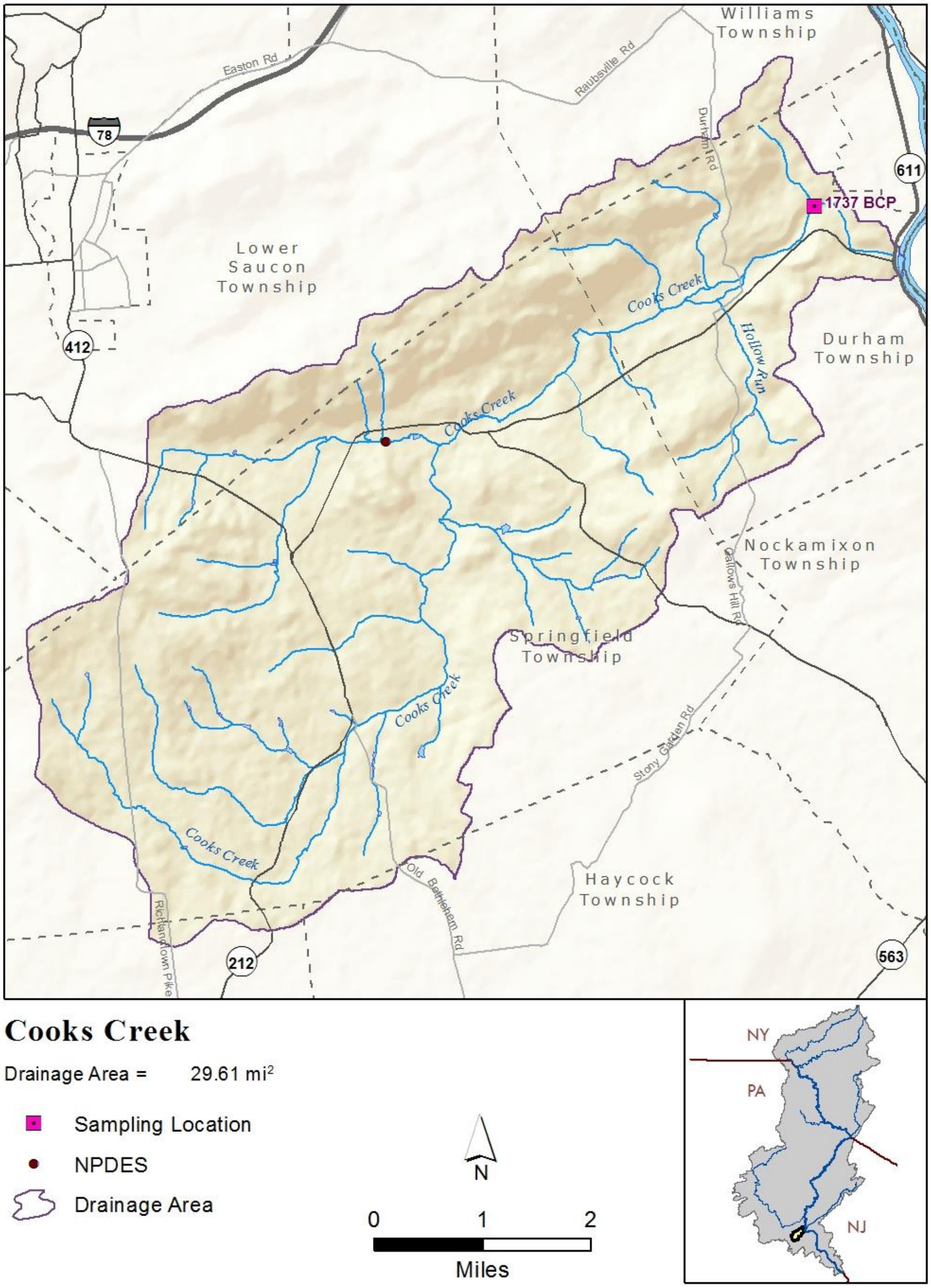
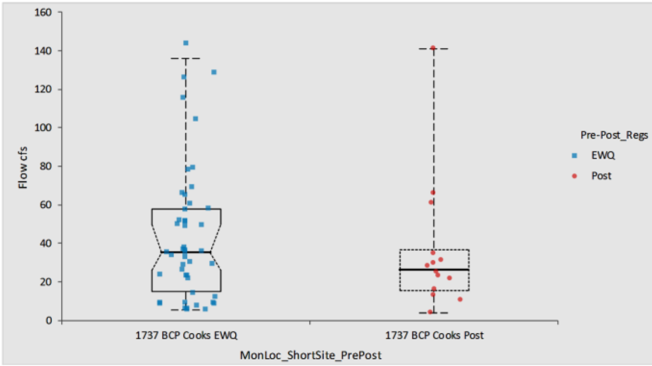

Williams Township
Lower Saucon Township
Durham Township
Nockamixon Township
Springfield Township
Haycock Township
1737 BCP
Cooks Creek
Hollow Run
Easton Rd
Raubsville Rd
Durham Rd
Gallows Hill Rd
Stony Garden Rd
Old Bethlehem Rd
Richlandtown Pike
78
611
412
212
563
Cooks Creek
Drainage Area = 29.61 mi²
Sampling Location
NPDES
Drainage Area
N
0
1
2
Miles
NY
PA
NJ

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



N	61

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	5.70	15.2	35.3	57.8	143.8	42.6
1737 BCP Cooks Post	4.00	15.7	26.5	36.7	141.0	21.1

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period. Although the range of flow conditions sampled was equal, fewer samples were collected within the 40 to 140 cfs range. Flow is plotted on a logarithmic scale.

Kruskal-Wallis test

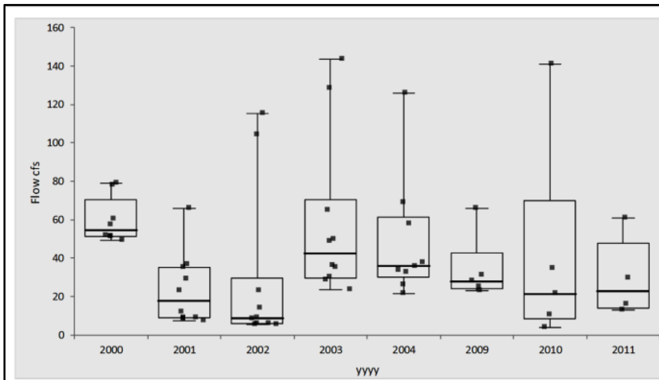
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	64.4	1.37
1737 BCP Cooks Post	14	216.1	15.43

H statistic	0.89
X^2 approximation	0.89
DF	1
p-value	0.3455 [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.

An insufficient number of samples were collected in the post-EWQ period (n=14). In the future, bi-weekly instead of monthly sampling is recommended.

At the Red Bridge Road site, the upstream Cooks Creek watershed area is 29.6 square miles. The watershed is about 60% forested, and 1.3% urban land cover. The watershed is about 36% underlain by carbonate bedrock, so expected water quality includes significant limestone influence.



N	61

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	49.2	51.6	54.4	70.5	79.0	19.0
2001	7.4	8.8	17.7	35.4	65.9	26.7
2002	5.7	6.0	8.8	29.8	115.5	23.8
2003	23.9	29.8	42.6	70.4	143.8	40.6
2004	21.7	30.3	35.9	61.6	125.9	31.3
2009	23.0	24.3	28.0	42.6	65.9	18.3
2010	4.0	8.3	21.4	70.0	141.0	61.7
2011	13.0	14.2	22.8	48.0	61.0	33.8

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 44.5 cfs; and harmonic mean flow is about 24.1 cfs (USGS StreamStats retrieval February 2013) which is more typical of summer flow conditions. Though DRBC sampled a wide range of flows, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were estimated using either a gage-discharge rating constructed by DRBC or a Delaware River Basin adaptation of the USGS BaSE* program once DRBC stopped maintaining the gage. There was an excellent correspondence between sample flows determined by the DRBC gage and BaSE-derived estimates. Maintaining a gage at DRBC's monitoring site is not economically viable.

*Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.)

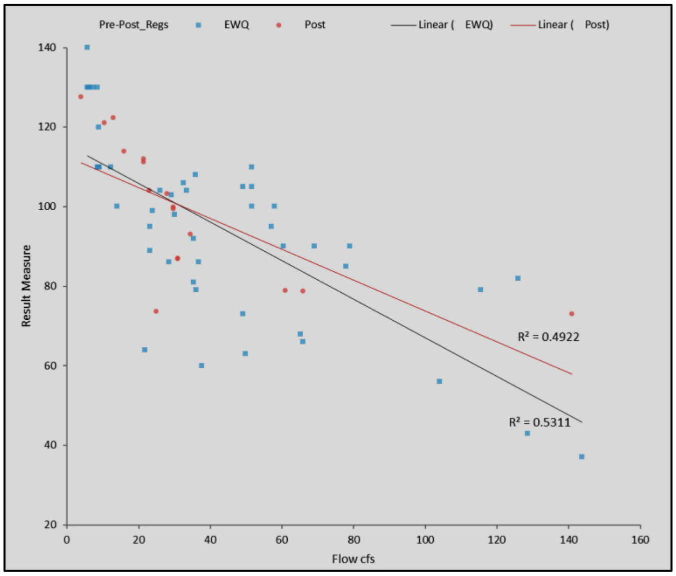
Upstream ICP: Delaware River at Riegelsville 1748 ICP
Downstream ICP: Delaware River at Milford 1677 ICP

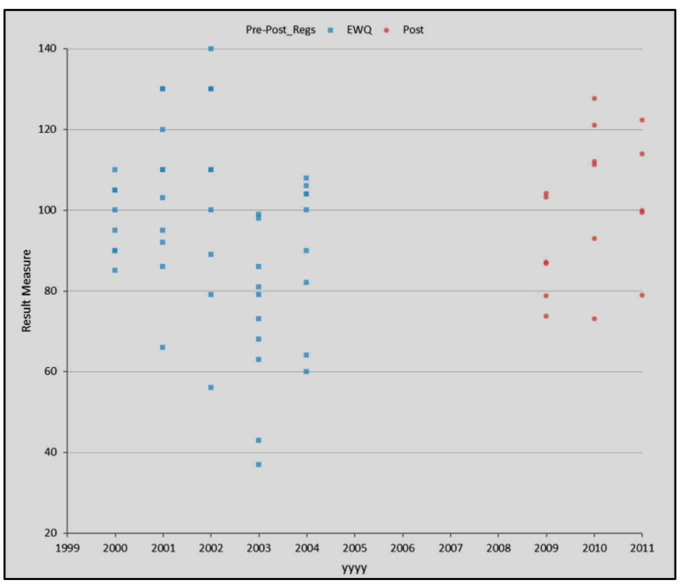
Chapter 13: 1737 BCP Cooks Creek, PA

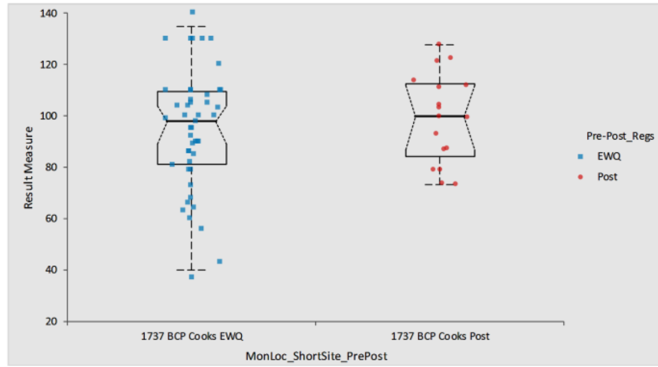
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2N):

Median 98 mg/l
Lower 95% Confidence Interval 89 mg/l
Upper 95% Confidence Interval 104 mg/l
Defined in regulations as a flow-related parameter

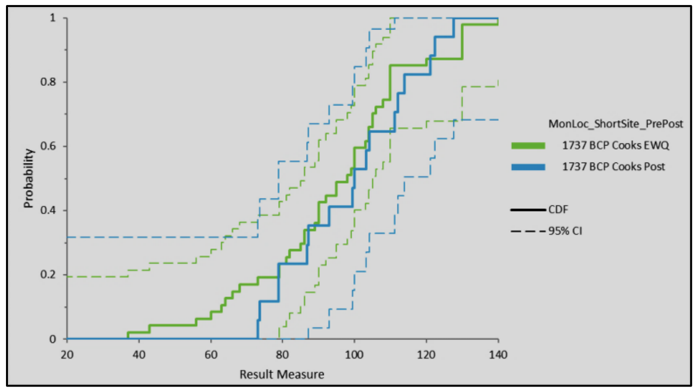






N | 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	37	81	98	110	140	29
1737 BCP Cooks Post	73	84	100	113	128	28



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	38.4	0.82
1737 BCP Cooks Post	17	106.3	6.25

H statistic	0.42
X^2 approximation	0.42
DF	1
p-value	0.5180[1]

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

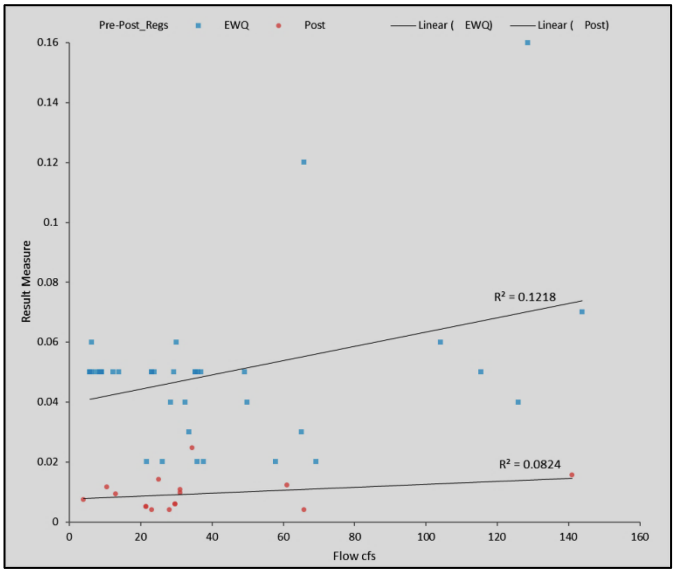
No water quality degradation is evident here. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow and concentration are plotted directly with no transformations.

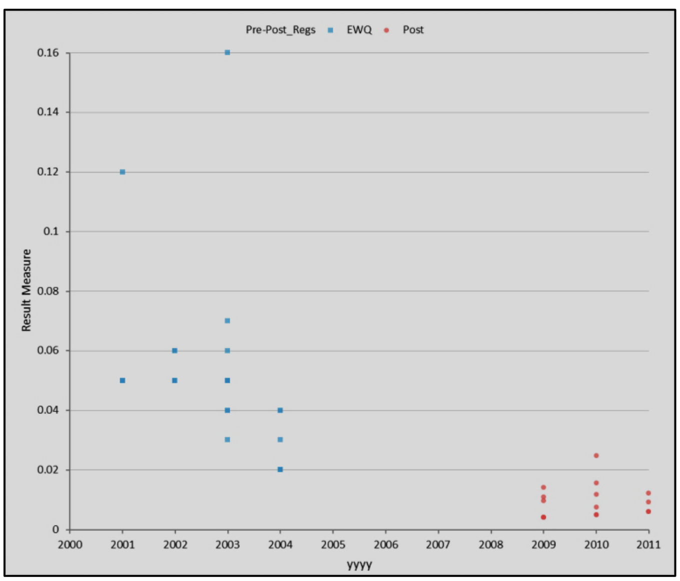
Chapter 13: 1737 BCP Cooks Creek, PA

Ammonia Nitrogen as N, Total mg/l

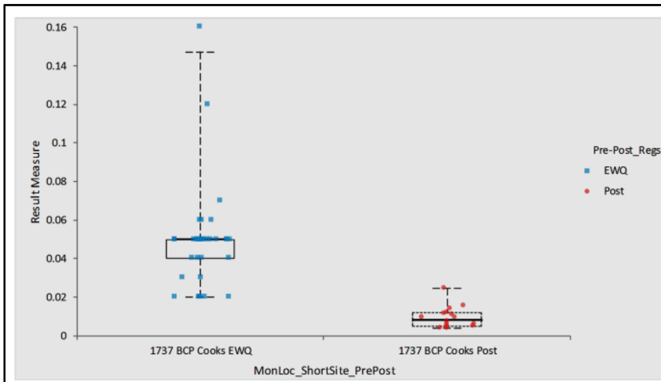
Existing Water Quality (Table 2N):

Median <0.05 mg/l
Lower 95% Confidence Interval <0.05 mg/l
Upper 95% Confidence Interval <0.05 mg/l



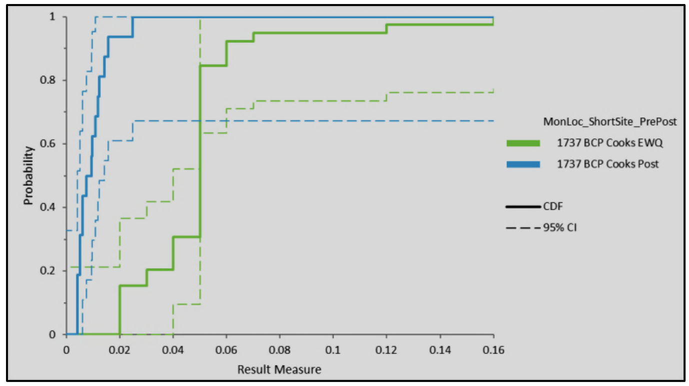


No water quality degradation is evident here. Ammonia concentrations apparently declined. Uncertainty was introduced into comparisons by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. Post-EWQ median ammonia concentration was below the EWQ lower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



N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.02	0.04	0.05	0.05	0.16	0.01
1737 BCP Cooks Post	0.00	0.01	0.01	0.01	0.02	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	2400.9	61.56
1737 BCP Cooks Post	16	5852.3	365.77

H statistic	34.12
X^2 approximation	34.12
DF	1
p-value	<0.0001 [1]

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

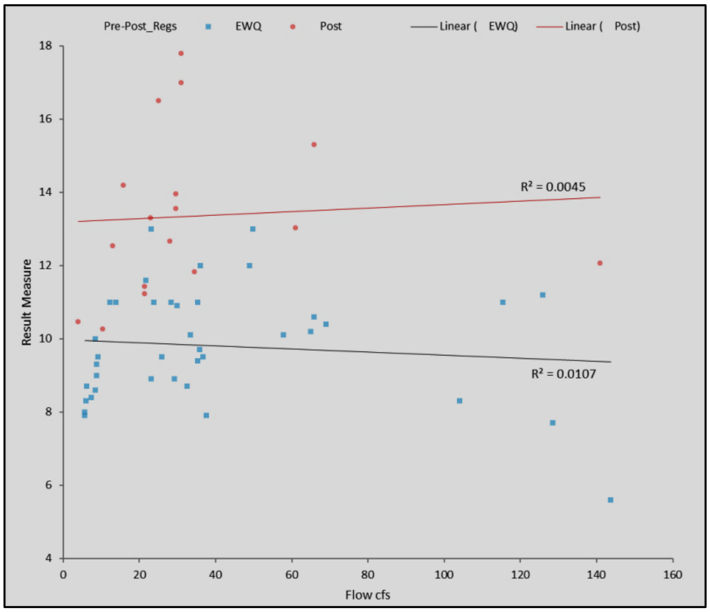
No independent data were available to validate results. EWQ data possessed 30/39 undetected results, which interfered with calculation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. 2009-2011 detection levels were very low (0.004-0.006 mg/l), yet there were still 7/16 undetected results. Thus we may have measured actual very low concentrations rather than a real change in ambient concentrations. Evidence of water quality improvement may be indicated where the post-EWQ data contained no concentrations higher than 0.02 mg/l, unless this is a laboratory artifact.

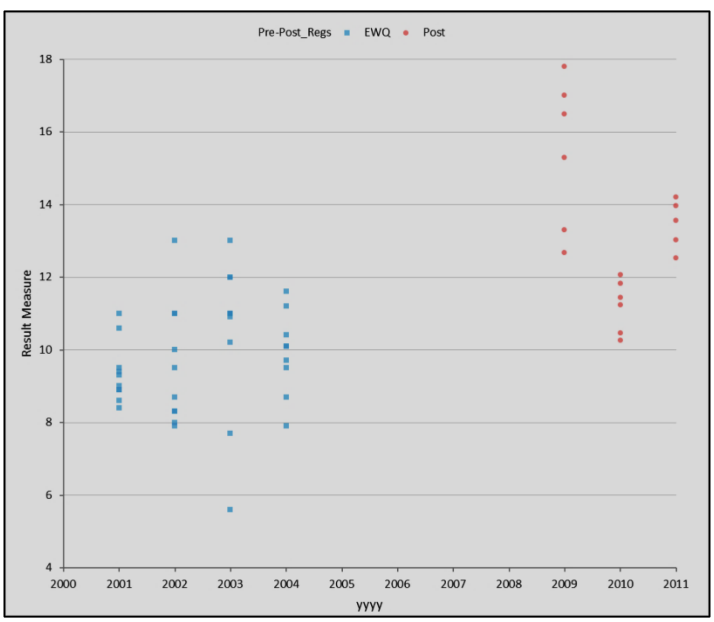
Chapter 13: 1737 BCP Cooks Creek, PA

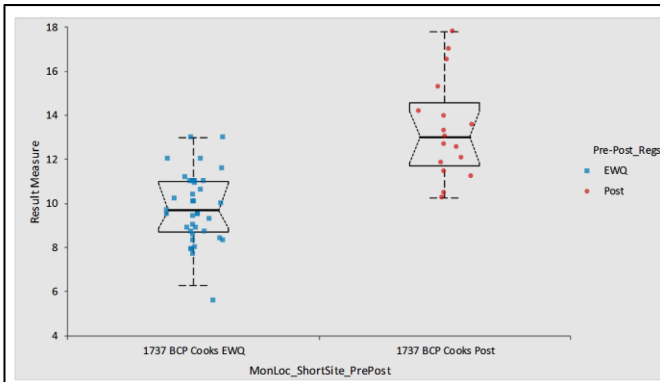
Chloride, Total mg/l

Existing Water Quality (Table 2N):

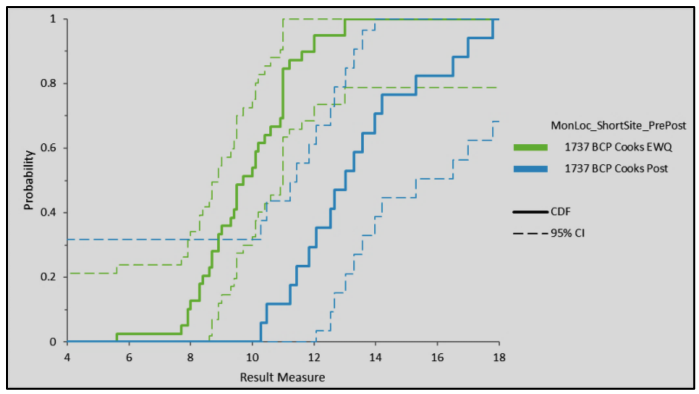
Median 9.7 mg/l
Lower 95% Confidence Interval 8.9 mg/l
Upper 95% Confidence Interval 10.9 mg/l







N	56					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	5.6	8.7	9.7	11.0	13.0	2.3
1737 BCP Cooks Post	10.3	11.7	13.0	14.6	17.8	2.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	2046.3	52.47
1737 BCP Cooks Post	17	4694.5	276.15

H statistic	25.38
X^2 approximation	25.38
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.

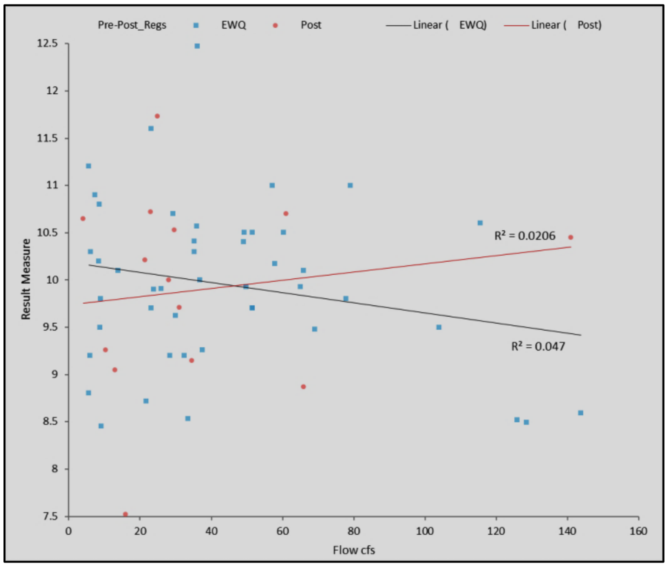
Water quality degradation is evident here. Chloride concentrations apparently rose by about 3 mg/l between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is unrelated to flow in this data set. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. No new discharge permits were issued in this watershed to account for an increase, so other sources should be investigated in this high quality watershed.

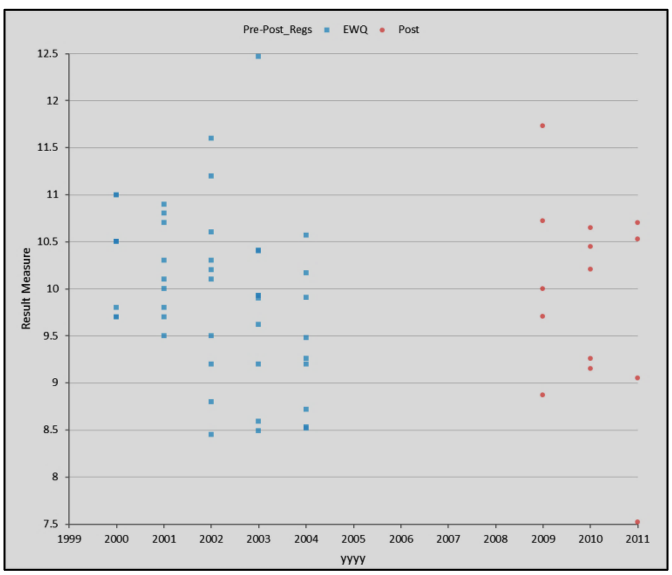
Chapter 13: 1737 BCP Cooks Creek, PA

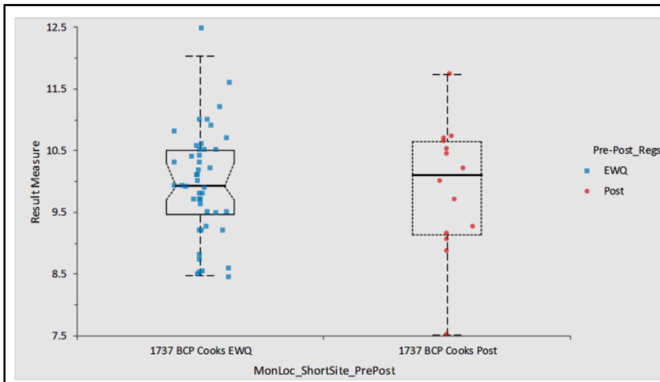
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2N):

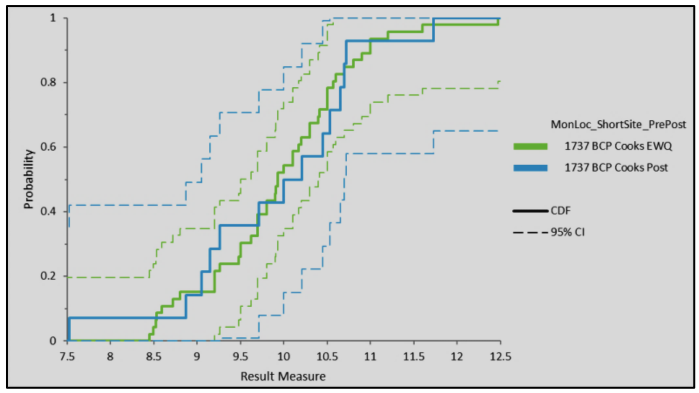
Median 9.93 mg/l
Lower 95% Confidence Interval 9.70 mg/l
Upper 95% Confidence Interval 10.30 mg/l







N	60					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	8.45	9.46	9.93	10.50	12.47	1.04
1737 BCP Cooks Post	7.52	9.14	10.11	10.65	11.73	1.51



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	2.4	0.05
1737 BCP Cooks Post	14	7.9	0.56

H statistic	0.03
X² approximation	0.03
DF	1
p-value	0.8544[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. 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.

Chapter 13: 1737 BCP Cooks Creek, PA

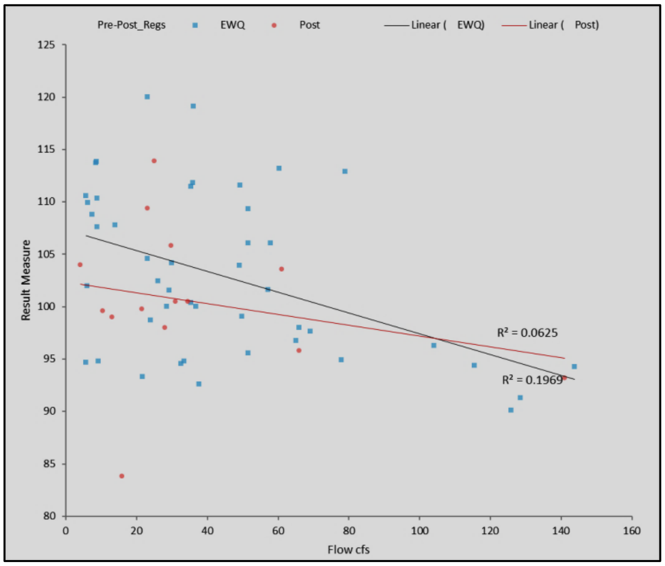
Dissolved Oxygen Saturation %

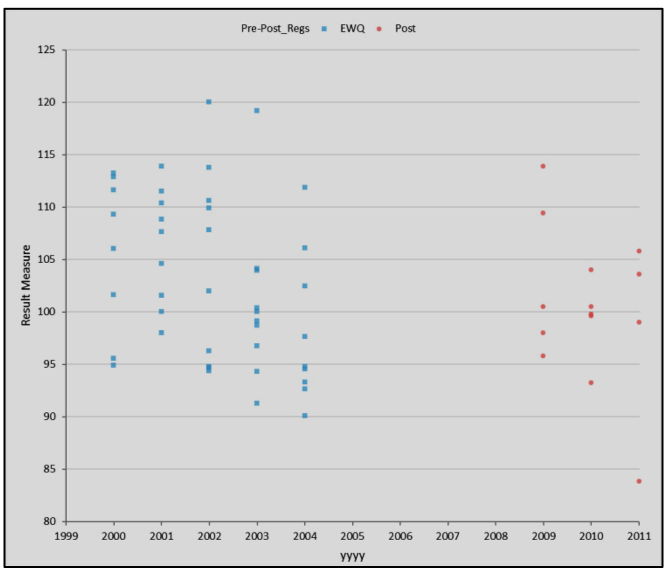
Existing Water Quality (Table 2N):

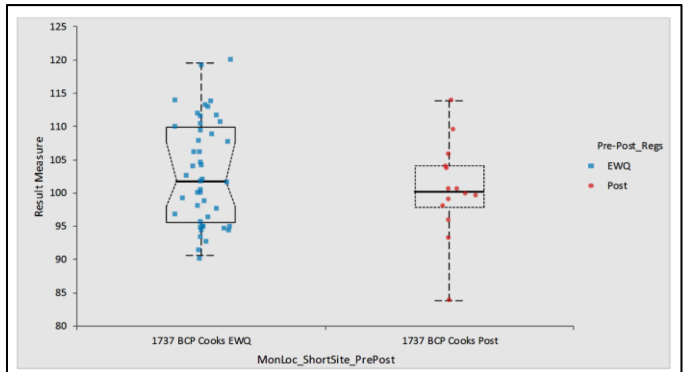
Median 102%

Lower 95% Confidence Interval 98%

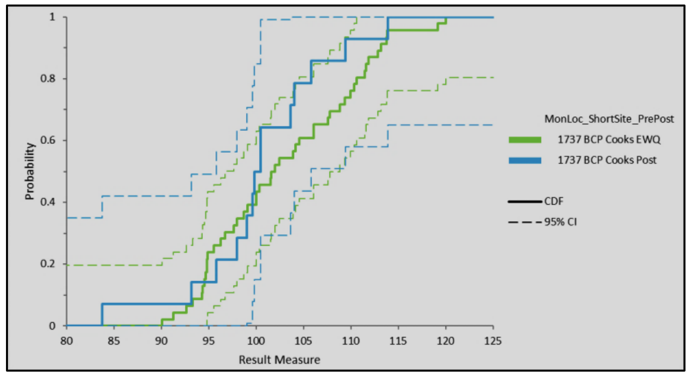
Upper 95% Confidence Interval 108%







N	60					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	90	96	102	110	120	14
1737 BCP Cooks Post	84	98	100	104	114	6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	34.8	0.76
1737 BCP Cooks Post	14	114.3	8.16

H statistic	0.49
X^2 approximation	0.49
DF	1
p-value	0.4845[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.

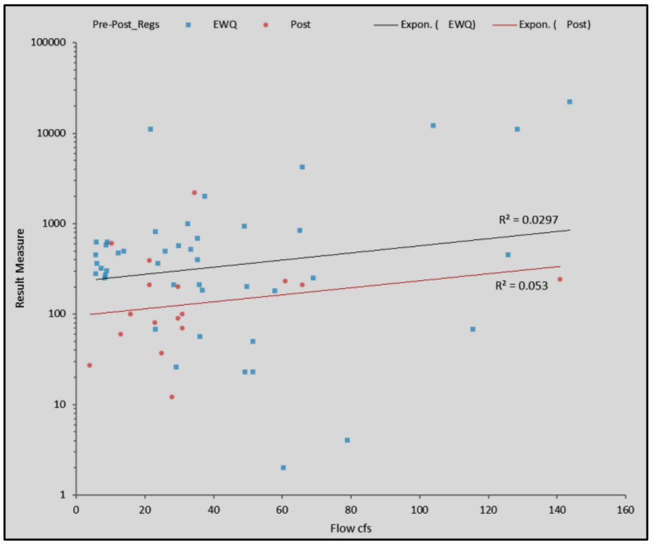
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals.

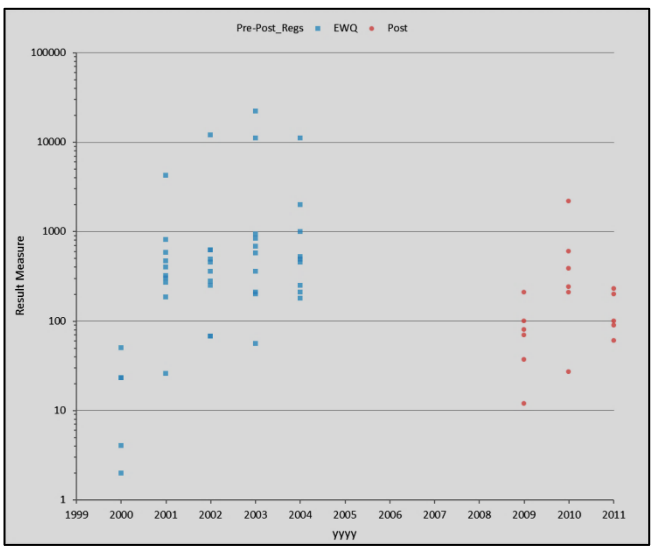
Chapter 13: 1737 BCP Cooks Creek, PA

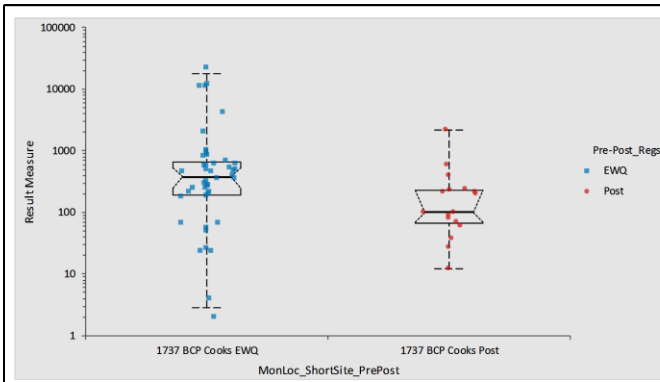
Enterococcus colonies/100 ml

Existing Water Quality (Table 2N):

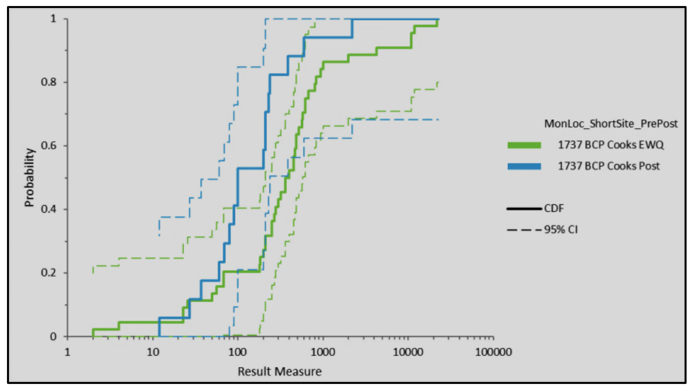
Median 380/100 ml
Lower 95% Confidence Interval 250/100 ml
Upper 95% Confidence Interval 520/100 ml







N	61					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	2	191	380	655	22000	464
1737 BCP Cooks Post	12	67	100	233	2200	167



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	44	528.6	12.01
1737 BCP Cooks Post	17	1368.0	80.47

H statistic	6.02
X² approximation	6.02
DF	1
p-value	0.0141 [1]

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

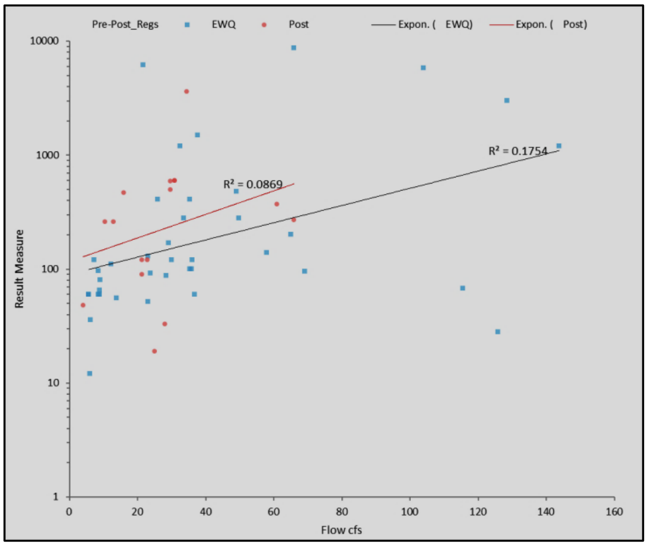
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations are plotted on a logarithmic scale, and the regression is an exponential relationship. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval.

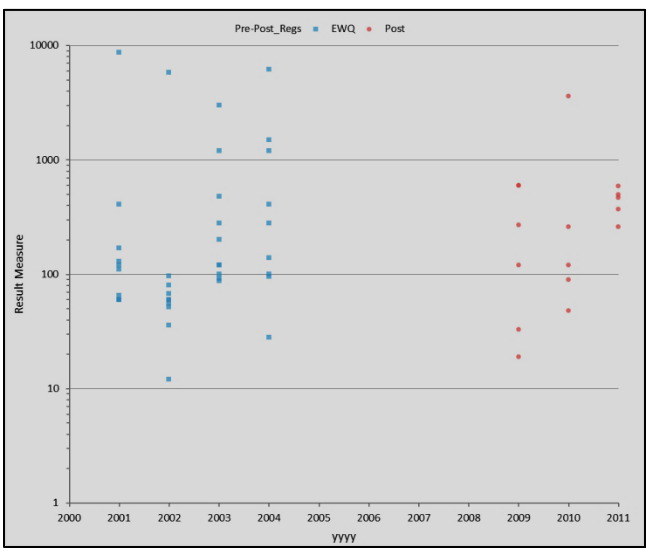
Chapter 13: 1737 BCP Cooks Creek, PA

Escherichia coli colonies/100 ml

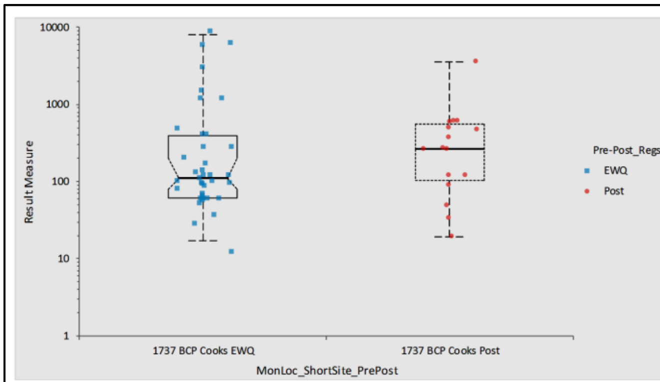
Existing Water Quality (Table 2N):

Median 110/100 ml
Lower 95% Confidence Interval 80/100 ml
Upper 95% Confidence Interval 200/100 ml
Defined in regulations as a flow-related parameter

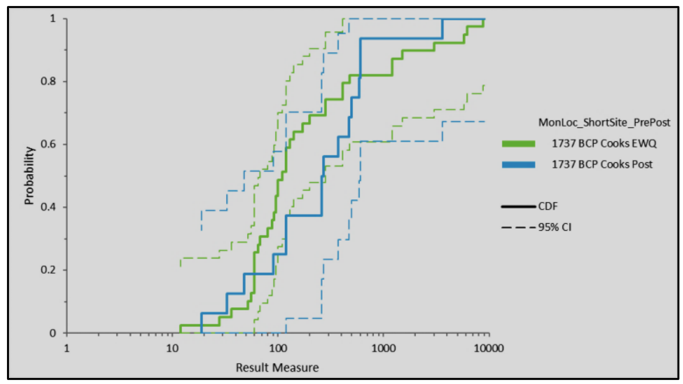




Water quality degradation is evident here. E. coli concentrations appeared to measurably increase between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency.



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	12	61	110	388	8740	328
1737 BCP Cooks Post	19	103	265	553	3600	450



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	80.4	2.06
1737 BCP Cooks Post	16	196.0	12.25

H statistic	1.08
X^2 approximation	1.08
DF	1
p-value	0.2990 [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.

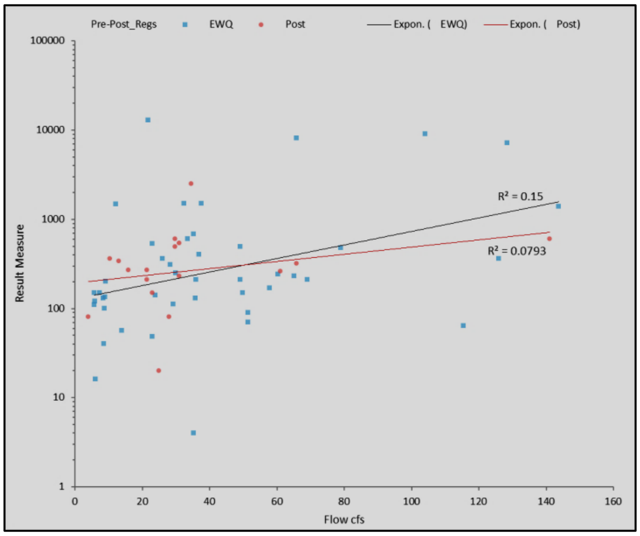
Post-EWQ median E. coli rose above the EWQ 95% confidence interval, but the post-EWQ data set contained no high-flow samples. Note that concentrations are plotted on a logarithmic scale. E. coli concentrations are unrelated to flow in both data sets, and should not have been classified as flow-related in EWQ rules. Insufficient independent data were available at this site to validate results.

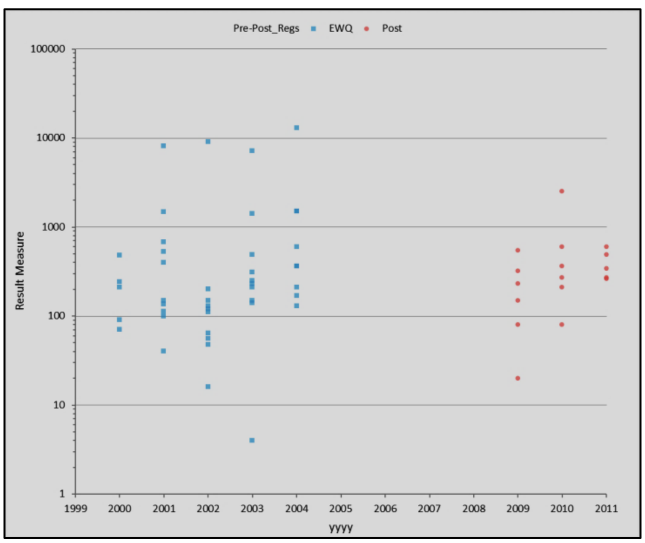
Chapter 13: 1737 BCP Cooks Creek, PA

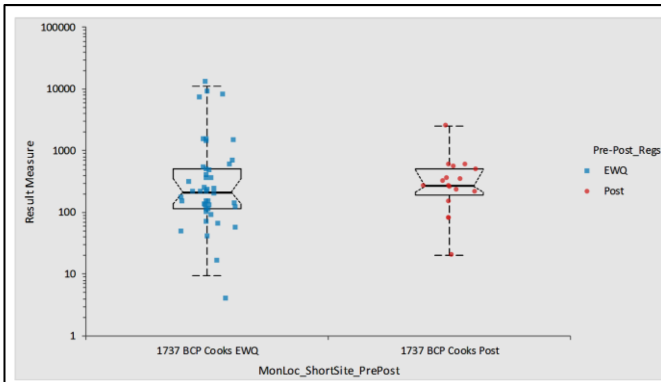
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2N):

Median 210/100 ml
Lower 95% Confidence Interval 140/100 ml
Upper 95% Confidence Interval 360/100 ml

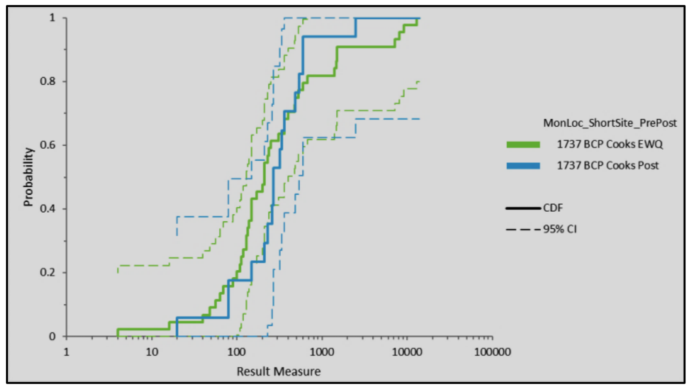






N	61					

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	4	115	210	513	13000	398
1737 BCP Cooks Post	20	190	270	507	2500	317



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	44	52.4	1.19
1737 BCP Cooks Post	17	135.5	7.97

H statistic	0.60
X² approximation	0.60
DF	1
p-value	0.4398 [1]

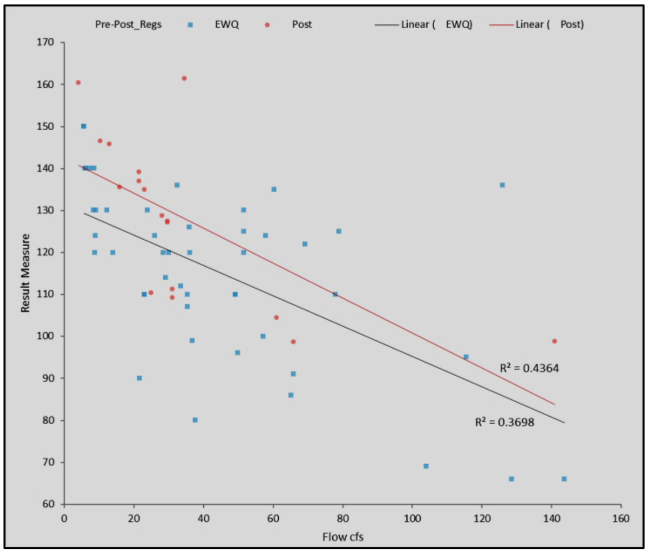
H0: $\theta_1 = \theta_2 = \theta \ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

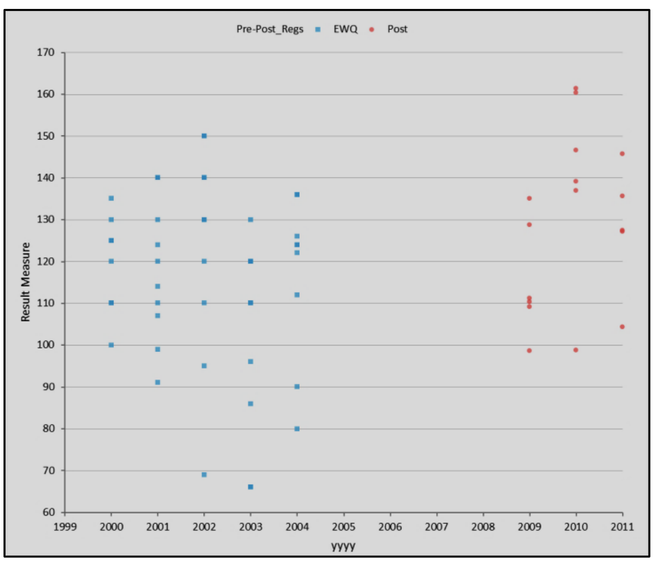
No water quality degradation is evident here. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations are plotted on a logarithmic scale.

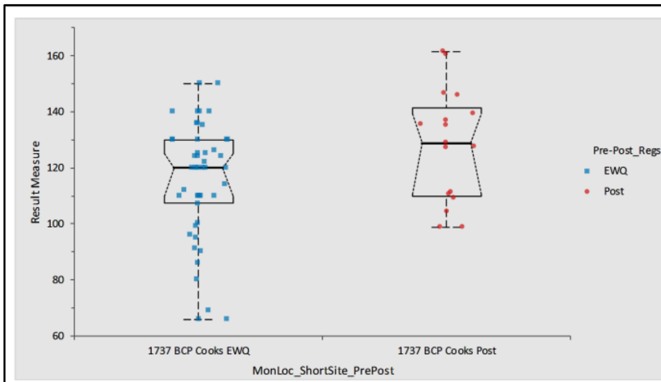
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2N):

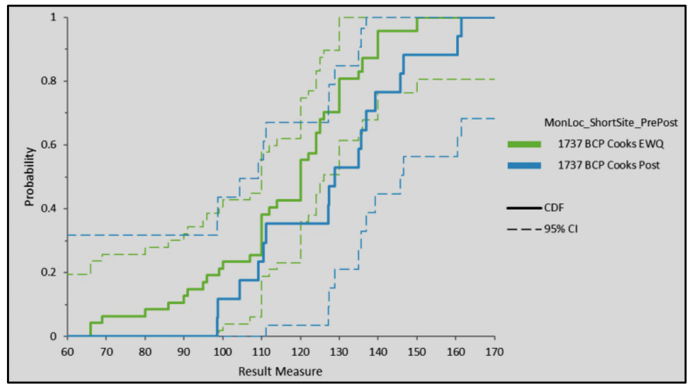
Median 120 mg/l
Lower 95% Confidence Interval 110 mg/l
Upper 95% Confidence Interval 125 mg/l
Defined in regulations as a flow-related parameter







N	64					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	66	108	120	130	150	23
1737 BCP Cooks Post	99	110	129	141	161	31



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	306.4	6.52
1737 BCP Cooks Post	17	847.1	49.83

H statistic	3.34
X^2 approximation	3.34
DF	1
p-value	0.0678 [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.

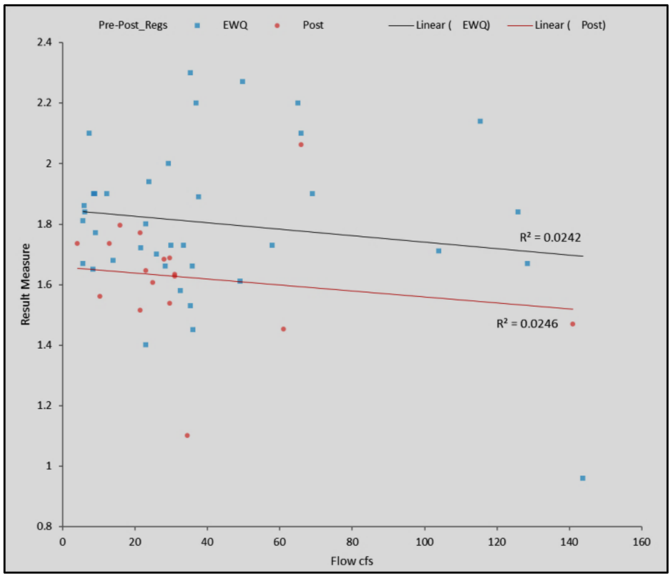
No water quality degradation is evident here. Hardness did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness rose above the EWQ upper 95% confidence interval, but the increase was not significant because too few post-EWQ samples were taken (n=17) to be able to distinguish a real difference between the two periods.

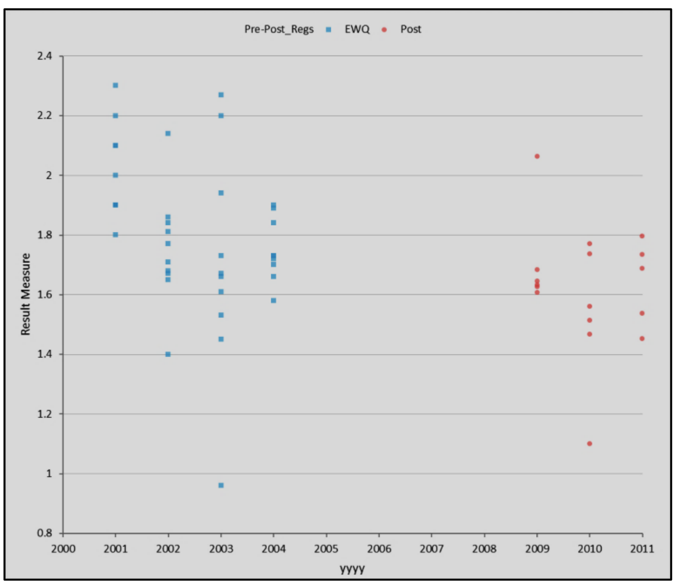
Chapter 13: 1737 BCP Cooks Creek, PA

Nitrate + Nitrite as N, Total mg/l

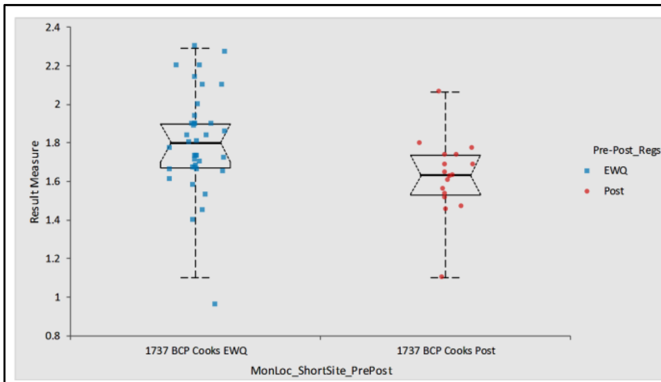
Existing Water Quality (Table 2N, as Nitrate only):

Median 1.80 mg/l
Lower 95% Confidence Interval 1.70 mg/l
Upper 95% Confidence Interval 1.90 mg/l



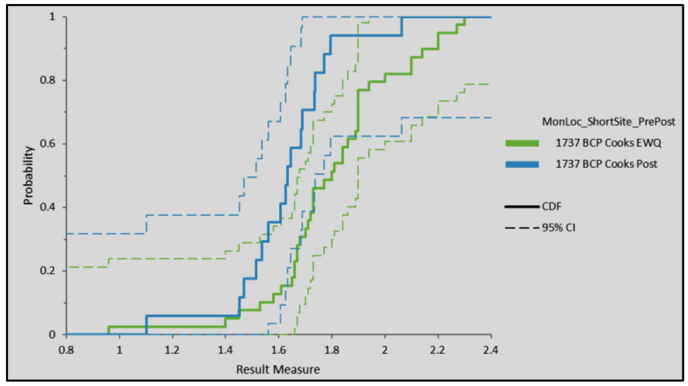


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Nitrate is unrelated related to flow in both data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



N	56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.96	1.67	1.80	1.90	2.30	0.23
1737 BCP Cooks Post	1.10	1.53	1.63	1.74	2.06	0.21



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	660.5	16.94
1737 BCP Cooks Post	17	1515.3	89.14

H statistic	8.19
X^2 approximation	8.19
DF	1
p-value	0.0042 [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.

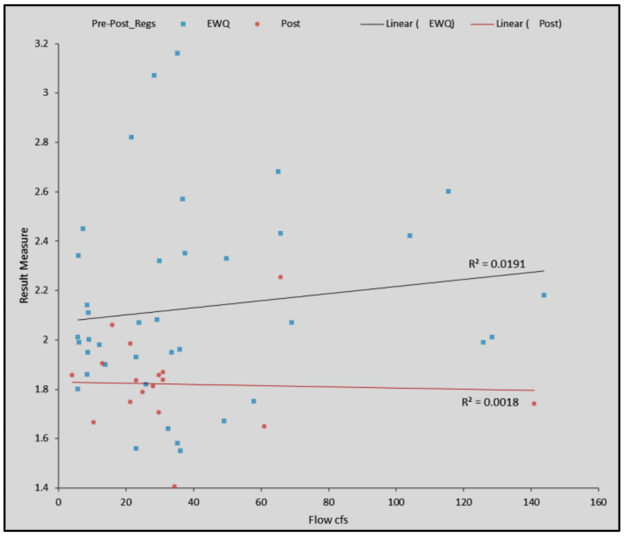
Post-EWQ concentrations fell below the EWQ lower 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of results. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in Cooks Creek that problems with interpretation did not arise; so the decline may represent an improvement in water quality.

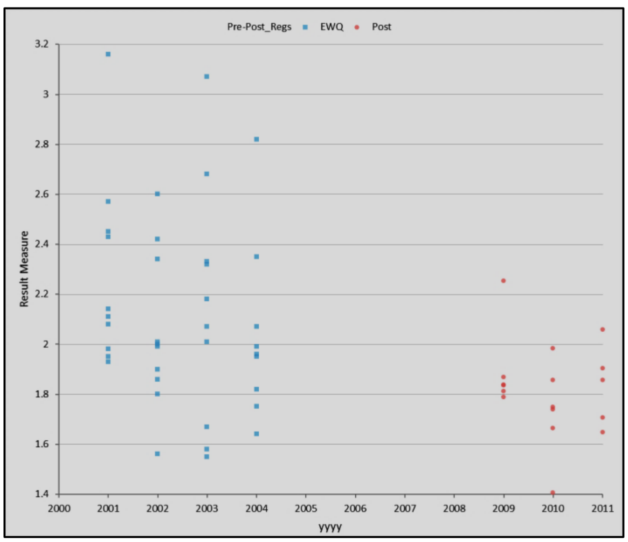
Chapter 13: 1737 BCP Cooks Creek, PA

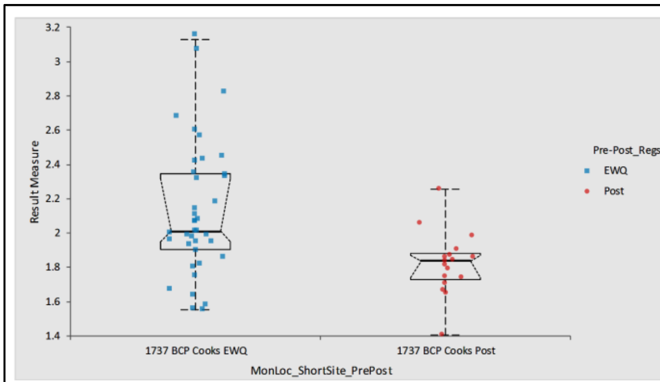
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2N):

Median 2.01 mg/l
Lower 95% Confidence Interval 1.95 mg/l
Upper 95% Confidence Interval 2.32 mg/l

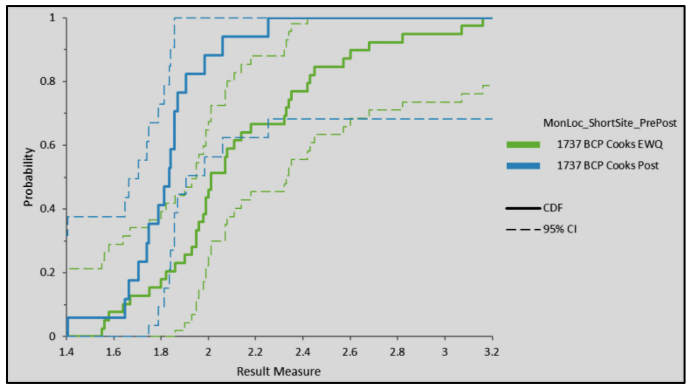






N	56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	1.55	1.91	2.01	2.35	3.16	0.44
1737 BCP Cooks Post	1.41	1.73	1.84	1.88	2.25	0.15



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	863.4	22.14
1737 BCP Cooks Post	17	1980.7	116.51

H statistic	10.69
X^2 approximation	10.69
DF	1
p-value	0.0011[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.

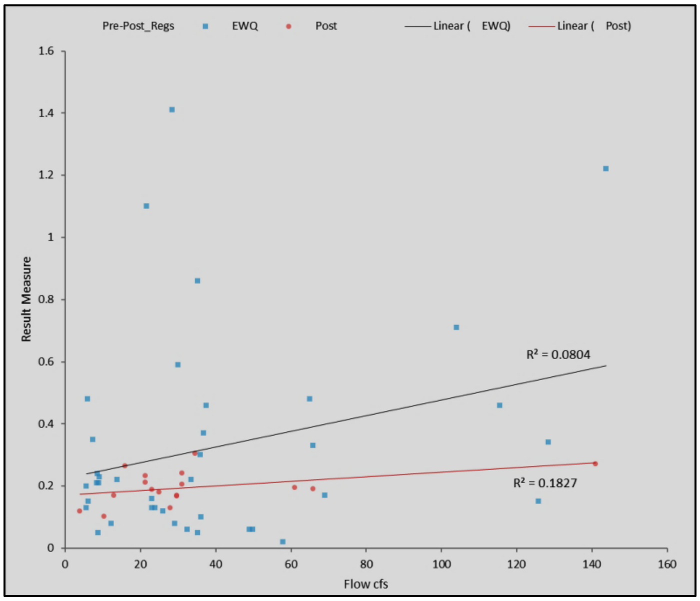
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TN is unrelated to flow in both data sets. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals.

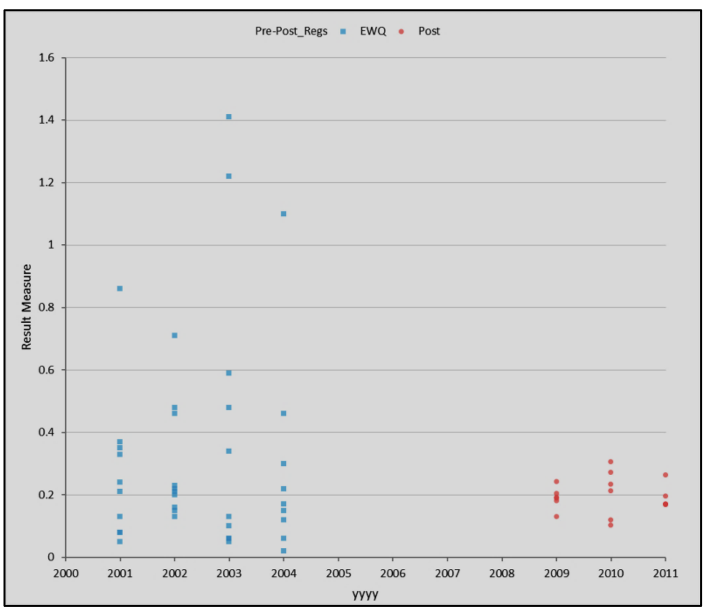
Chapter 13: 1737 BCP Cooks Creek, PA

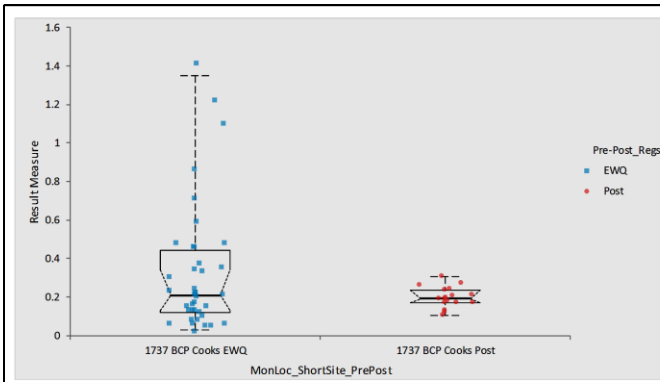
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2N):

Median 0.21 mg/l
Lower 95% Confidence Interval 0.13 mg/l
Upper 95% Confidence Interval 0.34 mg/l

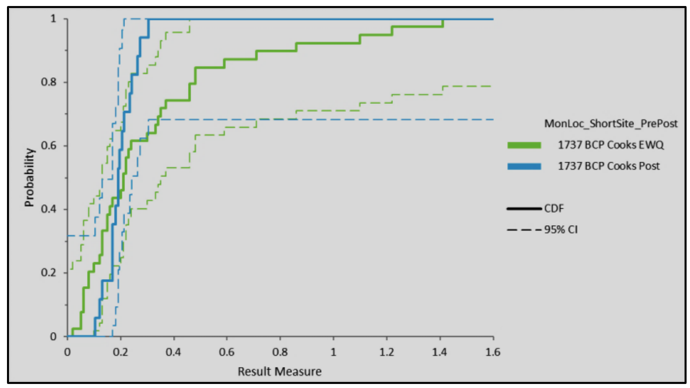






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.02	0.12	0.21	0.45	1.41	0.32
1737 BCP Cooks Post	0.10	0.17	0.19	0.24	0.31	0.07



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	20.8	0.53
1737 BCP Cooks Post	17	47.8	2.81

H statistic	0.26
X² approximation	0.26
DF	1
p-value	0.6115 [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.

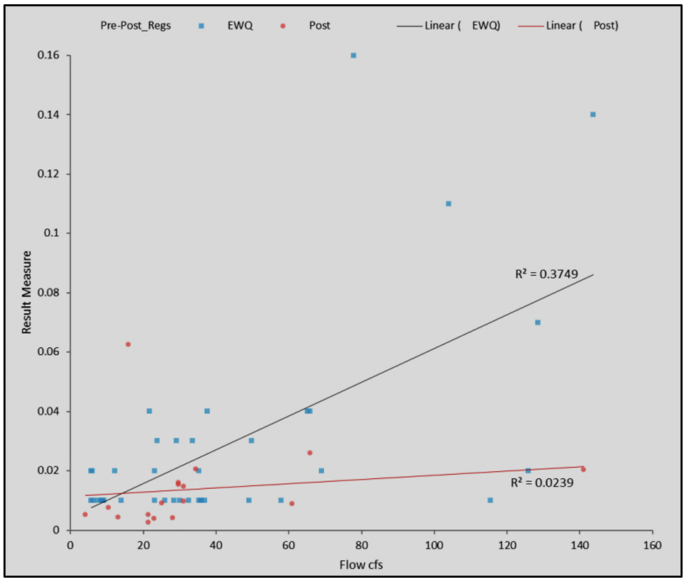
No water quality degradation is evident here. TKN concentrations apparently did not measurably change between the EWQ and post-EWQ periods, though the post-EWQ range was far narrower and all concentrations were less than 0.4 mg/l. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN was within the EWQ 95% confidence intervals.

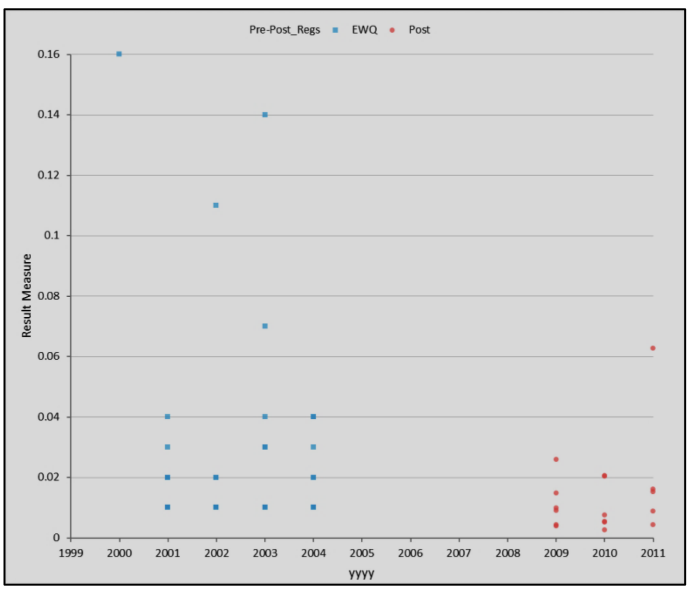
Chapter 13: 1737 BCP Cooks Creek, PA

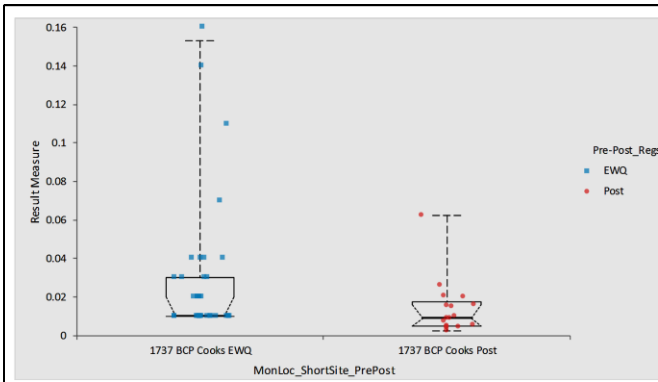
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2N):

Median 0.01 mg/l
Lower 95% Confidence Interval 0.01 mg/l
Upper 95% Confidence Interval 0.02 mg/l

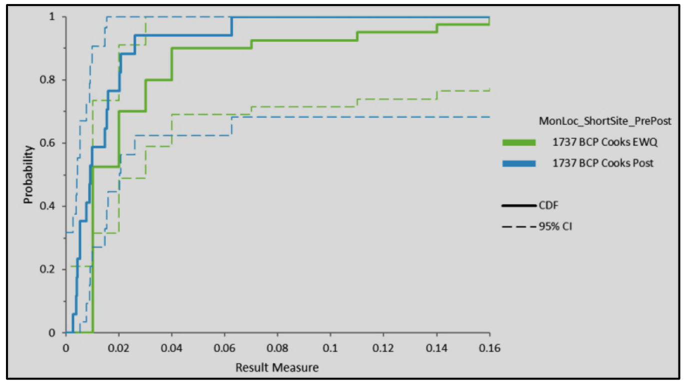






N | 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.010	0.010	0.010	0.030	0.160	0.020
1737 BCP Cooks Post	0.003	0.005	0.009	0.017	0.063	0.013



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	40	616.2	15.41
1737 BCP Cooks Post	17	1449.9	85.29

H statistic	7.91
X^2 approximation	7.91
DF	1
p-value	0.0049 [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.

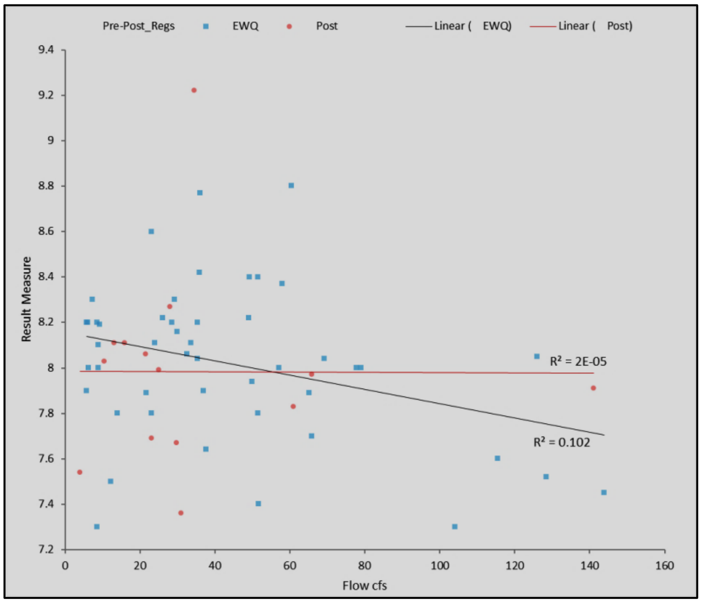
No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. OP is weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. Evidence for a water quality improvement is that there were no post-EWQ concentrations higher than 0.07 mg/l. There were no independent data to confirm results.

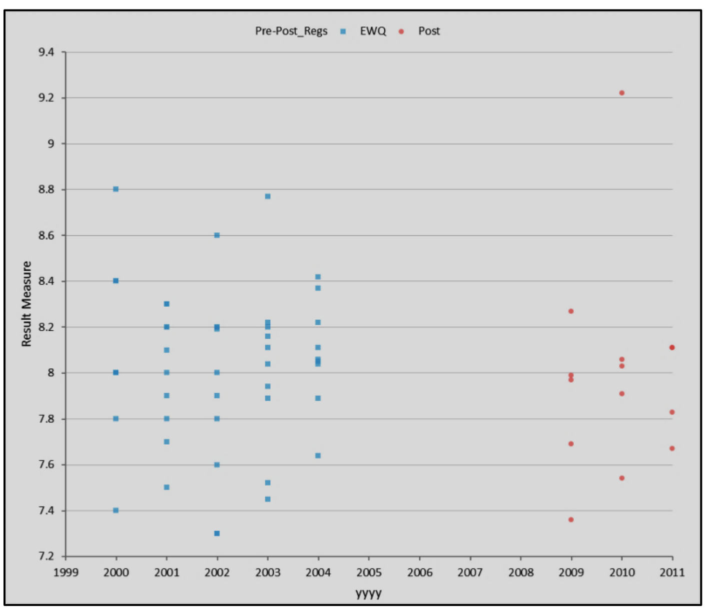
Chapter 13: 1737 BCP Cooks Creek, PA

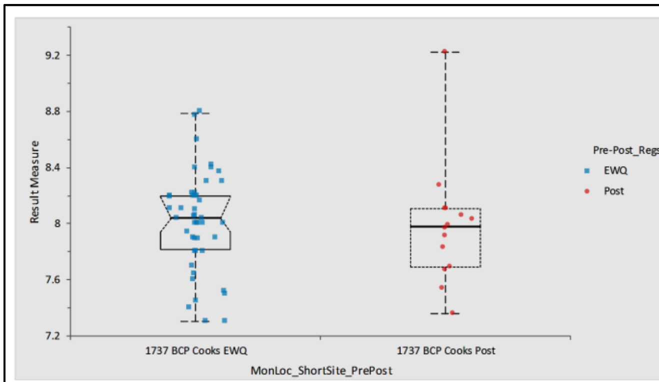
pH

Existing Water Quality (Table 2N):

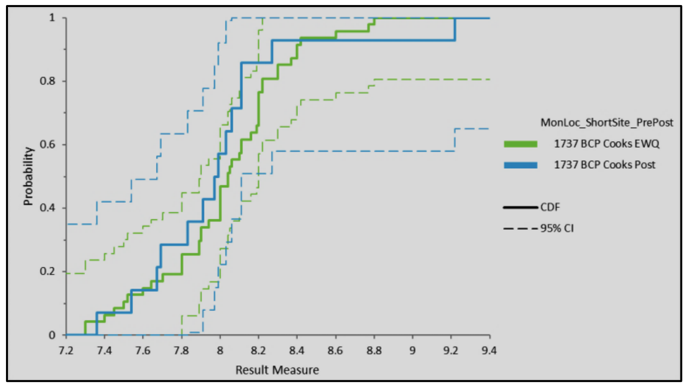
Median 8.04 standard units
Lower 95% Confidence Interval 7.94 standard units
Upper 95% Confidence Interval 8.19 standard units







N	61					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	7.30	7.82	8.04	8.20	8.80	0.39
1737 BCP Cooks Post	7.36	7.69	7.98	8.11	9.22	0.42



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	63.2	1.34
1737 BCP Cooks Post	14	212.2	15.15

H statistic	0.88
X² approximation	0.88
DF	1
p-value	0.3495 [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.

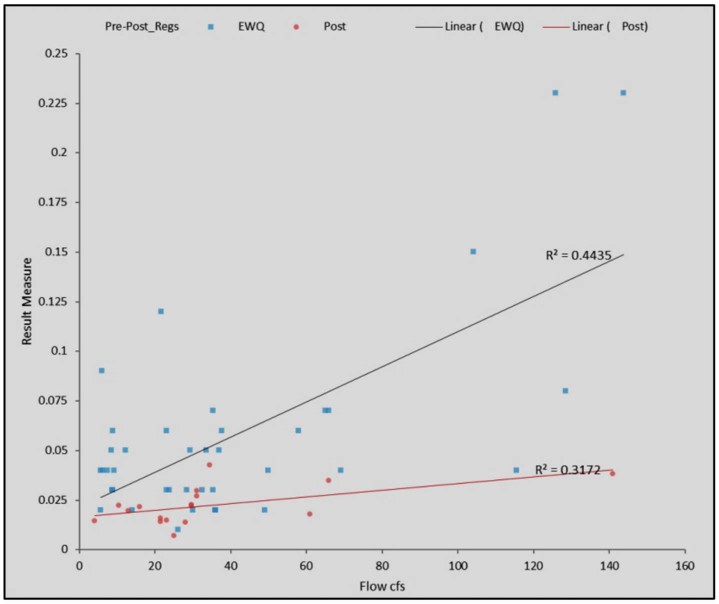
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. In 2010 there was one spike above pH 9, indicating high algal productivity during that sampling period.

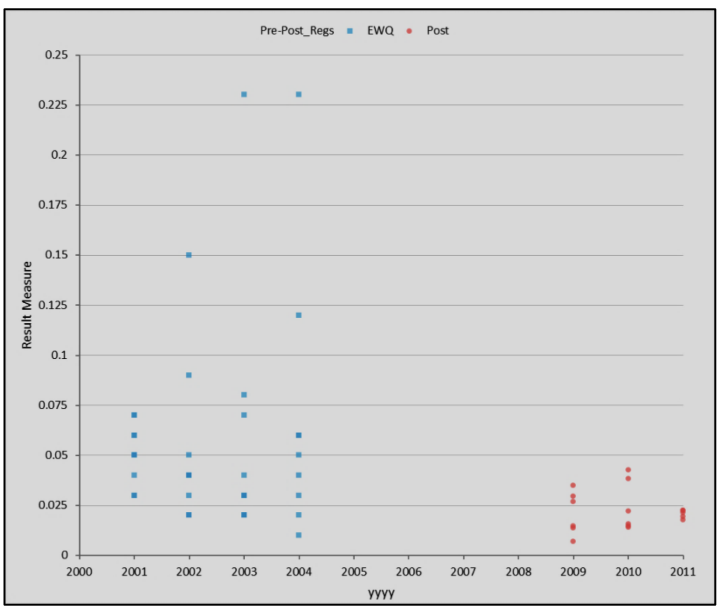
Chapter 13: 1737 BCP Cooks Creek, PA

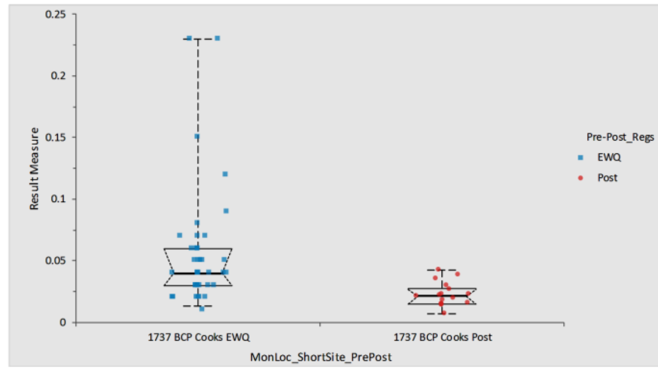
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2N):

Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.06 mg/l

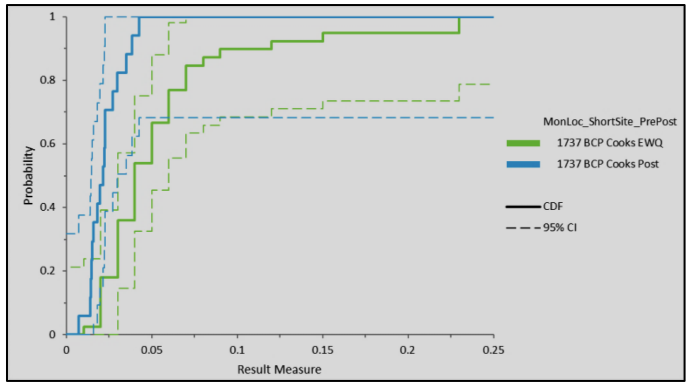






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.010	0.030	0.040	0.060	0.230	0.030
1737 BCP Cooks Post	0.007	0.015	0.022	0.028	0.043	0.013



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	1398.0	35.85
1737 BCP Cooks Post	17	3207.2	188.66

H statistic	17.42
X^2 approximation	17.42
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.

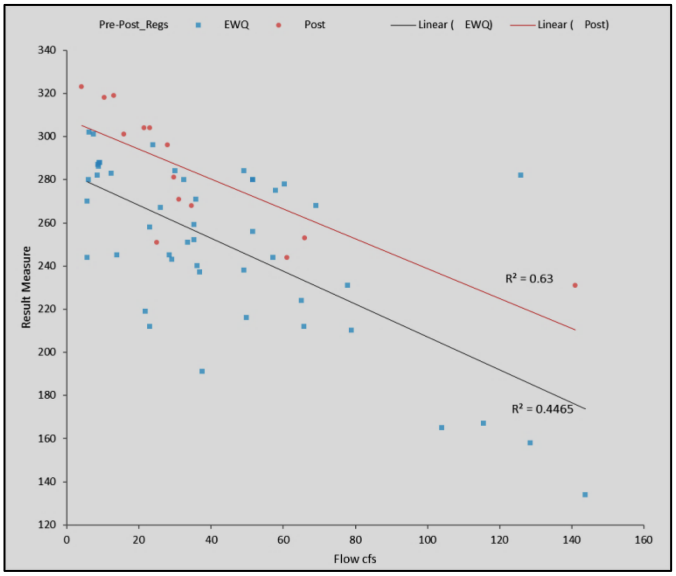
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. No independent data were available to confirm these results.

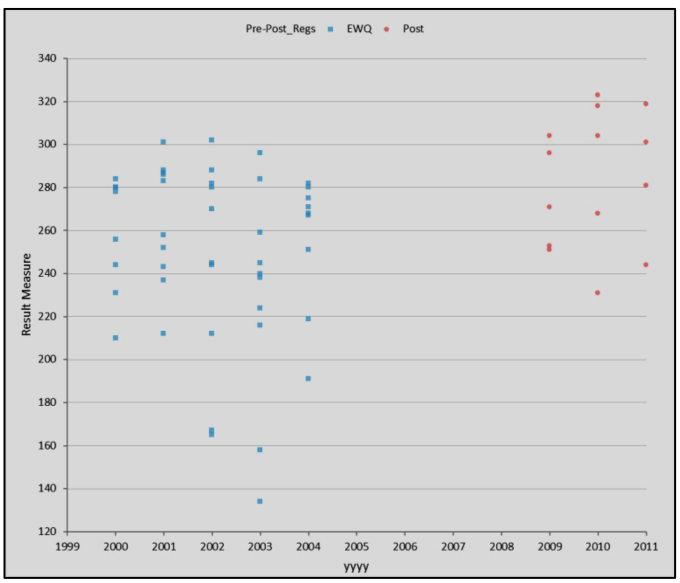
Chapter 13: 1737 BCP Cooks Creek, PA

Specific Conductance µmho/cm

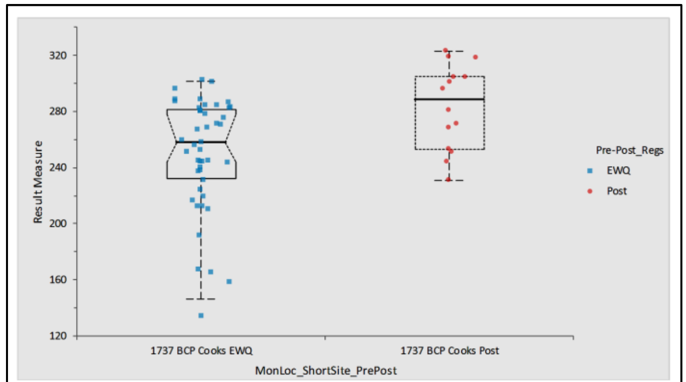
Existing Water Quality (Table 2N):

Median 258 µmho/cm
Lower 95% Confidence Interval 244 µmho/cm
Upper 95% Confidence Interval 278 µmho/cm
Defined in regulations as a flow-related parameter



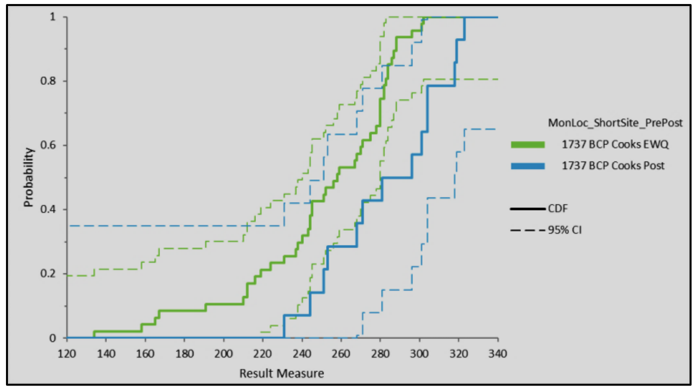


Water quality degradation is evident here. Specific conductance rose by 31 µmho/cm; above the EWQ upper 95% confidence interval. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency.



N | 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	134	232	258	282	302	50
1737 BCP Cooks Post	231	253	289	305	323	52



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	524.4	11.16
1737 BCP Cooks Post	14	1760.6	125.76

H statistic	7.26
X^2 approximation	7.26
DF	1
p-value	0.0071[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.

Specific conductance is inversely related to flow in both data sets. Part of the increase may be attributable to fewer high-flow samples taken in the post-EWQ period. Unrelated to the increase, limestone-influenced streams like Cooks Creek generally possess higher specific conductance, alkalinity and hardness than the Piedmont watersheds downstream.

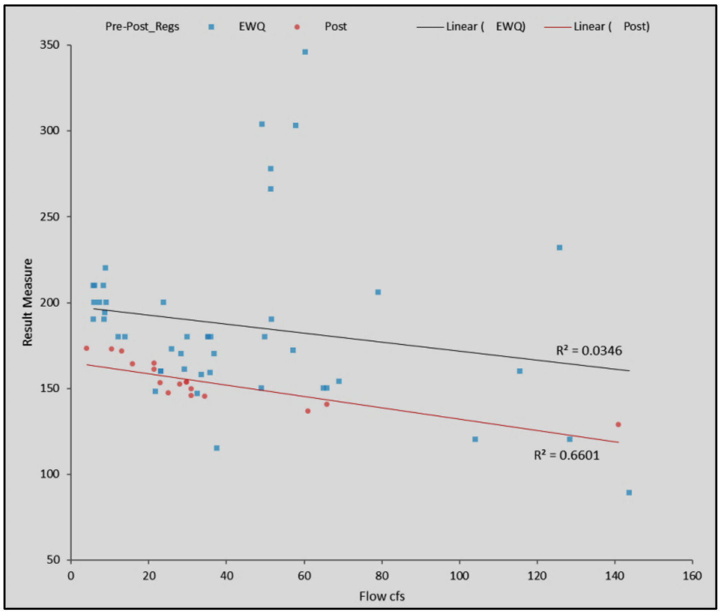
The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 258 to 289 µmhos/cm, which is a 12% increase in a few years' time.

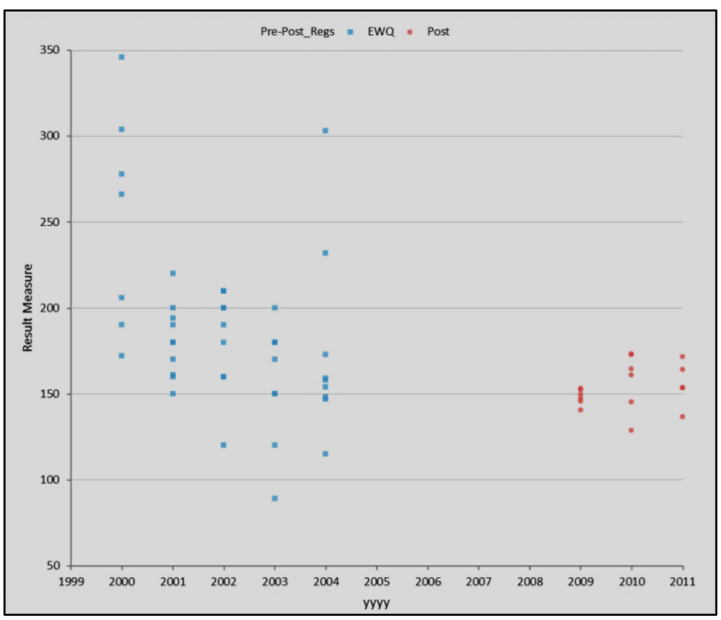
Chapter 13: 1737 BCP Cooks Creek, PA

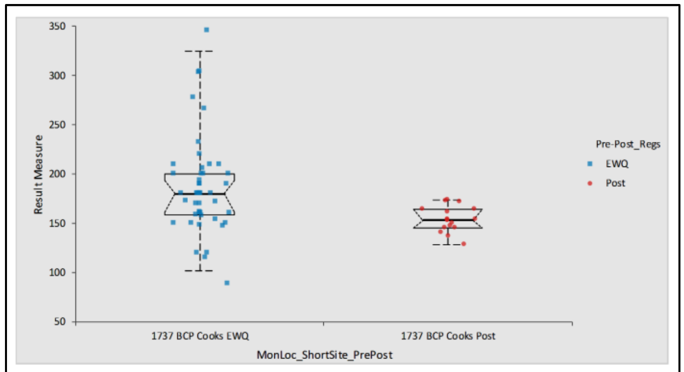
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2N):

Median 180 mg/l
Lower 95% Confidence Interval 161 mg/l
Upper 95% Confidence Interval 194 mg/l
Defined in regulations as a flow-related parameter

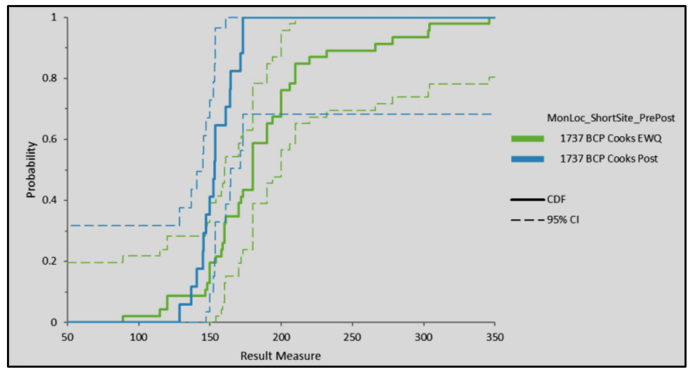






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	89	159	180	201	346	42
1737 BCP Cooks Post	129	146	153	164	173	19



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	1052.2	22.87
1737 BCP Cooks Post	17	2847.1	167.47

H statistic	11.63
X^2 approximation	11.63
DF	1
p-value	0.0006

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.

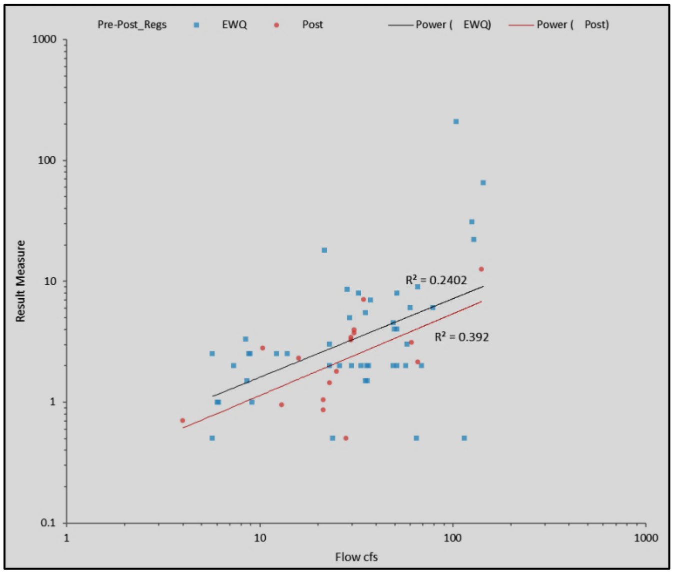
No water quality degradation is evident here. TDS apparently declined between the two periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. EWQ TDS is unrelated to flow though TDS was designated in the rules as flow related. Post-EWQ TDS is inversely related to flow though the regression is driven by a single high-flow sample. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ TDS 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.

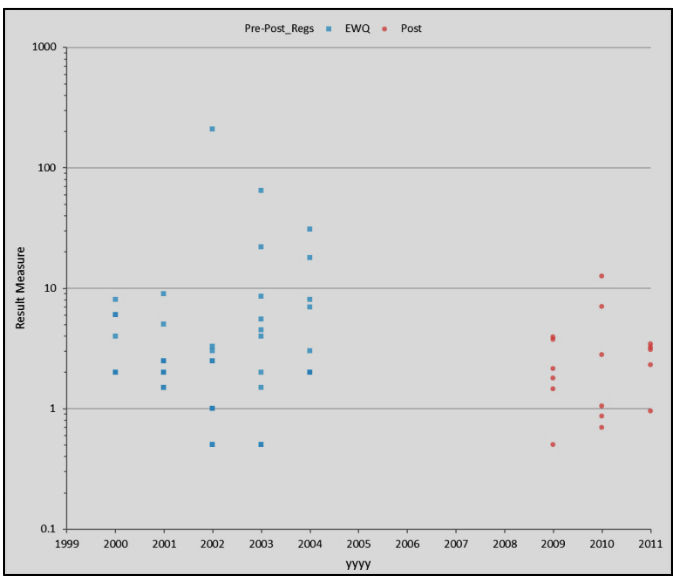
Chapter 13: 1737 BCP Cooks Creek, PA

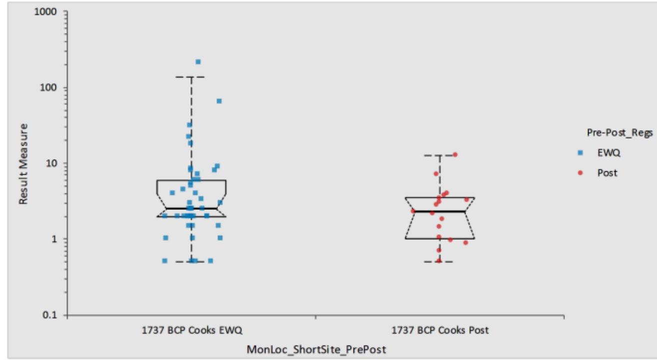
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2N):

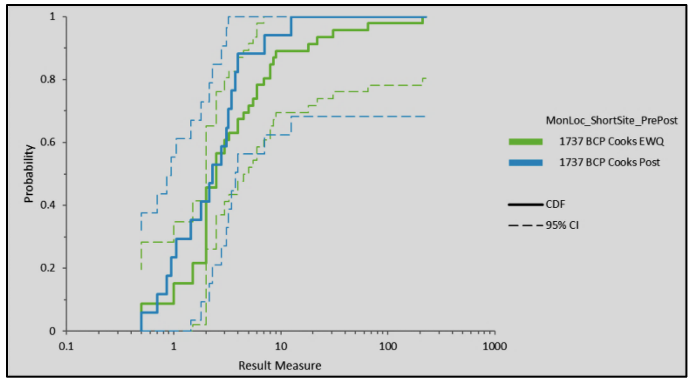
Median 2.5 mg/l
Lower 95% Confidence Interval 2.0 mg/l
Upper 95% Confidence Interval 4.0 mg/l
Defined in regulations as a flow-related parameter







N	63					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.5	2.0	2.5	6.0	210.0	4.0
1737 BCP Cooks Post	0.5	1.0	2.3	3.6	12.6	2.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	94.7	2.06
1737 BCP Cooks Post	17	256.2	15.07

H statistic	1.05
X^2 approximation	1.05
DF	1
p-value	0.3053[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.

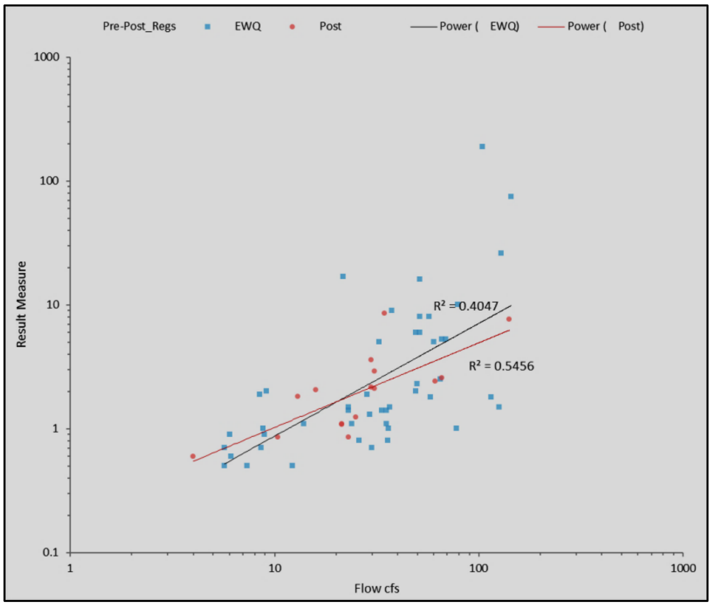
No water quality degradation is evident here. TSS did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell within the EWQ 95% confidence intervals. Both flow and concentration are plotted on a logarithmic scale.

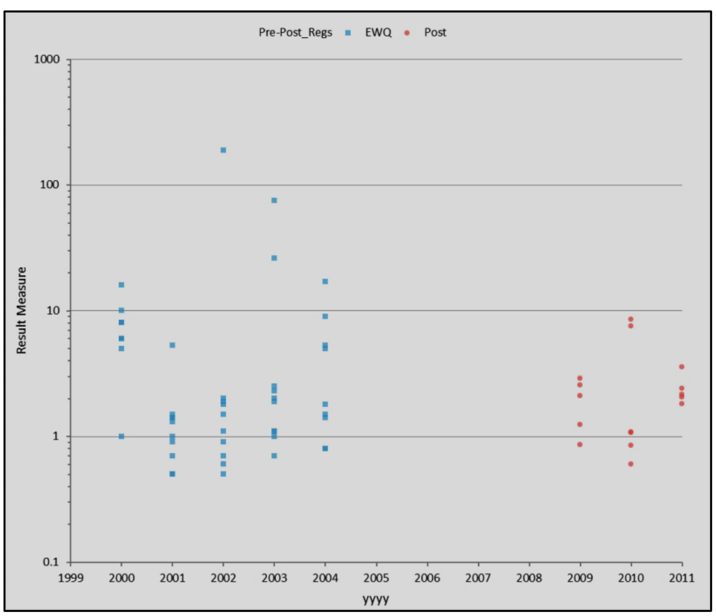
Chapter 13: 1737 BCP Cooks Creek, PA

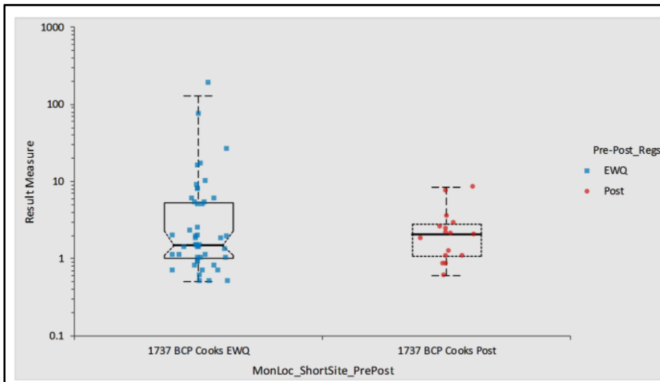
Turbidity NTU

Existing Water Quality (Table 2N):

Median 1.5 NTU
Lower 95% Confidence Interval 1.1 NTU
Upper 95% Confidence Interval 2.3 NTU
Defined in regulations as a flow-related parameter

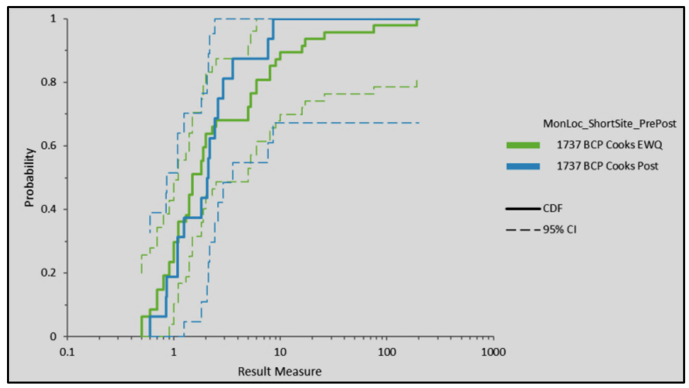






N	63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.50	1.00	1.50	5.30	190.00	4.30
1737 BCP Cooks Post	0.60	1.08	2.09	2.78	8.56	1.69



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	2.8	0.06
1737 BCP Cooks Post	16	8.3	0.52

H statistic	0.03
X^2 approximation	0.03
DF	1
p-value	0.8558 [1]

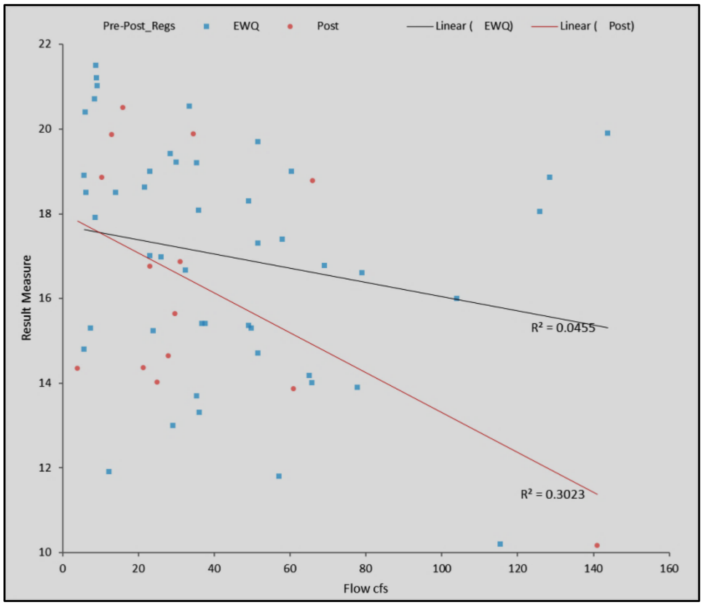
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

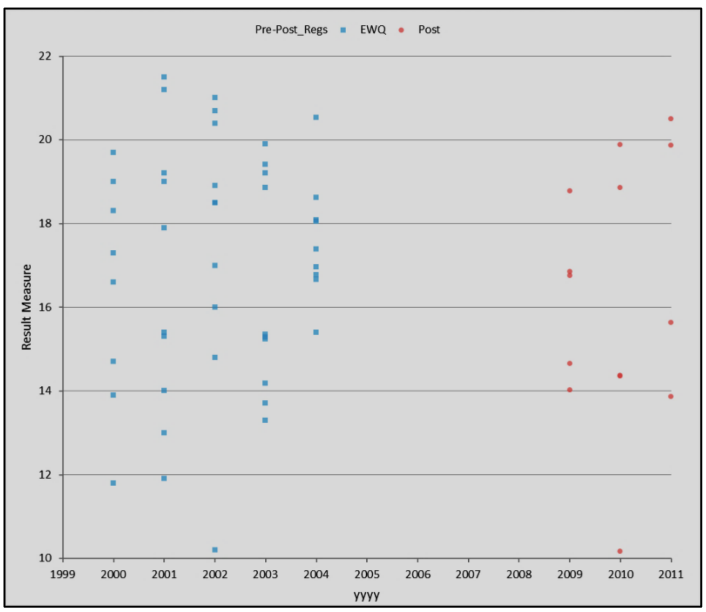
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is positively related to flow in both data sets. Both concentration and flow is represented on logarithmic scale, and the regression is a power relationship.

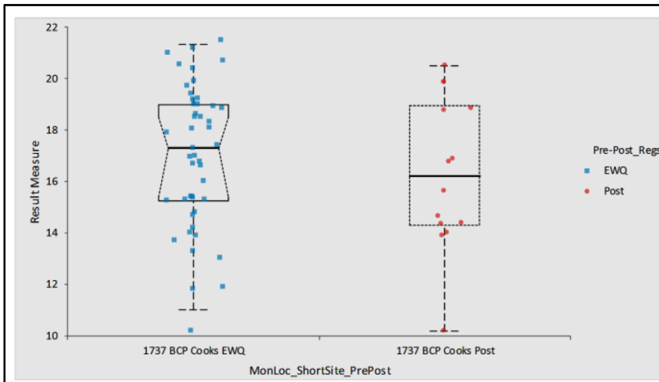
Chapter 13: 1737 BCP Cooks Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

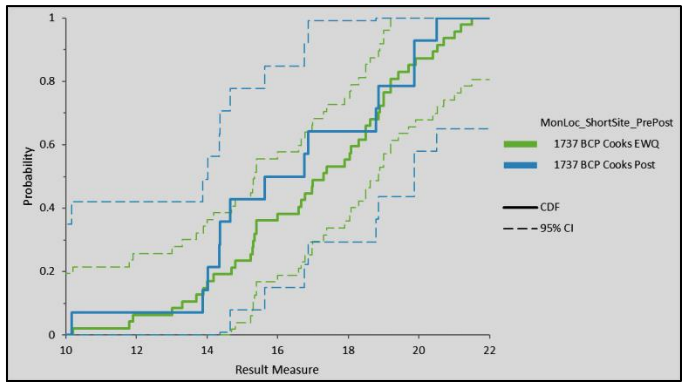






N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	10.2	15.2	17.3	19.0	21.5	3.8
1737 BCP Cooks Post	10.2	14.3	16.2	18.9	20.5	4.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	40.3	0.86
1737 BCP Cooks Post	14	135.2	9.65

H statistic	0.56
X² approximation	0.56
DF	1
p-value	0.4556 [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. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Water temperature is unrelated to flow in the EWQ data set, but weakly and inversely related to flow in the post-EWQ data set. Flows is plotted on a logarithmic scale.