Chapter 5: 1525 BCP Wickecheoke Creek, Hunterdon County, NJ

Wickecheoke Creek

Drainage Area = 27.01 mi²

- Sampling Location
- NPDES
- Stream Gage
- Drainage Area
Analysis of flow differences between the EWQ and post-EWQ periods:

Flow was higher during the post-EWQ period. Numerous samples were collected in the EWQ period when the flow was less than 3 cfs. The minimum flow sampled in the post-EWQ period was 3.4 cfs. This has a major effect upon analysis of within-site water quality changes between the two periods, especially for those parameters that are flow-related.

The 27 square mile watershed is about 48% forested, with less than 1% urban land cover. There is no carbonate bedrock in the watershed.

Wickecheoke Creek is captured by the Delaware and Raritan Canal and is used as public water supply, exported outside the Delaware River Basin via the New Jersey Water Supply Authority. Its water quality influence upon the Delaware River is minimal except during high-flow conditions.

Annual May to September flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. “Normal” annual median flow is about 29 cfs at this location, but the summer seasonal flow is much less. The geology of this watershed is such that almost all rainfall runs off almost immediately. Very little water infiltrates into groundwater to be held back as baseflow to the stream. Like several other Piedmont streams of the Lower Delaware, this “flashy” condition means that for most of the summer there is very little water in what appears to be an over-sized channel. When it rains, the channel fills quickly but not for a long duration. Unless it rains frequently, normal flow conditions are not sustained. Thus in the figure above, only during the relatively wet summers of 2003, 2009 and 2011 were near-normal flow conditions represented by these samples.

Upstream ICP: Delaware River at Bulls Island 1554 ICP
Downstream ICP: Delaware River at Lambertville 1487 ICP
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Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2V):

Median 40 mg/l
Lower 95% Confidence Interval 33 mg/l
Upper 95% Confidence Interval 43 mg/l

Defined in regulations as a flow-related parameter

No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals, and the post-EWQ data were under-represented by dry weather samples. Flow is plotted on a logarithmic axis.
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Ammonia Nitrogen as N, Total mg/l

Existing Water Quality (Table 2V):

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

No water quality degradation is evident. Ammonia concentrations apparently declined. However, differences in flow conditions, detection limits, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty to conclusions.

Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. No independent data were readily available to validate the decline. DRBC’s post-EWQ detection limit was lower than during the EWQ period. EWQ data possessed high frequencies of non-detect results (23 of 30 samples). Thus EWQ was established as “less than” 0.05 mg/l, which was the detection limit at the time. Even with lower detection levels for post-EWQ samples, there were still 5 out of 17 non-detect results. The decline in concentration at least partially is due to adoption of more sensitive laboratory methods rather than a real change in ambient Wickecheoke Creek concentrations.
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Chloride, Total mg/l

Existing Water Quality (Table 2V):

Median 17 mg/l
Lower 95% Confidence Interval 15 mg/l
Upper 95% Confidence Interval 18 mg/l
Defined in regulations as a flow-related parameter

Water quality degradation is evident. Chloride concentrations increased by 6.8 mg/l (40%) between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Flow is plotted on a logarithmic scale. With no new discharge permits issued in the watershed, we suspect that other sources such as winter road salting may be the main reason for the increase.
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Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2V):

Median 9.45 mg/l
Lower 95% Confidence Interval 8.95 mg/l
Upper 95% Confidence Interval 9.90 mg/l

No water quality degradation is evident. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets.
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Dissolved Oxygen Saturation %

Existing Water Quality (Table 2V):

Median 101%
Lower 95% Confidence Interval 96%
Upper 95% Confidence Interval 104%

No water quality degradation is evident. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Flow is plotted on a logarithmic scale.

Dissolved oxygen saturation is nicely balanced in Wickecheoke Creek, rarely dipping below 90% or rising above 120%. There are some algae blooms, as indicated by the highest saturation levels, but the blooms never appear to last long. The short duration of algae blooms is probably due to washout by storms. Even a small rain event can scour the Wickecheoke Creek stream bottom of excess algal growth.
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Enterococcus colonies/100 ml

Existing Water Quality (Table 2V):

Median 170/100 ml
Lower 95% Confidence Interval 84/100 ml
Upper 95% Confidence Interval 300/100 ml

No water quality degradation is indicated. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. Enterococcus concentrations are very weakly related to flow in both data sets, but results are highly variable.

Post-EWQ median enterococcus concentrations were well above the EWQ upper 95% confidence interval, but variability is so high that the rise is statistically meaningless.
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Escherichia coli colonies/100 ml

Existing Water Quality (Table 2V):

Median 52/100 ml
Lower 95% Confidence Interval 40/100 ml
Upper 95% Confidence Interval 76/100 ml

Some evidence of water quality degradation is indicated. E. coli concentrations apparently rose between the EWQ and Post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. No independent data were available at this site to validate DRBC results. The increase is reported as such in the summary matrix, but confidence in the conclusion is low because of low N and high variability.
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Fecal coliform colonies/100 ml

Existing Water Quality (Table 2V):

Median 92/100 ml
Lower 95% Confidence Interval 65/100 ml
Upper 95% Confidence Interval 190/100 ml

No water quality degradation is indicated. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. Fecal coliform concentrations are positively but weakly related to flow. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals, but the data were naturally variable and N was low. Note that concentrations and flows are plotted on a logarithmic scale.
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Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2V):

Median 58 mg/l
Lower 95% Confidence Interval 51 mg/l
Upper 95% Confidence Interval 62 mg/l
Defined in regulations as a flow-related parameter

No water quality degradation is indicated. Hardness did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. Hardness is inversely related to flow. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.
Nitrate + Nitrite as N, Total mg/l

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

- Median 1.83 mg/l
- Lower 95% Confidence Interval 1.69 mg/l
- Upper 95% Confidence Interval 2.20 mg/l

No water quality degradation is indicated. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, differences in flow conditions and potential laboratory artifacts introduced uncertainty. In both data sets, nitrate is inversely but weakly related to flow. On the annual plot, 2002-2003 EWQ nitrates appear to match well with post-EWQ nitrate + nitrite for 2009.

Nitrate + Nitrite concentrations are assumed to be equivalent for comparison with EWQ nitrate concentrations, since EWQ nitrite concentrations were never detected. Note that flows are plotted on a logarithmic scale. Independent data were not available for validation of the apparent decline in concentrations shown by DRBC. Post-EWQ, median nitrate + nitrite concentrations fell below the EWQ lower 95% confidence interval. There was no interference by undetected values in either data set.
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Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2V):

Median 2.12 mg/l
Lower 95% Confidence Interval 1.99 mg/l
Upper 95% Confidence Interval 2.65 mg/l

No water quality degradation is indicated. TN apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions. TN is weakly related to flow in the post-EWQ period, but unrelated to flow in the EWQ period due to skewing of the regression by an outlier sample. Note that flows are plotted on a logarithmic scale.

DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.
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Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2V):

Median 0.44 mg/l
Lower 95% Confidence Interval 0.30 mg/l
Upper 95% Confidence Interval 0.70 mg/l

No water quality degradation is indicated. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions. TKN concentration is unrelated to flow in both data sets.

TKN ranges less widely and is less variable in the post-EWQ data set. Post-EWQ median TKN fell below the EWQ lower 95% confidence interval. Unlike nitrate + nitrite and other parameters, the TKN data sets are more directly comparable since there are no discrepancies in detection limits throughout the two periods. The main difference was that there were less dry weather post-EWQ TKN samples. Because of method stability, the decrease in concentrations may indicate a real improvement in water quality.
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2V):

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

No water quality degradation is indicated. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions.

Orthophosphate is weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Note that flows are plotted on a logarithmic scale. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. There were no independent data to confirm DRBC results. DRBC detection limits improved between the two periods, but there was no interference in calculation of the median by non-detect results. Some improvement in water quality may be evident in that there are no values above 0.04 mg/l in the post-EWQ data set.
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pH, units

Existing Water Quality (Table 2V):

Median 7.53 standard units
Lower 95% Confidence Interval 7.40 standard units
Upper 95% Confidence Interval 7.70 standard units

No water quality degradation is indicated. pH did not measurably change between the EWQ and post-EWQ periods. Under higher flow conditions, pH tends toward neutral, though pH is unrelated to flow in both data sets. Post-EWQ median pH fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.
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Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2V):

Median 0.06 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.07 mg/l

No water quality degradation is indicated. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions.

Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. No independent data were available to confirm these results. The compressed appearance of data on these graphs is caused by a single high outlier value from a sample taken in September 2003 (0.55 mg/l). The cause for the high value is unknown.
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Specific Conductance µmho/cm

Existing Water Quality (Table 2V):

Median 183 µmho/cm
Lower 95% Confidence Interval 175 µmho/cm
Upper 95% Confidence Interval 200 µmho/cm

Defined in regulations as a flow-related parameter

Water quality degradation is evident. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. In both data sets, specific conductance is inversely related to flow. Note that flows are plotted on a logarithmic scale. The rise in specific conductance may be attributable to the concurrent rise in chloride concentrations. No new dischargers are present in the watershed. Specific conductance has risen from a median of 183 µmho/cm to 218 µmho/cm, a 19% increase in a short time span.

Kruskal-Wallis test

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<th>Result Measure by MonLoc_ShortSite_PrePost</th>
<th>n</th>
<th>Rank sum</th>
<th>Mean rank</th>
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</thead>
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<td>819.8</td>
<td>21.57</td>
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<tr>
<td>1525 BCP Wickech Post</td>
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<td>2076.8</td>
<td>138.45</td>
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H statistic = 12.15
X² approximation = 12.15
DF = 1
p-value = 0.0005

H₀: θ₁ = θ₂ = ... = θ
H₁: θᵢ ≠ θⱼ for at least one i, j

Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.
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Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2V):

Median 130 mg/l
Lower 95% Confidence Interval 120 mg/l
Upper 95% Confidence Interval 134 mg/l
Defined in regulations as a flow-related parameter

No water quality degradation is evident. TDS did not measurably change between the EWQ and post-EWQ periods. TDS is inversely and strongly related to flow in both data sets. Stream flows were different between the two periods, so flow accounts for some of the apparent decline in TDS even though the decline was not statistically significant. Post-EWQ median TDS was below the EWQ 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Note that flows are plotted on a logarithmic scale.

Kruskal-Wallis test

<table>
<thead>
<tr>
<th>Result Measure by</th>
<th>n</th>
<th>Rank sum</th>
<th>Mean rank</th>
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<tr>
<td>1525 BCP Wickech Post</td>
<td>17</td>
<td>503.1</td>
<td>29.61</td>
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</table>

H statistic = 2.98
DF = 1
p-value = 0.0842

H0: θ1 = θ2 = θ…
The median of the populations are all equal.
H1: θi ≠ θj 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.
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Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2V):

Median 1.0 mg/l
Lower 95% Confidence Interval <0.5 mg/l
Upper 95% Confidence Interval 1.5 mg/l
Defined in regulations as a flow-related parameter

No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is positively related to flow in both data sets, though the relationship is weaker in the EWQ data because of numerous non-detect results in the data that were estimated at the detection limit concentration (22 of 39 samples). Post-EWQ median TSS was within the EWQ 95% confidence intervals. Note that both flow and concentration are plotted on a logarithmic scale.
Turbidity NTU

Existing Water Quality (Table 2V):

Median 1.2 NTU
Lower 95% Confidence Interval 0.7 NTU
Upper 95% Confidence Interval 2.0 NTU
Defined in regulations as a flow-related parameter

No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. In both data sets, the turbidity vs. flow relationship is positive, though the EWQ relationship is weak. Note that both concentration and flow are represented on logarithmic scales.
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Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is not related to flow in the EWQ data set, but inversely and weakly related to flow in the post-EWQ data set. There were less cool temperatures in the post-EWQ data set. Note that flows are plotted on a logarithmic scale.