Lower Delaware River Special Protection Waters Assessment of Measurable Changes to Existing Water Quality, Round 1: Baseline EWQ (2000-2004) vs. Post-EWQ (2009-2011)

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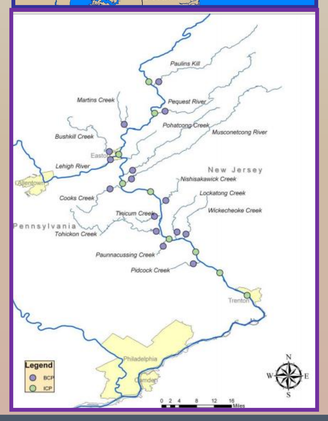
ABSTRACT

The Delaware River Basin Commission (DRBC) adopted the Special Protection Waters (SPW) program in 1992 to prevent degradation in the 197-mile non-tidal reach of the Delaware River and its tributaries where existing water quality is better than water quality standards. Under SPW, DRBC defines Existing Water Quality (EWQ) and monitors sites to ensure that established EWQ is being preserved. Data collected by DRBC, and other monitoring agencies, were used to define site-specific EWQ for locations within the non-tidal Delaware River and tributaries. DRBC recently performed an assessment to determine whether changes to EWQ have occurred between the definition period (2000-2004) and the assessment period (2009-2011) at 24 EWQ sites. For most water quality parameters at most locations, there was no degradation to EWQ and evidence of improved nutrient concentrations, demonstrating the importance and effectiveness of DRBC's Special Protection Waters program.

BACKGROUND



Special Protection Waters (SPW)

It is the policy of the Commission that there be no measurable change in existing water quality except towards natural conditions

SPW areas are in alignment with the National Park Service Wild and Scenic Rivers segments (Upper, Middle, and Lower Delaware)

SPW rules cover 6,780 of the 13,800 sq. mi. Delaware River Basin watershed area

SPW is an anti-degradation program adopted in 1992

DRBC approval required for new and expanding industrial and municipal wastewater treatment plants within SPW areas

National Park Service partners and DRBC monitor 85 sites within the 197-mile non-tidal stretch of SPW

Since 2016, EWQ has been defined for these 85 sites

The recent measurable change assessment discusses water quality at 24 sites within the 76-mile stretch of the Lower Delaware River

OBJECTIVES

- To define baseline Existing Water Quality for all SPW watersheds > 20 sq. mi. drainage area. These EWQ targets are provided to permit writers for development of discharge limits; or to non-point source planners as antidegradation targets for pollution reduction strategies.
- The ultimate objective is to assess the effectiveness of Special Protection Waters program and implementation measures; and to ensure that the water quality within SPW is maintained.
- To practically assess "measurable change" from baseline Existing Water Quality. Must account for differences in flow, analytical method and detection limit changes, number of samples, and timing of sample collections.

METHODS

Monitoring Methods

- May through September sampling
- Conventional parameters (Alkalinity, Hardness, Chlorides, TDS, TSS, Turbidity)
- Nutrients (TP, Orthophosphate, TN, Ammonia, TKN, Nitrate+Nitrite)
- Bacteria (Fecal coliforms, Enterococcus, E. coli)
- Field parameters (DO, DO%, pH, Specific Conductance, Temperature)
- Discharge from USGS's NWIS data and use of StreamStats and BaSE (Baseline Streamflow Estimator)
- All EPA or USGS methods, EPA-Approved QAPP
- QA sampling included Replicates, Field Blanks, and Sample Equipment Rinsate Blanks
- Note: a copy of the QAPP is available at:

http://www.state.nj.us/drbc/library/documents/SRMP_QAPP2013.pdf

Assessment Methods

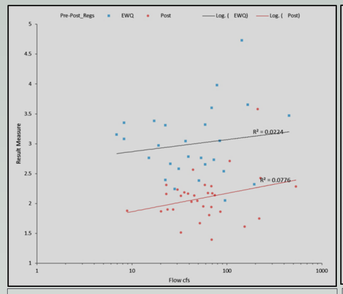
5 quantitative plots were used in combination for assessment of within-site changes to each parameter between the EWQ and post-EWQ time periods:

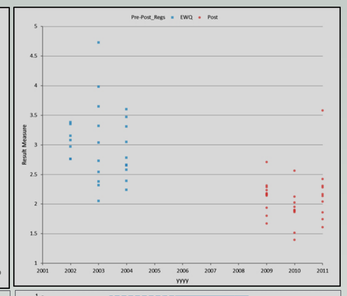
1. Scatter Plot of Concentration vs. Stream Flow (cfs), EWQ vs. Post-EWQ (TOP LEFT)
2. Scatter Plot of Annual Concentration, 2000-2011 (TOP RIGHT)
3. Box Plot Comparison of EWQ vs. Post-EWQ Concentrations (LOWER LEFT)
4. Cumulative Distribution Function (CDF) Comparison of EWQ vs. Post-EWQ (MIDDLE RIGHT)
5. Kruskal-Wallis Statistical Test of Difference between EWQ and Post-EWQ (LOWER RIGHT)

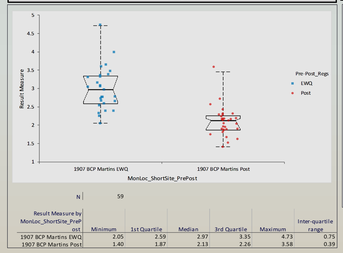
*The decision whether "measurable change" has occurred is an overall qualitative judgement rather than solely reliant on direct quantitative tests. All plots, along with the statistical test, allow for a fairly accurate judgement of measurable change within a replicable decision process.

RESULTS

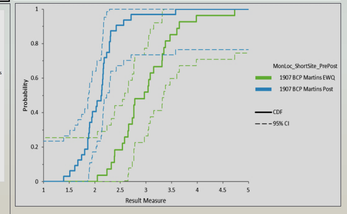
Example: Total Nitrogen as N (mg/L) at Martins Creek (Northampton County, PA):







Result Measure by MonLoc_ShortSite_PrePost	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	59	2.05	2.59	2.97	3.35	4.73	0.75
1907 BCP Martins Post		1.40	1.87	2.13	2.26	3.58	0.39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	27	5125.5	189.83
1907 BCP Martins Post	32	4324.5	135.14

H statistic	32.03
X^2 approximation	32.03
DF	1
p-value	<0.0001*

H_0: $\theta_1 = \theta_2$ for all i,j
The median of the populations are all equal.
H_1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
* Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

RESULTS

Site Color Key: Dark Blue = Interstate Control Point (ICP); Dark Red = Pennsylvania Tributary Boundary Control Point (BCP); Dark Green = New Jersey Tributary Boundary Control Point (BCP)

	Parameter / Site Number	Del. River at Trenton 1343 ICP	Del. River at Washngtn Crossing 1418 ICP	Pidcock Creek, PA 1463 BCP	Delaware River at Lambrtville 1487 ICP	Wicke-cheoke Creek, NJ 1525 BCP	Lockatong Creek, NJ 1540 BCP	Delaware River at Bulls Island 1554 ICP	Pauna-cussing Creek, PA 1556 BCP	Tohickon Creek, PA 1570 BCP	Tinicum Creek, PA 1616 BCP	Nishi-sakawick Creek, NJ 1641 BCP	Del. River at Milford 1677 ICP	Cooks Creek, PA 1737 BCP	Musco-netcong River, NJ 1746 BCP	Del. River at Rieglsvll 1748 ICP	Pohat-cong Creek, NJ 1774 BCP	Lehigh River, PA 1837 BCP	Del. River at Easton 1838 ICP	Bushkill Creek, PA 1841 BCP	Martins Creek, PA 1907 BCP	Pequest River, NJ 1978 BCP	Del. River at Belvidere 1978 ICP	Paulins Kill River, NJ 2070 BCP	Del. River at Portland 2074 ICP
Field	Dissolved Oxygen (DO) mg/l											~													
	Dissolved Oxygen Saturation %											~													
	pH, units																								
	Water Temperature, degrees C																								
Nutrients	Ammonia Nitrogen as N, Total mg/l																								
	Nitrate + Nitrite as N, Total mg/l																**								
	Nitrogen as N, Total (TN) mg/l																**								
	Nitrogen, Kjeldahl, Total (TKN) mg/l																								
	Orthophosphate as P, Total mg/l																								
	Phosphorus as P, Total (TP) mg/l																								
Bacteria	Enterococcus colonies/100 ml	~			~																				
	Escherichia coli colonies/100 ml	**	**	**	**	**	**			**	**	**													
	Fecal coliform colonies/100 ml																								
Conventionals	Alkalinity as CaCO3, Total mg/l																								
	Hardness as CaCO3, Total mg/l											~													
	Chloride, Total mg/l			**		**	**	**	**	**		**	**	**	**	**	**	**	~	**	**	**	**		**
	Specific Conductance µmho/cm			**		**	**	~	**	**	**	**	**	**	**	~	**	**	~	~	~	**	~		
	Total Dissolved Solids (TDS) mg/l																								
	Total Suspended Solids (TSS) mg/l																								
	Turbidity NTU																								

KEY: = No indication of measurable change to EWQ; ** = Indication of measurable water quality change toward more degraded status; ~ = Weak indication of measurable water quality change toward more degraded status

Downstream ← → Upstream

CONCLUSIONS

88% of tests reveal no evidence of water quality degradation and actually may reveal some improvements in many areas.

Chlorides and Specific Conductance increased at almost all locations. These were not major increases, but statistically significant. It is likely that winter de-icing salt may be the cause behind these increases.

E. Coli concentrations increased from Nishisakawick Creek (Frenchtown) southward. Bacteria source tracking if trends continue.

Nitrogen (TN and N+N) increased in Pohatcong Creek. Sources are unknown.

Based upon these results combined with cumulative watershed modeling of multiple dischargers, Special Protection Waters rules appear to be effective in controlling nutrients. Many discharge permits were designed with stringent effluent limits using EWQ antidegradation targets.