

Delaware River Basin Commission

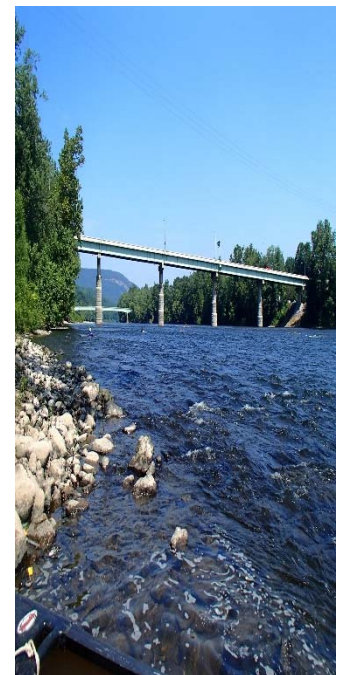
Special Protection Waters: Lower Delaware Measurable Change Assessment

*DRBC Science and Water Quality Management
Scenic Rivers Monitoring Program*

Water Quality Advisory Committee

*Robert Limbeck,
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July 28, 2016*

*Presented to an advisory committee of the DRBC on July 28, 2016.
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Special Protection Waters Reaches of the Delaware River



Special Protection Waters (SPW) Policy: “No measurable change to Existing Water Quality (EWQ) unless due to natural conditions”

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

Monitored by the DRBC/NPS Scenic Rivers Monitoring Program (SRMP)

What is the Scenic Rivers Monitoring Program?

- Long-standing partnership of DRBC and 3 National Park Service units
- Monitor Delaware River and tributary water quality
- Special Protection Waters rule development and assessment
- High priority for implementation in all 3 NPS management plans
 - Upper Delaware: Don Hamilton, Jamie Myers, Jessica Newbern
 - Middle Delaware: Allan Ambler
 - Lower Delaware: DRBC Staff
- Lab: NJ Dept. of Health, Environmental Chemistry and Laboratory Services
- 85 Sites: 28 Interstate; 11 NY tributaries; 30 PA tributaries; 16 NJ tributaries
 - 29 UPDE sites: 11 ICP, 18 BCP (5 BCP sites still completing EWQ)
 - 27 DEWA sites: 7 ICP, 20 BCP (2 BCP sites still completing EWQ)
 - 29 LDEL sites: 10 ICP, 19 BCP (2 BCP sites still completing EWQ)



Monitoring Methods

- May through September sampling, some monthly, some bi-weekly
- 22 parameters
- 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)
- Flow monitoring (Gage Height, Discharge)
- All EPA or USGS methods, EPA-Approved QAPP
- Quality Assurance 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



Lower Delaware Assessment is Necessary Check on Effectiveness of SPW

- Intense effort was required:
 - 20 parameters x 24 sites = 440 assessments
 - 5 plots per assessment – 2,200 analyses contributed to results
 - Flow analyses, frequency and normality checks, and graphic display revisions required about another 1,800 plots
 - Assessment was not automated – took a long time because each analysis had to be reformatted, properly scaled and individually interpreted (Analyse-It VBA code cannot be edited, and default graphs are almost never acceptable)
- All data are available from DRBC and are in STORET/WQX
- Automate next assessment 2018-2020 using R-Project

Tools used:

USGS Stream Stats v.2 and v.3 (watershed delineations & characteristics)

DRBC gage-discharge relationships (through 2009)

USGS gages & Delaware River Basin BaSE program (Stuckey et. al.)

DRBC-WQDB = MS Access and Excel (~ 170,000+ water quality records)



Lower Delaware (LDEL) Sites

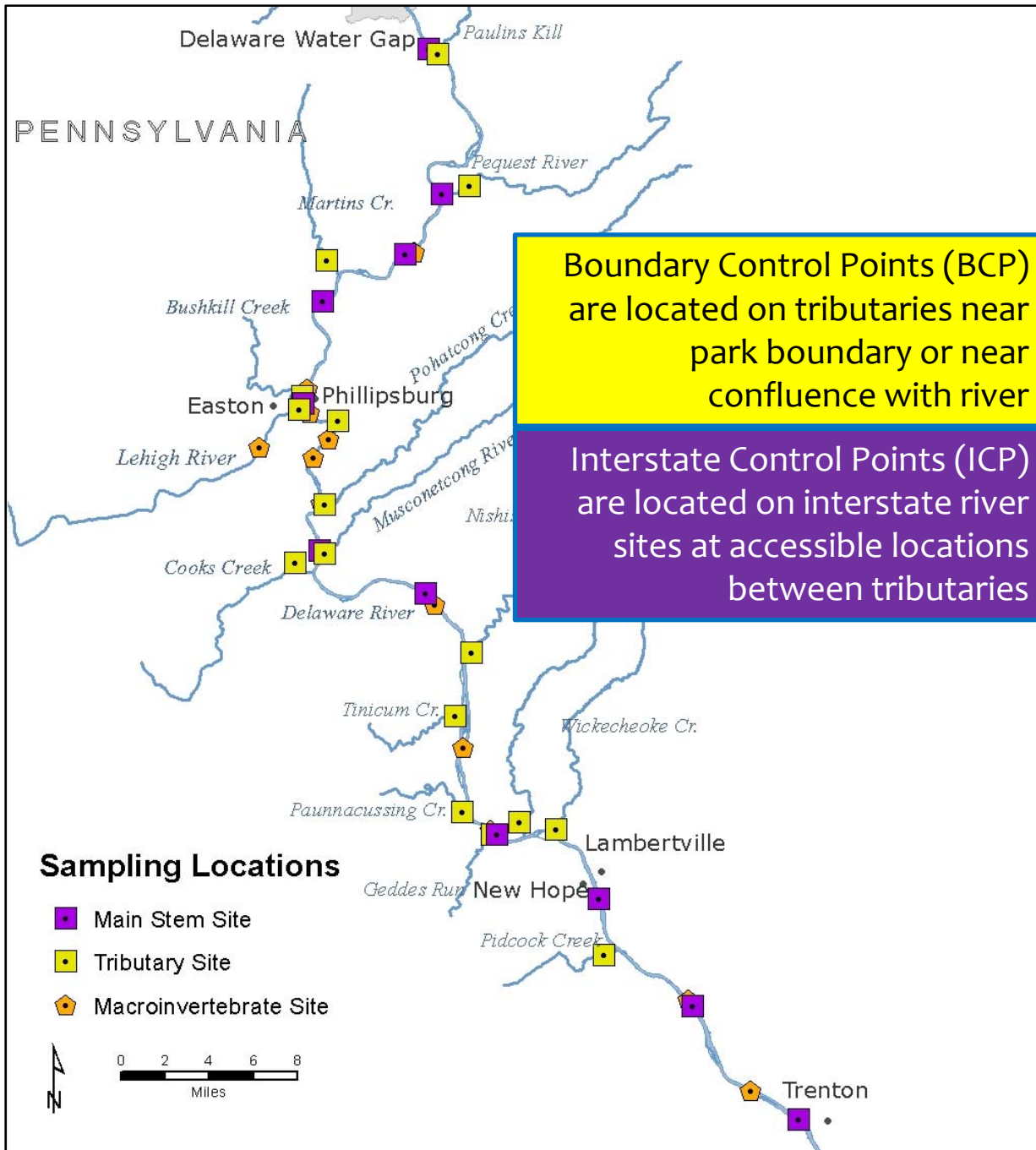
EWQ established 2000-2004 (n=40-50)

SPW Rules 2008

Designated as Significant Resource Waters

Assessment 1:
2009-2011 (n=15-30)

Assessment 2 planned
2019-2021



There are 24 Chapters in the Lower Delaware Measurable Change Assessment

Delaware R at Trenton

Jacobs Creek, NJ

Delaware R at Washington Crossing

Jericho Creek, PA

Pidcock Ck, PA

Delaware R at Lambertville

Alexauken Creek, NJ

Wickecheoke Ck, NJ

Lockatong Ck, NJ

Delaware R at Bulls Island

Paunacussing Ck, PA

Tohickon Ck, PA

Tinicum Ck, PA

Nishisakawick Ck, NJ

Delaware R at Milford/UBE

Hakihokake Creek, NJ

Gallows Run, PA

Cooks Ck, PA

Musconetcong River, NJ

Delaware R at Riegelsville

Pohatcong Ck, NJ

Lopatcong Creek, NJ

Lehigh River, PA

Delaware R at Easton

Bushkill Ck, PA

Delaware R at Sandts Eddy

Martins Ck, PA

Pequest River, NJ

Delaware R at Belvidere

Paulins Kill, NJ

Delaware R at Portland

Slateford Creek, PA

Black: 2000-2004 Site Specific EWQ established by rules; Part of Measurable Change Assessment

Green: EWQ completed 2010-2013; Lopatcong includes NJDEP and Hydroqual data

Red: EWQ to be completed 2014-2016, complementing NJDEP/USGS existing data

Blue: EWQ to be completed 2017-2019 (dischargers present in watersheds)



Special Protection Waters Objective: Antidegradation of Existing Water Quality

- *It is the policy of the Commission that there be no measurable change in existing water quality except towards natural conditions in waters considered by the Commission to have exceptionally high scenic, recreational, ecological, and/or water supply values.*

– Sec 3.10.3A.2.

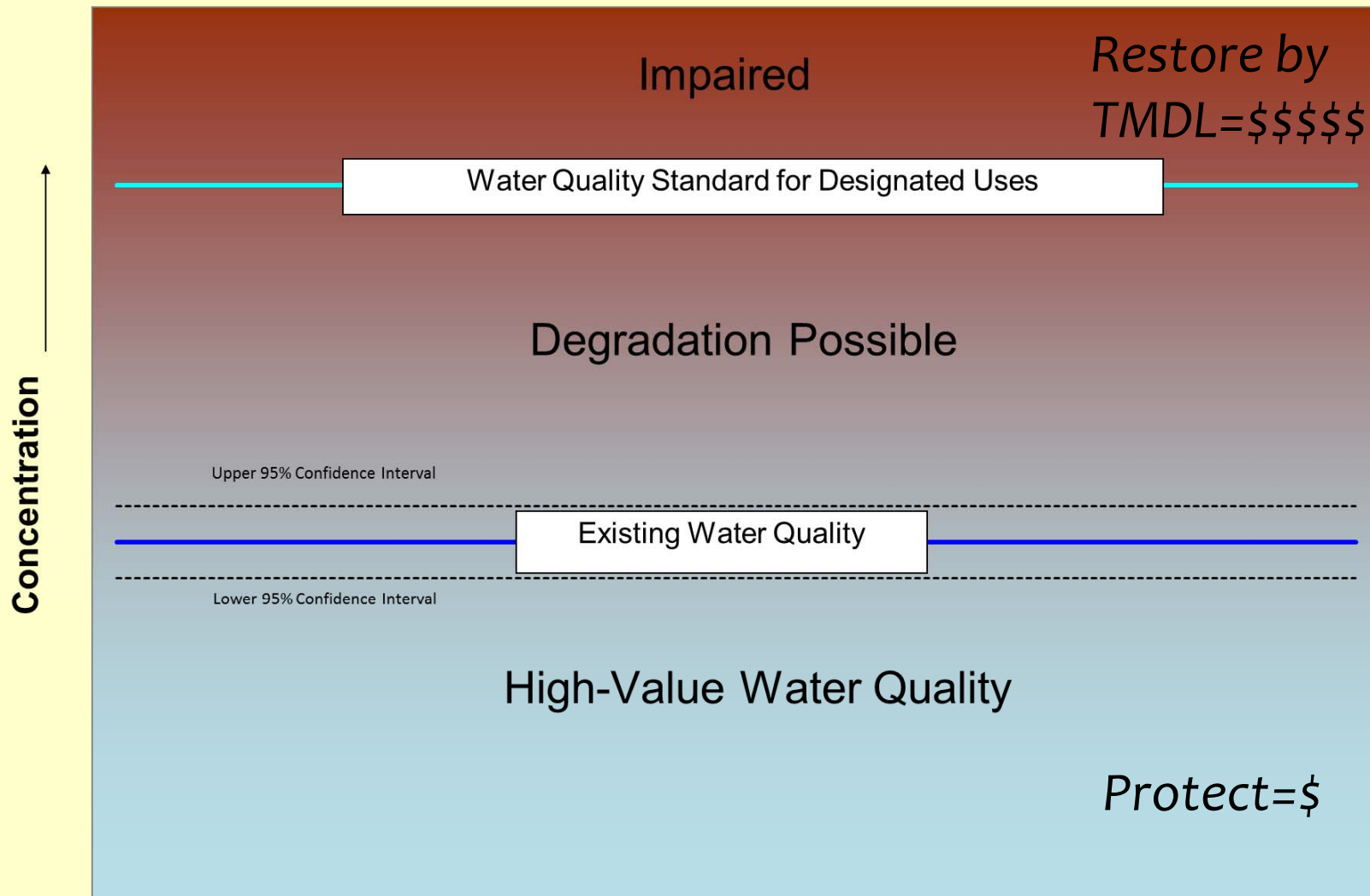
Assess to confirm this

Define this



EWQ Targets are Policy, Not Criteria

Comparison of Existing Water Quality versus Standards



Lower Delaware Measurable Change Assessment 2009-2011

2016



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)
DELAWARE RIVER BASIN COMMISSION, SCENIC RIVERS MONITORING PROGRAM



DRBC | West Trenton, NJ

DRBC Publication is Available

Release (pdf) July 2016

Executive Summary,
24 Chapters (one per site),
3 Appendices:

New ICP/BCP sites

Statistical Guide

Flow Estimation Methods



DRBC Measurable Change Assessment Process: Primary Question=Has Degradation Occurred?

Quantitative plots and statistical tests 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
2. Scatter Plot of Annual Concentration, 2000-2011
3. Box Plot Comparison of EWQ vs. Post-EWQ Concentrations
4. Cumulative Distribution Function (CDF) Comparison of EWQ vs. Post-EWQ
5. Kruskal-Wallis Statistical Test of Difference between EWQ and Post-EWQ

Examples follow



Summary Matrix of Measurable Changes: 440 Within-Site Comparisons at a Glance

Mostly Good News:
88% of water quality tests showed no degradation

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		Del. River at Trenton	Del. River at Washngtn Crossing	Pidcock Creek, PA	Delaware River at Lambrtville	Wicke-cheokee Creek, NJ	Lockatong Creek, NJ	Delaware River at Bulls Island	Pauna-cussing Creek, PA	Tohickon Creek, PA	Tinicum Creek, PA	Nishi-sakawick Creek, NJ	Del. River at Milford	Cooks Creek, PA	Musco-netcong River, NJ	Del. River at Rieglsvll	Pohat-cong Creek, NJ	Lehigh River, PA	Del. River at Easton	Bushkill Creek, PA	Martins Creek, PA	Pequest River, NJ	Del. River at Belvidere	Paulins Kill River, NJ	Del. River at Portland
Site Number-->		1343 ICP	1418 ICP	1463 BCP	1487 ICP	1525 BCP	1540 BCP	1554 ICP	1556 BCP	1570 BCP	1616 BCP	1641 BCP	1677 ICP	1737 BCP	1746 BCP	1748 ICP	1774 BCP	1837 BCP	1838 ICP	1841 BCP	1907 BCP	1978 BCP	1978 ICP	2070 BCP	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																								
Bacteria	Phosphorus as P, Total (TP) mg/l																								
	Enterococcus colonies/100 ml	~			~																				
	Escherichia coli colonies/100 ml	**	**	**	**	**	**			**	**	**													
Conventionals	Fecal coliform colonies/100 ml																								
	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 EWO								** = Indication of measurable water quality change toward more degraded status					~ = Weak indication of measurable water quality change toward more degraded status										

Lower Delaware Assessment Findings: Measurable Changes 2000-2011

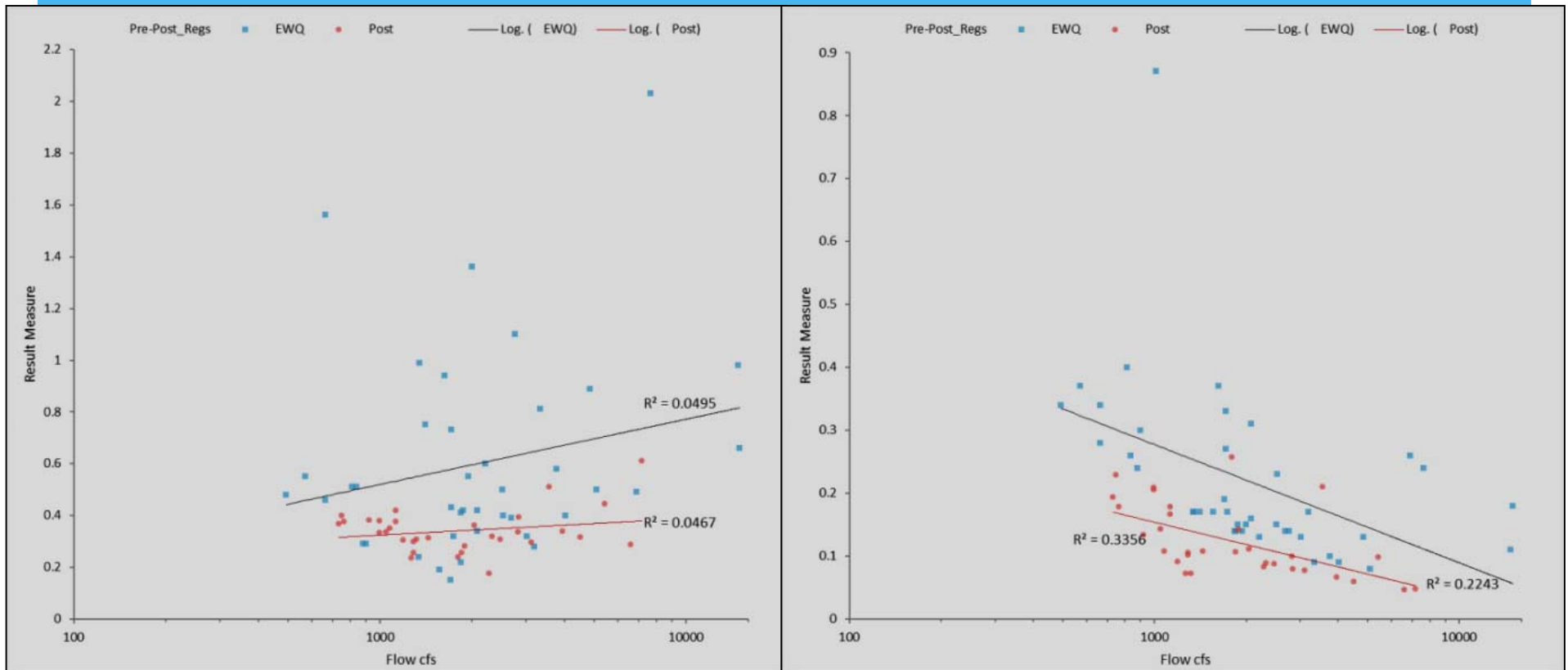
88% of tests revealed no evidence of water quality degradation; many revealed water quality improvement.

Nutrients improved at most sites since 2000. Only Pohatcong Creek increased.

Chlorides and Specific Conductance increased at almost all locations (winter road salting is most likely cause). Both parameters are unregulated, as are DOT practices. Further continuous monitoring planned; we want to work with co-regulators on issue.

E. Coli concentrations increased from Nishisakawick Creek (Frenchtown) southward.

Water Quality Improvement Examples

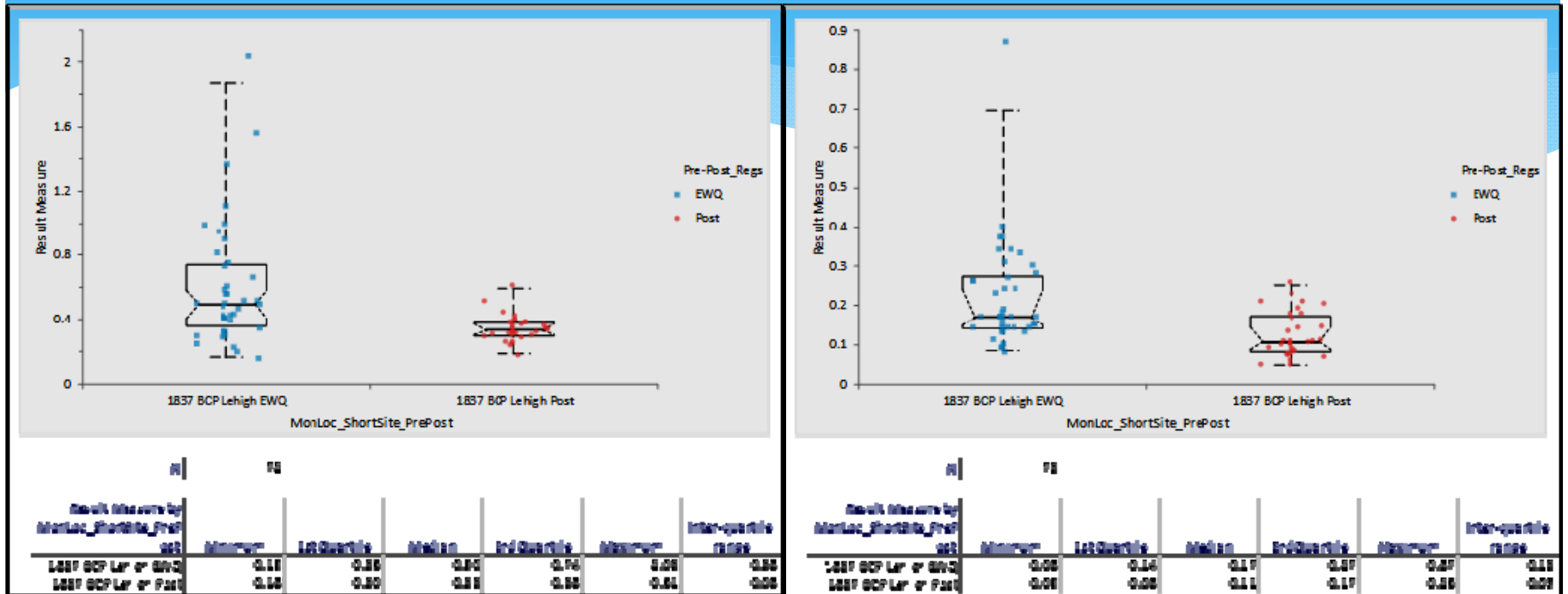


Lehigh River: Kjeldahl Nitrogen

Lehigh River: Total Phosphorus

SPW management actions may have contributed to Lehigh River nutrient reductions through numerous project review dockets. This may be an early indicator of SPW effectiveness.

EWQ vs. Post-EWQ Box Plot



Lehigh River: Kjeldahl Nitrogen

Lehigh River: Total Phosphorus

Another view of the improvements seen in Lehigh River water quality. These improvements were statistically significant.



Expected Next Steps

- * Publish Lower Delaware Measurable Change Assessment Report – July 2016
- * Public Outreach:
 - * Interactive story maps on website
 - * More data mining and stories to post
 - * Present to AWRA in September; watershed groups
- * Companion Report – Special Protection Waters Atlas

Existing Water Quality Atlas of the Delaware River Special Protection Waters

Delaware River Basin Commission

Existing Water Quality Atlas of the Delaware River Special Protection Waters



DRBC Special Protection Waters Program

May 2016



Currently under review

Maps, Watershed Population, Land Use & Flow Statistics, and Site-Specific Existing Water Quality Tables from West Branch Delaware River to Trenton

85 Locations

Upper Delaware: 11 ICP's, 19 BCP tribs.

Middle Delaware: 7 ICP's, 20 BCP tribs.

Lower Delaware: 10 ICP's, 18 BCP tribs.
(28 DR sites & 57 tributary watersheds)

Best existing scientific knowledge of water quality, flow and characteristics of the Delaware River and its tributaries.

Atlas Preparation: Many Sources, Many Thanks

Extensively Used Information Sources:

National Water Quality Data Portal

- Site Specific EWQ includes 1999-2015 USGS, PA, NY, NJ water quality data + SRMP

3 USGS/NPS Studies:

- Delaware Water Gap 2002-2004: Ward Hickman and Jeff Fisher
- Upper Delaware 2005-2007: Jason Siemion and Pete Murdoch
- Upper Delaware 2012-2015: Lisa Senior

USGS Gages at or near Control Point Locations

USGS Stream Stats v.2 and v.3 (PA application primarily used)

USGS Delaware River Basin BaSE Model (Marla Stuckey)

U.S. Census, 2000 and 2010 Block Data



Boundary Control Points (BCP) are located on tributaries near park boundary or near confluence with river

Interstate Control Points (ICP) are located on interstate river sites at accessible locations between tributaries

Upper Delaware (UPDE) Sites

SPW Rules 1992: Reach-wide Only, EWQ for Tributaries was not Described

29 sites: Site-Specific EWQ SRMP 2006-2011 (n=30-50) + state/USGS data

Designated as Outstanding Basin Waters

Assessment 1 Planned: 2019-2021



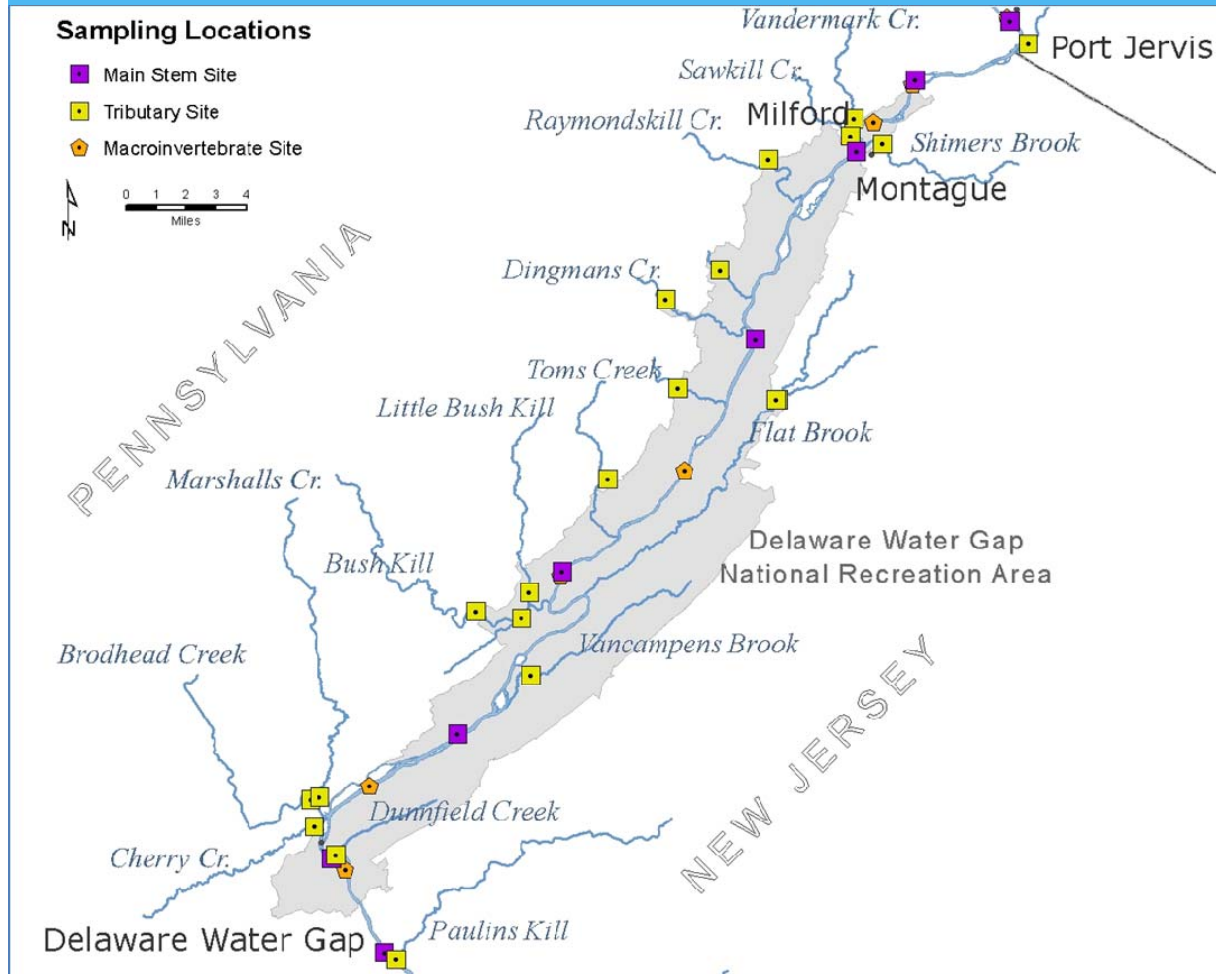
Upper Delaware Site List

29 sites: 11 Interstate; 10 NY; 8 PA Watersheds

Delaware R at Mill Rift
Mongaup River, NY
Delaware R at Pond Eddy
Mill Brook, NY
Shohola Creek, PA
Halfway Brook, NY
Delaware R at Barryville/Shohola
Beaver Brook, NY
Lackawaxen River, PA
Delaware River above Lackawaxen
Masthope Creek, PA
Tenmile River, NY
Delaware R at Narrowsburg
Calkins Creek, PA
Delaware R at Damascus/Cochecton

Callicoon Creek, NY
Delaware R at Callicoon
Little Equinunk Creek, PA
Delaware R at Kellams Bridge
Basket Creek, NY
Delaware R at Lordville
Equinunk Creek, PA
East Branch Delaware River, NY
Shehawken Creek, PA
West Branch Delaware R Hancock
Sands Ck, NY
Balls Ck, PA
West Branch Delaware R Hale Eddy
Oquaga Creek, NY

Middle Delaware (DEWA) Sites



SPW Rules 1992: Reach-wide Only, EWQ for Tributaries was not Described

27 sites: Site-Specific EWQ
2002-2004 USGS; SRMP
Supplemented 2006-2011

Designated as Outstanding
Basin Waters

Assessment 1 Planned:
2019-2021

Middle Delaware Site List

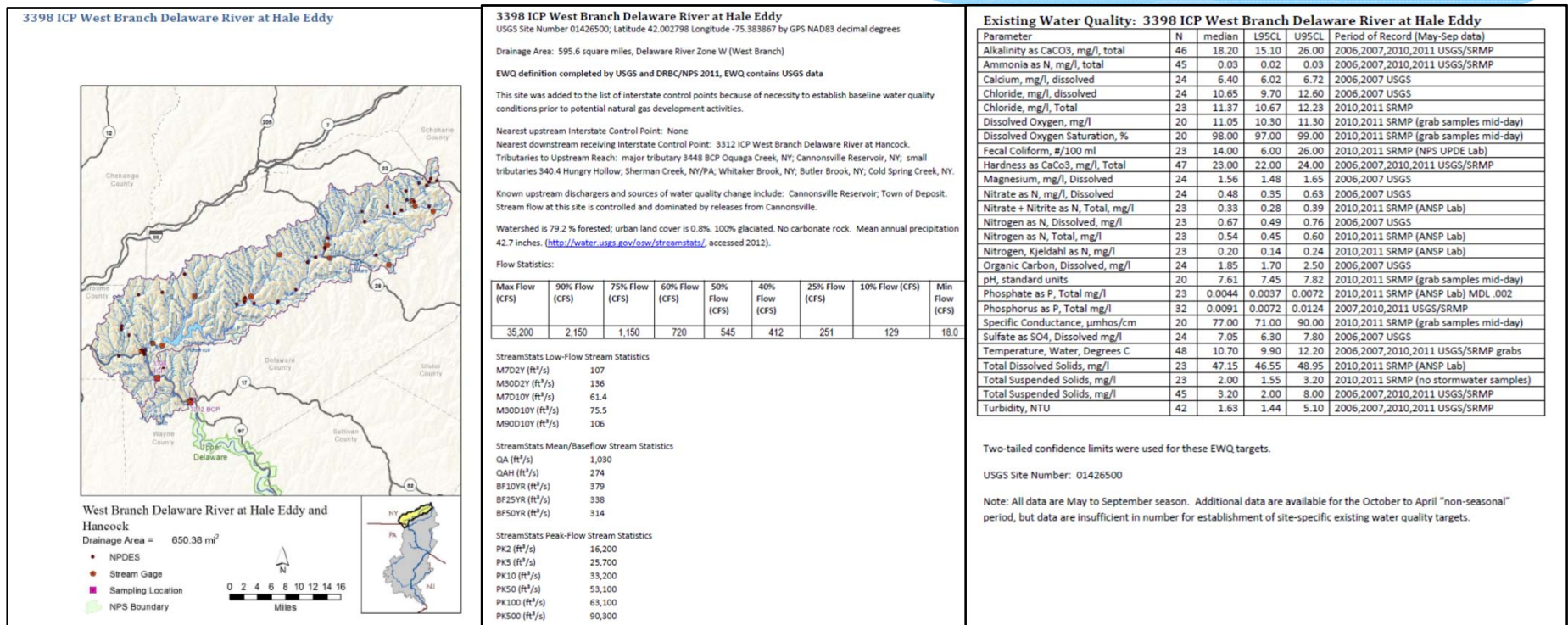
27 sites: 7 Interstate; 6 NJ, 1 NY, 13 PA Watersheds

Dunnfield Creek, NJ
Delaware R at Kittatinny Visitor Center
Cherry Creek, PA
Brodhead Creek, PA
Marshalls Creek at DEWA Bdy, PA
Delaware R at Smithfield Access
Van Campens Brook, NJ
Flat Brook at Flatbrookville, NJ
Flat Brook at DEWA Bdy, NJ
Little Flat Brook at DEWA Bdy, NJ
Bushkill Creek at DEWA Bdy, PA
Little Bushkill Creek at DEWA Bdy, PA
Sand Hill Creek at DEWA Bdy, PA
Delaware R at Bushkill Access

Toms Creek at DEWA Bdy, PA
Hornbecks Creek at DEWA Bdy, PA
Delaware R at Dingmans Access
Dingmans Creek at DEWA Bdy, PA
Adams Creek at DEWA Bdy, PA
Raymondskill Creek at DEWA Bdy, PA
Delaware R at Milford Beach (Montague)
Shimers Brook at DEWA Bdy, NJ
Sawkill Creek at DEWA Bdy, PA
Vandermark Creek at DEWA Bdy, PA
Delaware R at DWGNRA Northern Boundary
Neversink River, NY
Delaware R at Port Jervis



Existing Water Quality Atlas Contents



Example: West Branch Delaware River at Hale Eddy – Map, Site Facts, EWQ Table

Work in Progress & Other Products

SRMP and DRBC Monitoring Section:

1. Sampling 13 sites in 2016 – 6 annual ICP sites (Delaware River); 6 new EWQ BCP sites: Alexauken; Hakiwokake; Cherry; Flat Brook; Basket; Little Equinunk. Revisit Paulins Kill during Columbia Dam removal project (TNC/American Rivers)
2. Planning large measurable change assessment 2019-2021: select about 50 UPDE, DEWA and LDEL sites.
3. Placing all LDEL assessment and EWQ Atlas materials on DRBC map service: <http://www.state.nj.us/drbc/basin/map/interactive-map.html>
4. Creating a Delaware River Explorer using R and Shiny, similar to John Yagecic's Boat Run Explorer for the Estuary: <https://johnyagecic.shinyapps.io/BoatRunExplorer/>
5. Make all water quality and biological data available on DRBC's web site

Contacts

We are available to meet about more detailed discussion of these products.

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