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National Monitoring Network for Coastal Waters and Their Tributaries: the Delaware River Basin Pilot Inventory and Demonstration Projects

National Water Quality Monitoring Council Meeting

March 10, 2009

Eric Vowinkel
USGS New Jersey Water Science Center
USGS Acting Executive Secretary
National Monitoring Network for Coastal Waters and Their Tributaries
of the National Water Quality Monitoring Council
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Josh Kohut
Rutgers University Institute of Marine and Coastal Sciences
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Organizations represented

- **Eric Vowinkel**
  - U.S. Geological Survey, New Jersey Water Science Center (USGS/NJWSC)
  - National Water Quality Monitoring Council/Methods and Data Comparability Board (NWQMC/MDCB)
  - Other Federal Agencies (USEPA, NOAA)
  - New Jersey Water Monitoring Coordination Council (NJWMCC)
- **Josh Kohut**
  - Rutgers University Institute of Marine and Coastal Sciences (IMCS) Coastal Ocean Observation Laboratory (RUCOOL)
  - Mid-Atlantic Coastal Ocean Observation Regional Association (MACOORA)
  - Other university collaborations

Outline of presentation—questions?

- Summary
  - Organizations and interest in the Network
  - Overview of what have was learned during Pilot Inventory
- Issues: What water issues are you addressing?
- Stakeholders
  - Who are the major stakeholders
  - How are we connecting with the regional IOOS
- Current progress
  - What monitoring is being done now and why?
  - How does this relate to your goals?
- Needs: What else do you need to fill gaps/challenges?
- Next steps:
  - What products/outcomes do you expect?
  - What information would you convey to help refine Network design for other Pilot areas just starting up?

What have you learned from the Pilot Inventory?

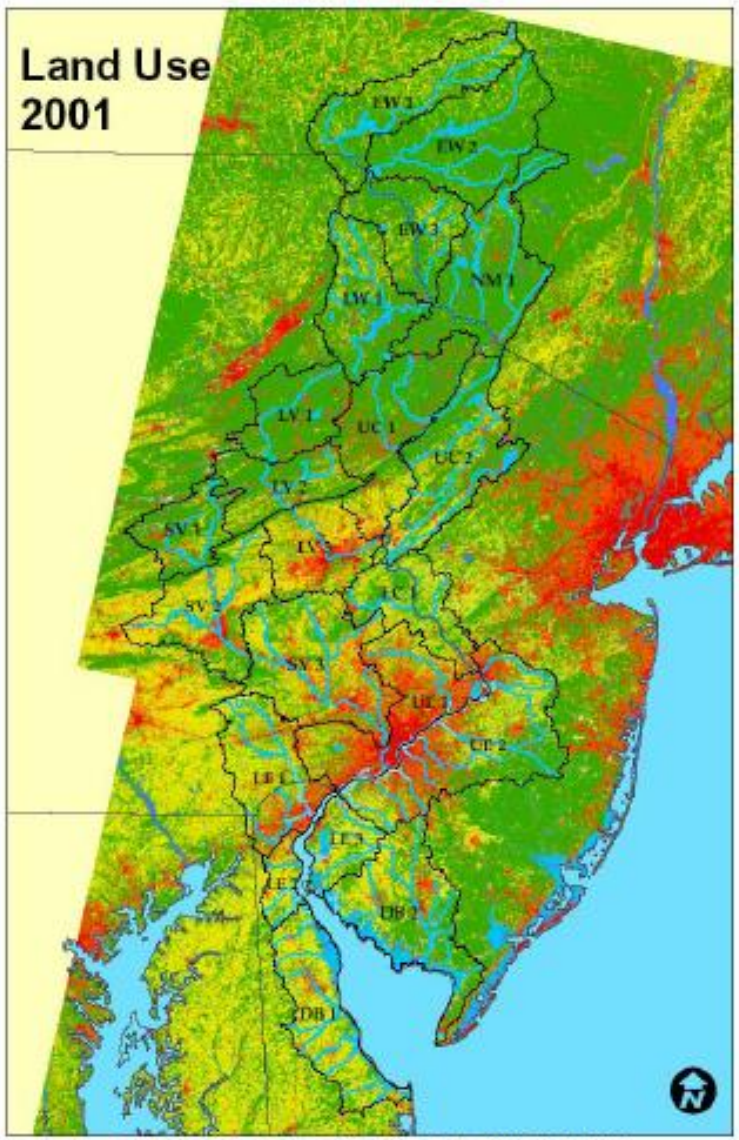


Figure 5.5. Land use in the Delaware River Basin, 2001. (NOAA CSC)

- Upper Watershed:
  - "pristine" recreational area
  - water supply for >15 million

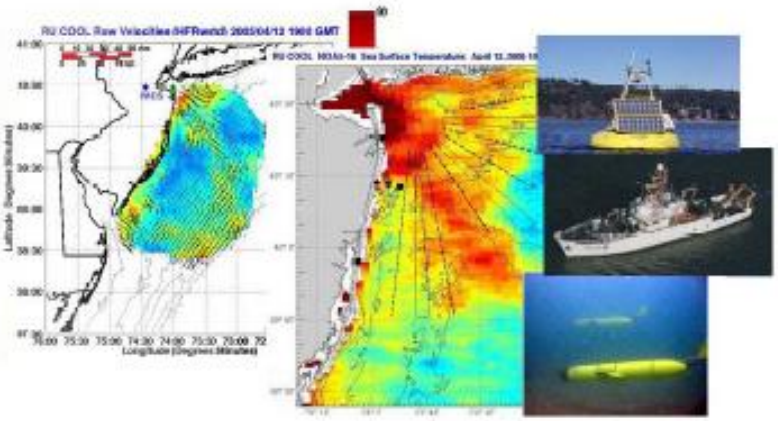
Tidal River:
- 4th largest US urban center
- world's largest freshwater port
- 70% of east coast oil
- Major industry buildup

Lower Estuary:
- Water fowl, finfish, shellfish
- Horseshoe crab population
- Dense human population

Data Inventory and Pilot Study Reports with gap analyses

Linking Elements of the Integrated Ocean Observing System (IOOS) With the Planned National Water Quality Monitoring Network

Proceedings from the NOAA-Supported Workshop
19-21 September, 2005



Edited by: Peter M. Rowe, Ph.D.; M. Jawed Hameedi, Ph.D.; and Michael P. Weinstein, Ph.D.

NOAA Technical Memorandum NOS NCCOS 48

Delaware River Basin Commission
DELAWARE · NEW JERSEY
PENNSYLVANIA · NEW YORK
UNITED STATES OF AMERICA

DELAWARE RIVER BASIN
NATIONAL WATER QUALITY MONITORING NETWORK
PILOT STUDY
FINAL REPORT

REPORT COORDINATORS:	Mr. Robert Tudor (Delaware River Basin Commission) Dr. Eric F. Vowinkel (USGS, NJ Water Science Center)

RESOURCE COMPARTMENT WORKGROUP CHAIRS:

Estuaries Workgroup Chair:	Dr. Jonathan H. Sharp (College of Marine and Earth Studies, University of Delaware)
Near-shore Workgroup Chair:	Mr. Robert Connell (NJ Dept. of Environmental Protection)
Off-shore Workgroup Chair:	Dr. Scott Glenn, (Institute of Marine and Coastal Sciences, Rutgers Univ.) Dr. Josh Kohut (Institute of Marine and Coastal Sciences, Rutgers Univ.)
Rivers Workgroup Chair:	Dr. Eric F. Vowinkel (USGS, NJ Water Science Center)
Groundwater Workgroup Chair:	Dr. Eric F. Vowinkel
Wetlands Workgroup Chair:	Dr. Danielle Kreeger (Partnership for the Delaware Estuary)
Atmospheric Deposition Workgroup Chair:	Dr. Lisa A. Rodenburg (Dept. of Environmental Sciences, Rutgers Univ.)
Data Management Workgroup Chair:	Dr. David R. Legates (Dept. of Geography, University of Delaware)

February 7, 2008

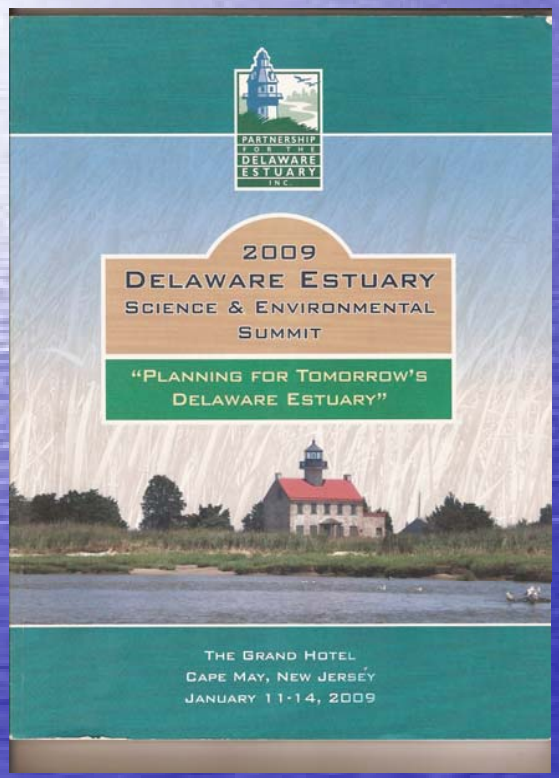
http://acwi.gov/monitoring/network/

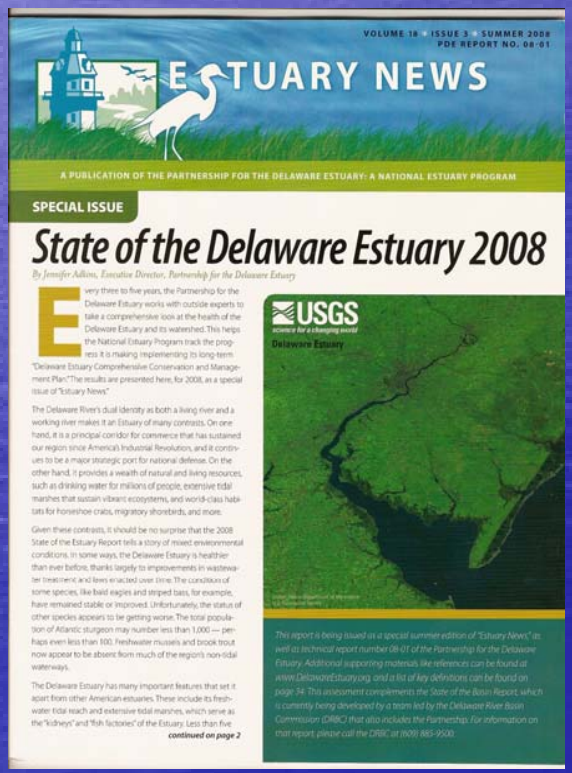
http://www.ccma.nos.noaa.gov/publications/IOOSTechMemo.pdf

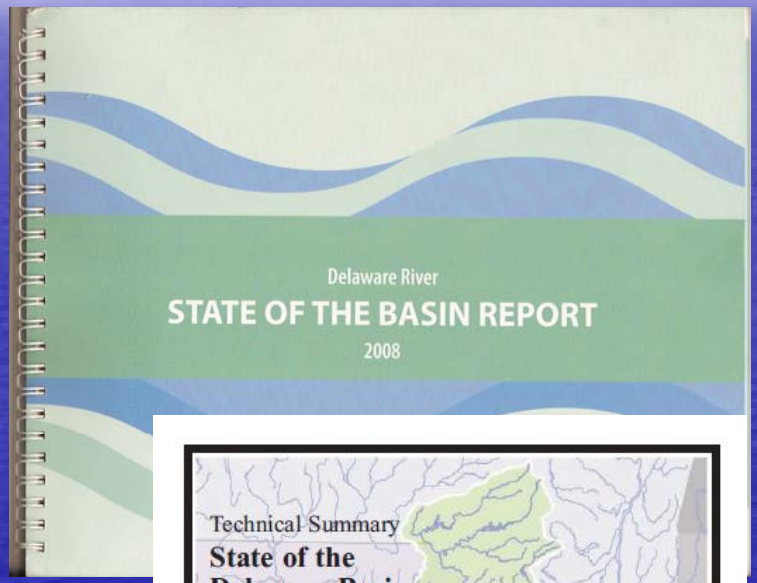
Delaware River Basin and Estuary recent reports and conference highlights

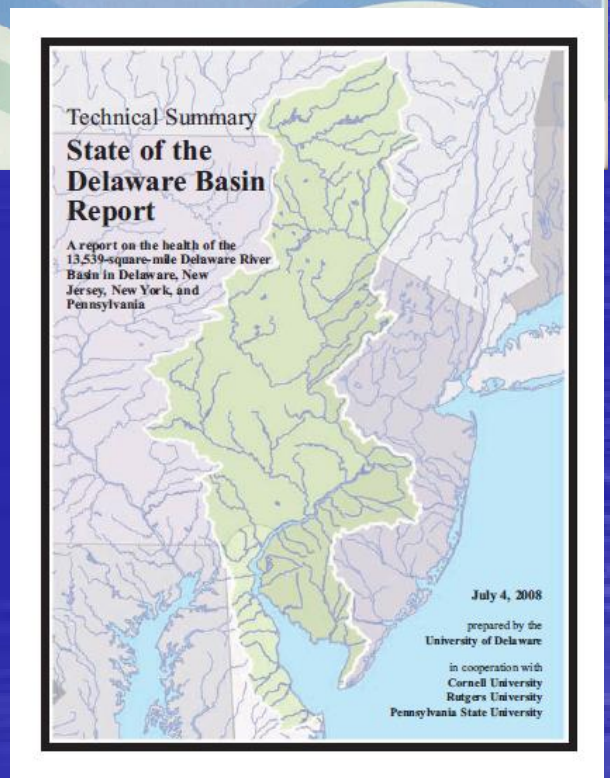
http://www.state.nj.us/drbc/SOTB/index.htm

http://www.delawareestuary.org/









http://dspace.udel.edu:8080/dspace/bitstream/19716/3808/1/StateoftheDelRiverBasin08.pdf

What have you learned from the Pilot Inventory?

- The DRB area is data rich for water monitoring
- Many organizations participate in water quality/quantity issues that are valuable to the National Network and/or other networks
- Monitoring gaps were identified
- MACOORA and NJ Water Monitoring Coordination Council have provided great opportunities for scientists and managers to gather and discuss how to collaborate
- These groups are committed to connecting monitoring from the watersheds, estuaries, coasts to the ocean
- Desperately need to have a centralized One-Stop Shop web page for water-data in the DRB

NOAA Grant Proposal related to real-time monitoring and data management in the Delaware Basin

Monitoring Infrastructure

The Delaware Estuary Watershed to Ocean Observing System (DEWOOS)

A Pilot Integrated Observing System Linking Monitoring of Watershed, Estuary and Coastal Ocean

A Planning Concept from:
Delaware River Basin Commission
University of Delaware
Rutgers University
US Geological Survey
NOAA
States of New Jersey and Delaware
Partnership for the Delaware Estuary
DE, NJ and PA Sea Grant

- Upgrades to USGS real-time sites
- Delaware Memorial Bridge (UDel)
- Buoys for oyster beds (NJDEP)
- Cape May Ferry (UDel)
- AUV for shallow estuary (UDel)
- Moorings lower estuary (UDel)
- AUV for offshore (RU/UDel)
- CODAR for Delaware Estuary (UDel/RU) to complete RCOOS
- Atmospheric (RU)
- Wetlands (PDE)
- DEWOOS Data Management

PROPOSAL COVER SHEET

Development of a Delaware Basin Watershed to Ocean Water-Quality-Data Exchange Portal and Upgrades to Real-Time Observation Systems as Part of the National Monitoring Network for Coastal Waters and Their Tributaries

December 3, 2007

Principal Investigator: Robert Tudor
Deputy Executive Director
Delaware River Basin Commission
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robert.tudor@drbc.state.nj.us

Additional sensors such as nitrate, chlorophyll, carbon, and PARS planned at selected sites

Water issues being addressed in the Delaware Basin Demonstration area

Environmental Indicators

- Land-use/landscape
- Water quantity/hydrology
- Water Quality
- Living resources

Water Quality concerns

- Oxygen depletion
- Nutrient enrichment
- Toxic contamination
- Sedimentation
- Harmful algal blooms
- Habitat degradation
- Invasions by exotic species
- Pathogens (indicator bacteria)

Indicators: Land use & Hydrology from 2008-09 recent publications

Delaware River Basin Indicator	Report Card	Trend
Landscape		
Population	Delaware Basin population projected to exceed 8,000,000 by 2010, an 800,000 increase from 7,200,000 in 1990.	▼
Land Use	The Delaware Basin gained 70 mi^2 of developed land between 1996 and 2001, a rate of 25 acres per day.	▼
Impervious Cover	Impervious cover is increasing with new development. Watersheds near Philadelphia exceed 10% impervious cover.	▼
Tidal Wetlands	20% of Delaware Bay watersheds covered by tidal wetlands.	▲
Tidal Wetland Buffers	35% of Delaware Bay watersheds covered with tidal wetland buffers	▲
Total Wetlands	The Delaware Basin has lost 4 mi^2 of wetlands between 1996 and 2001, a rate of 1.4 acres per day.	▼
Forest	The Delaware Basin lost 48 mi^2 of forest between 1996 and 2001,a rate of 17 acres per day. There are more forests now (54% in 2001) than 1930 (32%).	▼
Superfund Sites	USEPA identified 1,600 Federal Superfund sites in the Delaware Basin, many are being cleaned up and being remediated.	▲
Riparian corridor condition	Riparian areas along streams contain 1 to 4 miles of roadway per mi^2 of buffer.	●
National Wild and Scenic Rivers	EB/WB, Hancock, NY (73 mi), Del. Water Gap (40 mi), Maurice R. (35.4 mi), Lower Del. River, PA (38.9 mi), White Clay Creek in DE, PA (190 mi).	▲
Water Quantity and Hydrology		
Water Supply and Demand	8,264 mgd of peak surface water withdrawals in 1996,	●
Streamflow	Little or no changes in peak or low flow streamflows since 1990.	●
Groundwater quantity	In the Delaware Basin: 4,645 mgd groundwater available, 423 mgd withdrawn, 9% of groundwater used.	●
Flooding	Three major floods occurred along the Delaware River in 2004, 2005, and 2006.	▼
Dams (hydrologic impairment)	Dams removed or fish ladders installed along Schuylkill, Lehigh R., and Pennypack Creek. Dam removals proposed along Brandywine Creek.	▲

http://dspace.udel.edu:8080/dspace/bitstream/19716/3808/1/StateoftheDelRiverBasin08.pdf

Indicators: water quality

Delaware River Basin Indicator	Report Card	Trend
Water Quality		
Dissolved Oxygen	DO has improved or remained constant since 1990 at 11/12 stations along main stem and at 14/20 tributary stations.	▲
Nitrogen	N has remained constant since 1990 at 7/7 stations along the river and bay and at 15/16 tributary stations.	●
Phosphorus	P has improved or remained constant since 1990 at 7/7 stations along the river and bay and at 20/20 tributary stations.	▲
Total Suspended Sediment	TSS has remained constant since 1990 at 5/6 stations along the river and bay and at 19/19 tributary stations.	●
Copper	Cu has remained constant since 1990 at 5/5 stations along main stem and at 19/19 tributary stations.	●
Lead	Pb has remained constant since 1990 at 2/2 stations along main stem and improved or remained constant at 19/19 tributary stations.	▲
Zinc	Zn has improved or remained constant since 1990 at 5/5 stations along main stem and at 18/18 tributary stations.	▲
Mercury	Hg improved at Delaware R. at Trenton and EB/WB Delaware River and Neversink subwatersheds. Miles of Hg fish consumption advisories.	●
PCBs	PCBs detected in 84% of fish samples. PCBs in fish tissue declined over 25 yrs in basin.	●
Atrazine,	95 of 100 streams in Delaware River Basin had detectable levels of Atrazine.	▼
Metolachlor	83 of 103 streams in Delaware River Basin had detectable levels of Metolachlor.	▼
Water Temperature	Water temperatures constant since 1990 at 10/13 stations. Summer median and peak water temperature declined in EB/WB and Neversink River.	●
Fish Consumption Advisories	3,935 miles (17%) of Delaware River Basin streams have full/limited fish consumption advisories in 2006.	▼
Sec 303(d) Designated Uses /Impaired Streams	2,493 miles (11%) of Delaware River Basin streams are impaired according to the USEPA in 2004.	▼
Salt Line (chlorides)	Salt line fluctuates annually in the Delaware River between the mouth of the Schuylkill at Philadelphia and the Christina River at Wilmington.	●

Indicators: Living resources

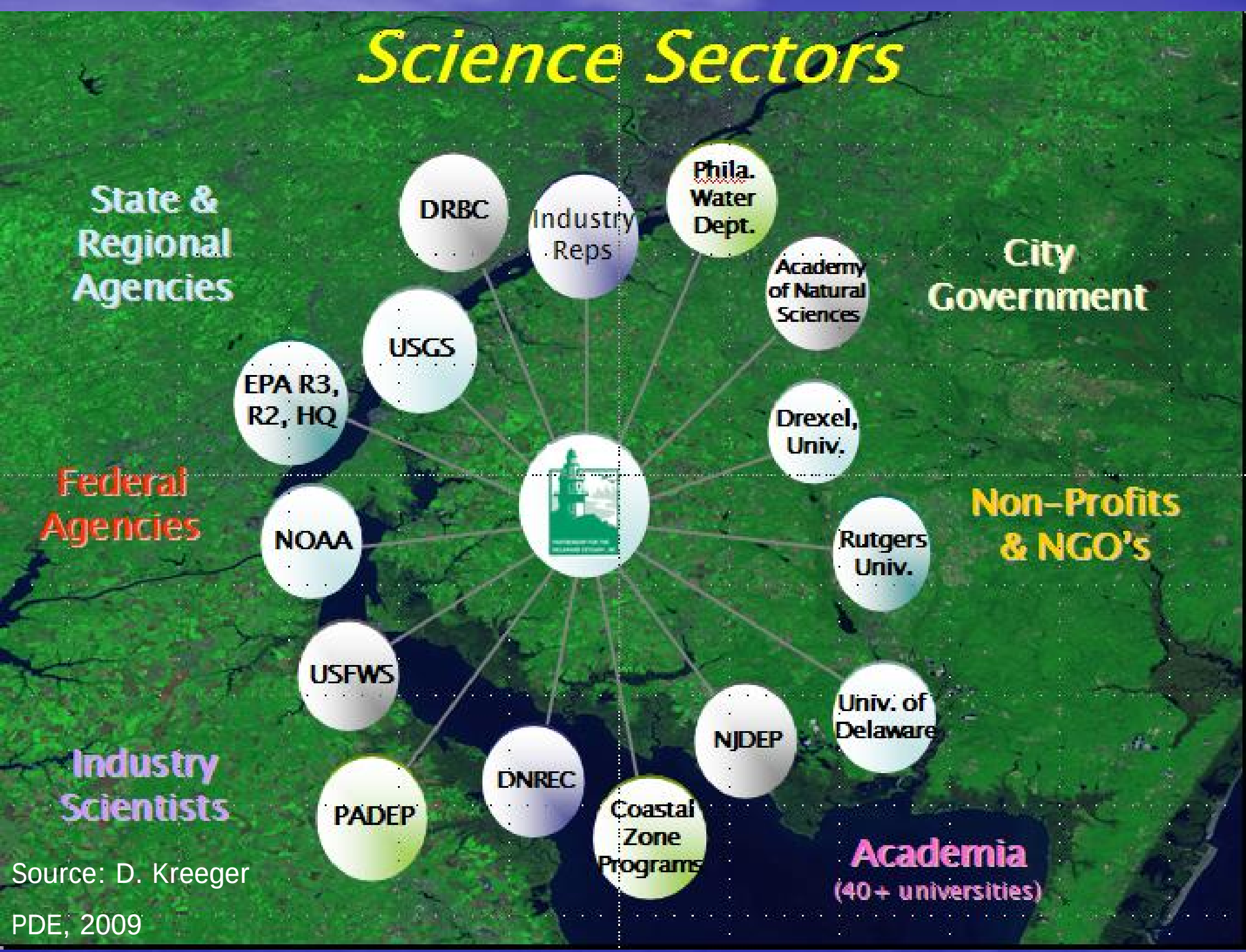
Delaware River Basin Indicator	Report Card	Trend
Living Resources		
Macroinvertebrates	Macroinvertebrate health ranges from good to poor.	●
Oyster Beds	500,000 bushels of shell planted in 2005 for Delaware Bay oyster restoration project.	▲
Eastern Oyster	Oyster landings in bay down to 100,000 bushels from 500,000 bushels during 1980s.	▼
Horseshoe Crab	Spawning index constant since 1990 at 0.8. although ISA declining along the DE side of the bay. DE/NJ have horseshoe crab harvest moratoriums.	▼
Blue Crab	DE/NJ blue crab landings at 2 to 5 million, up from 1 million during 1970s. Most lucrative shellfishery in bay. Value of harvest = $ 7 million.	▲
Freshwater Mussels	23% of native freshwater mussels are federally endangered and 7% are extinct.	▼
Zebra Mussels	Invasive mussel only detected in Lehigh River watershed near Easton so far. Numerous sightings in adjacent basins of Hudson and Susquehanna.	●
American Shad	Almost 200,000 migrating shad detected along Delaware River at Lambertville. Shad counted along the Schuylkill and Lehigh Rivers.	●
Brook Trout	The state fish of NJ, NY, and PA, about 15% of native brook trout habitat extirpated in Delaware River Basin with habitat remaining in 50% of Basin.	▼
Striped Bass	20,000 fish caught in 2005 and 40,000 in 2000 up from less than 5000 striped bass caught in 1990.	▲
Atlantic Sturgeon	In danger of extinction, only 2 fish caught in 2004, none in 2005. Atlantic sturgeon is on the DE endangered species list.	▼
Weakfish	Weakie abundance down to 50 per mile from at or above 150 fish per mile during 1990s.	▼
Summer Flounder	Fluke biomass at 50,000 metric tons in 2005, up from 30,000 tons in 2000.	▲
Louisiana Water Thrush	Breeding bird survey habitat down by more than 3% in much of the Delaware River Basin.	▼
Red Knot	The Delaware Bay red knot stopover population has declined since 1997. Peak numbers of over 100,000 in the 1980s have fallen to 13,455 in 2006 .	▼
Bald Eagle	Bald eagle nests have increased significantly in all four states in the Delaware as 96 nests spotted in the basin in 2004, up from 44 in 2001.	▲
Black Bear	Close to 5,000 black bear were spotted in NJ, NY, and PA up from 4,200 in 2002.	▲
Amphibians/Reptiles Bog Turtle	Bog turtle wetland habitat is declining as the reptile is a Federally endangered species and is on the NJ, NY, and PA state protected lists.	▼
Endangered Species	Almost 180 species on the DE, NJ, NY, and/or PA endangered species lists.	●

Who are your stakeholders?

Stakeholders: users of water data in the Delaware Basin

- Water quality managers
- Water supply managers
- Water security managers
- Public health officials
- Regulatory agencies
- Maritime traffic
- Search and rescue operations
- Boaters--marina and yacht clubs
- Fishermen
- Academia

Science Sectors



Source: D. Kreeger

PDE, 2009

Science & Management Committees

Yes!!!!

Source: D. Kreeger

PDE, 2009

Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)

http://www.macoora.org/

- Formed to integrate observations from Cape Hatteras to Cape Cod
- Four Themes identified at Annual Meeting October 22-23, 2008
  - Coastal Inundation
  - Maritime Safety
  - **Water Quality**
  - Ecosystem Based Management—Fisheries
- Water-quality workshop in March 11-12, 2008 in Philadelphia, PA

What are we doing now and why?

- USGS monitoring
- NOAA monitoring
- USEPA monitoring
- DRBC and DNREC Estuary Boat Run
- Selected State Monitoring
- MACOORA and Universities

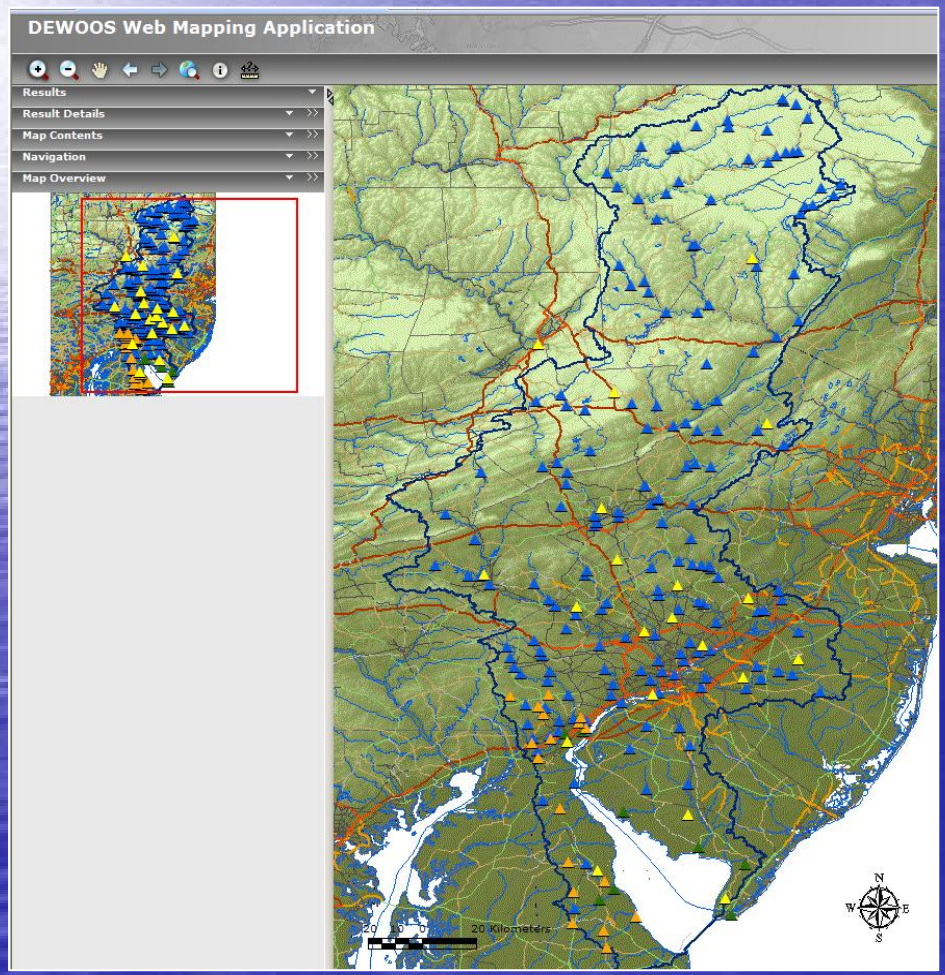
Monitoring Organizations and Resource Components Monitored

Org	Estuary/ Embayment	Nearshore Coast	Offshore Coast	Rivers	Ground Water	Atmos. Depos.	Wetlands	Beaches
USEPA	✓	✓✓	✓	✓✓				✓
NOAA	✓	✓	✓✓				✓	
USGS	✓			✓✓	✓✓		✓	
COE	✓			✓	✓			
DE DNREC	✓	✓		✓	✓	✓✓	✓	✓
PADEP	✓			✓	✓✓	✓	✓	✓
NJ DEP	✓✓	✓		✓✓	✓	✓		✓✓
UDEL	✓✓	✓	✓			✓		
RUTGERS	✓	✓✓	✓✓	✓		✓✓		
DRBC	✓✓			✓✓	✓	✓		
Estuary Program	✓			✓			✓	
Philadelphia	✓			✓✓	✓	✓	✓	
Camden				✓✓	✓	✓		
Power Utilities	✓✓			✓✓			✓✓	

Needs: What else do you need to fill gaps/challenges?

DEWOOS

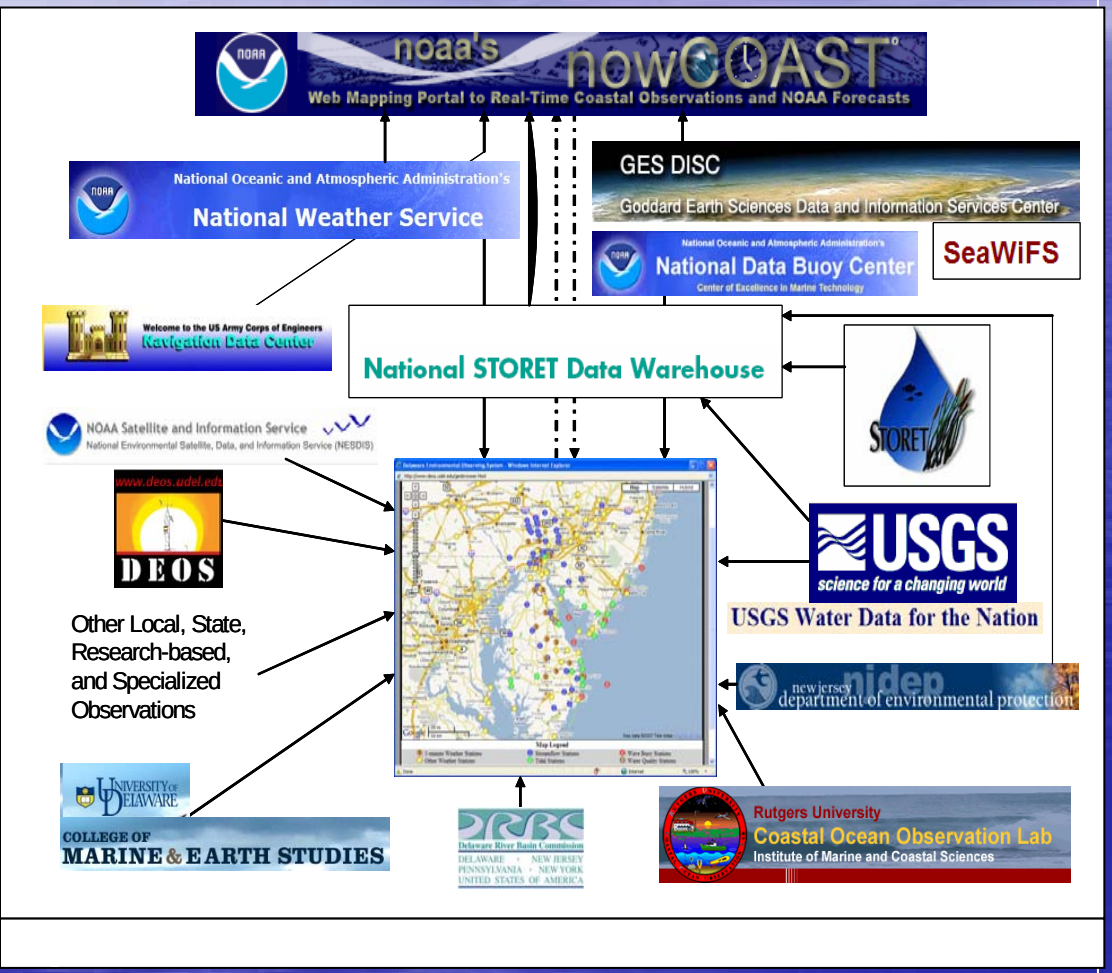
Delaware Estuary-to-Watershed-to-Ocean Observing System



http://www.dewoos.udel.edu/

- Proposed **integrated watershed and coastal environmental data-management system** that can be applied to a variety of watersheds across the nation—"**use the data we already have**".
- Initially based on DEOS concept
- MACOORA provided seed money to start project to David Legates at UDEL
- Demonstrate how a cooperative regional monitoring system can be linked to and enhance the National Water Quality Monitoring Network
- One-stop shopping web site for data in the DRB

DEWOOS Data Sources and Type Platforms

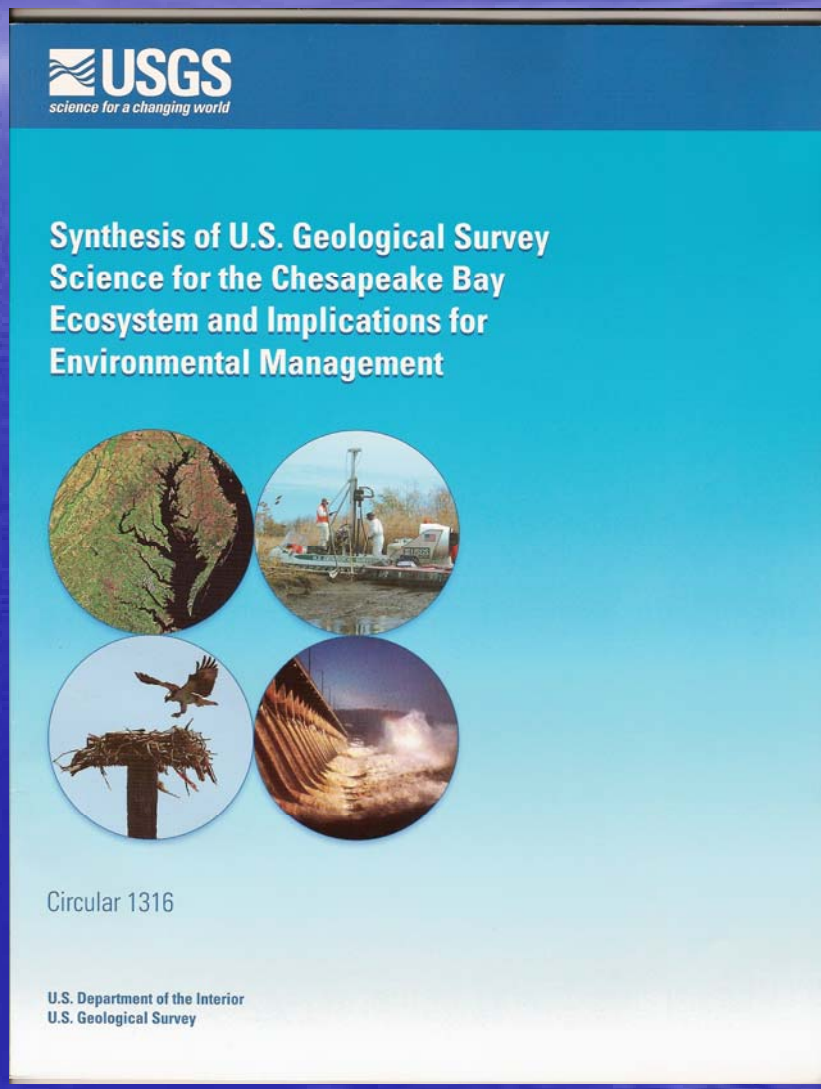


management systems.

- **Standard 'station-based'** data where an observing platform remains in a fixed position and records data on a regular basis.
- **Research-specific measurements** taken for a short time period.
- **Lagrangian observations** from observing platforms that move
- **Gridded data** acquired by remote sensing technology and spatial interpolation methodologies.

Next Steps

- What products/outcomes do you expect?
  - DEWOOS
  - Possible Report and Plan of Action: “Synthesis of monitoring and modeling for the Delaware River Basin Ecosystem and Implications for Environmental Management”
- What information would you convey to help refine Network design for other Pilot areas just starting up?
  - The National Network is a “network of networks”
  - Need to collaborate!!!
  - Think of what you would want to have monitored now thinking forward 30 years from now
  - Think sensors



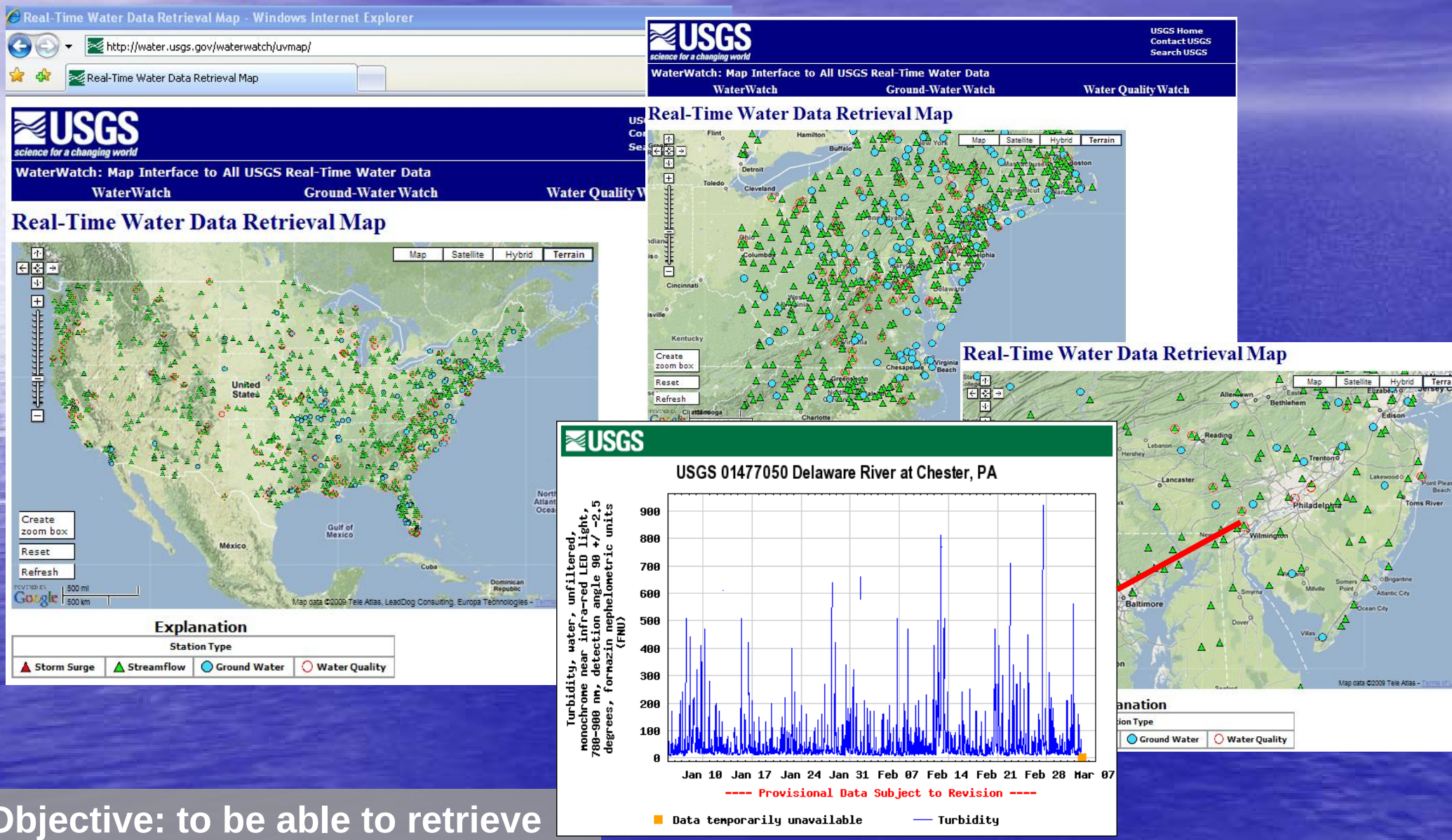
Where do we go from here?

- **Communicate, cooperate, collaborate** (find funding for continued development of DEWOOS)
- **Develop methods to integrate**
  - analysis of discrete point, continuous, probabilistic, satellite, water-quality data
  - atmospheric, river, ground water, wetlands, estuary, near coastal, and ocean observations to tell the story of water quality in the Delaware River Basin
- **Linking monitoring to models**
- **Implementation phase???**
- **Water-quality website on MACOORA homepage**
- **Contaminants**—do we include "contaminants of emerging concern" in National Network?

Questions at the end of Josh Kohut’s presentation

USGS Continuous real-time water data

http://water.usgs.gov/waterwatch/uvmap

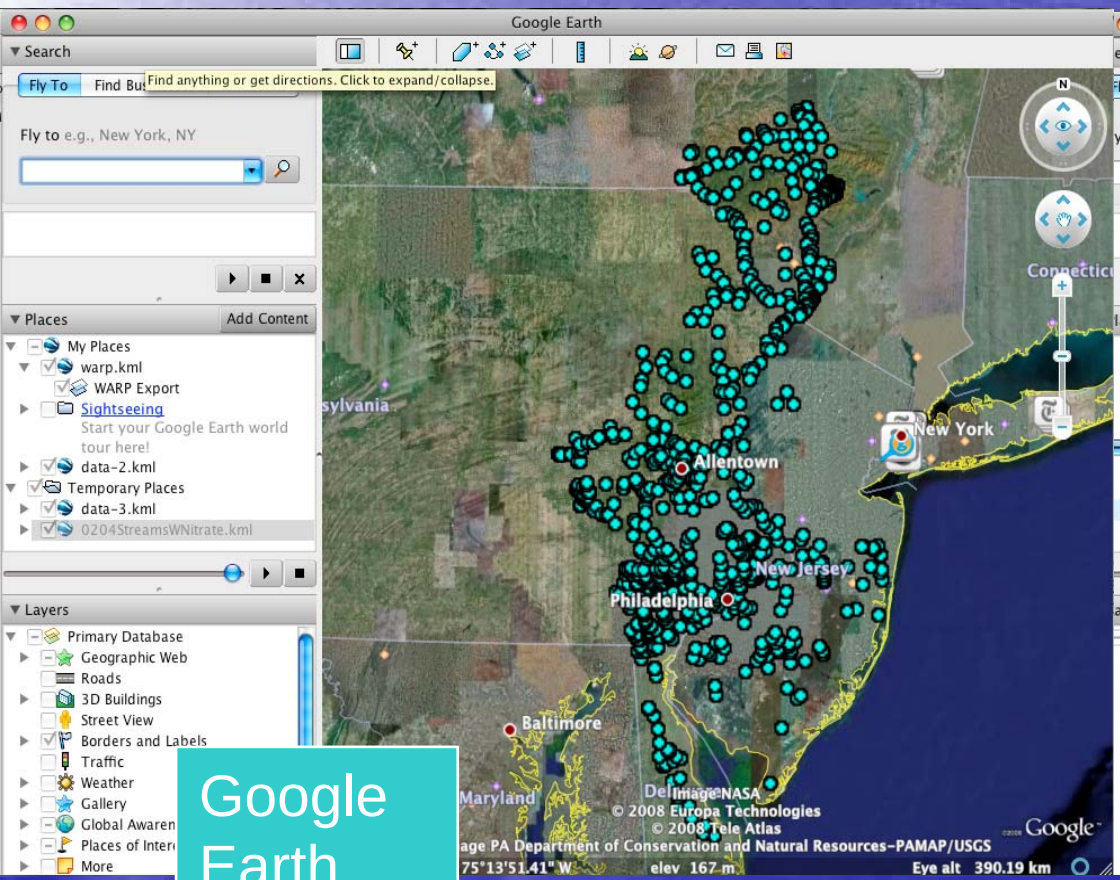


Objective: to be able to retrieve all USGS real-time data by IOOS Region and hydrologic basin

USGS/EPA Data Exchange

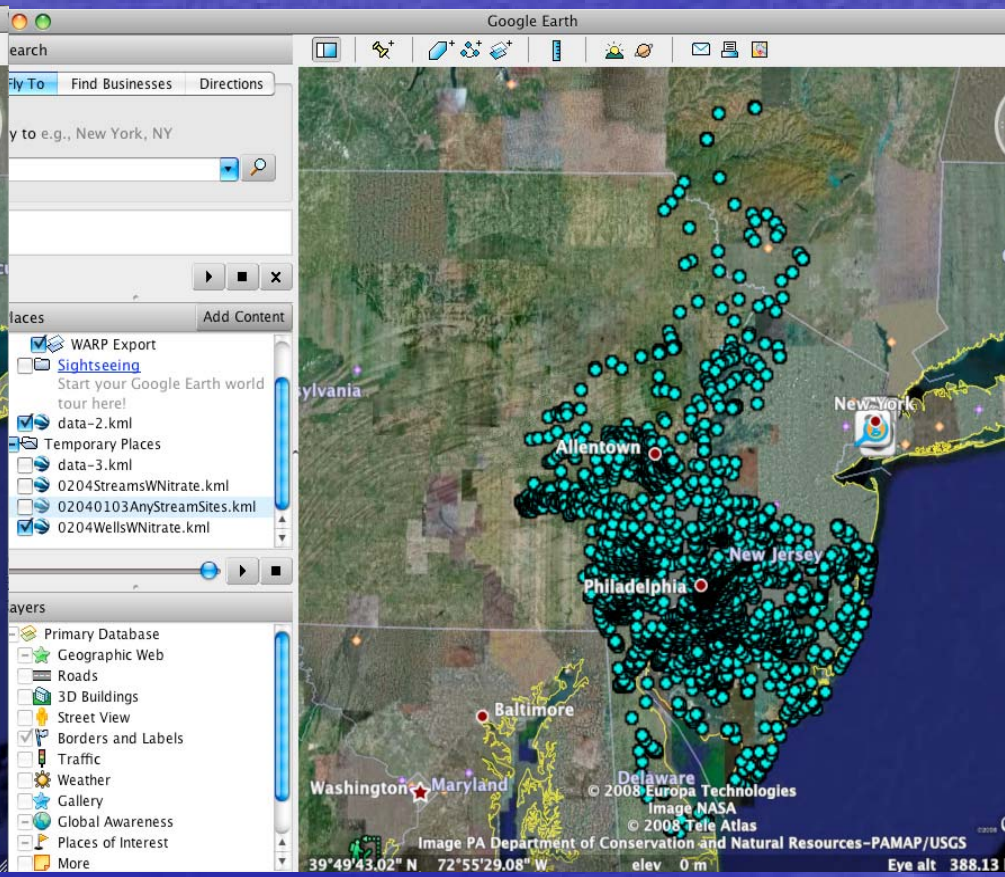
USGS: Jon Scott, Nate Booth, Dorrie Gellenbeck, I-Lin Kuo
USEPA: Dwane Young

Example: Discrete water-quality sites with nitrate data in the Delaware River Basin (HUC0204) from USGS/NWIS



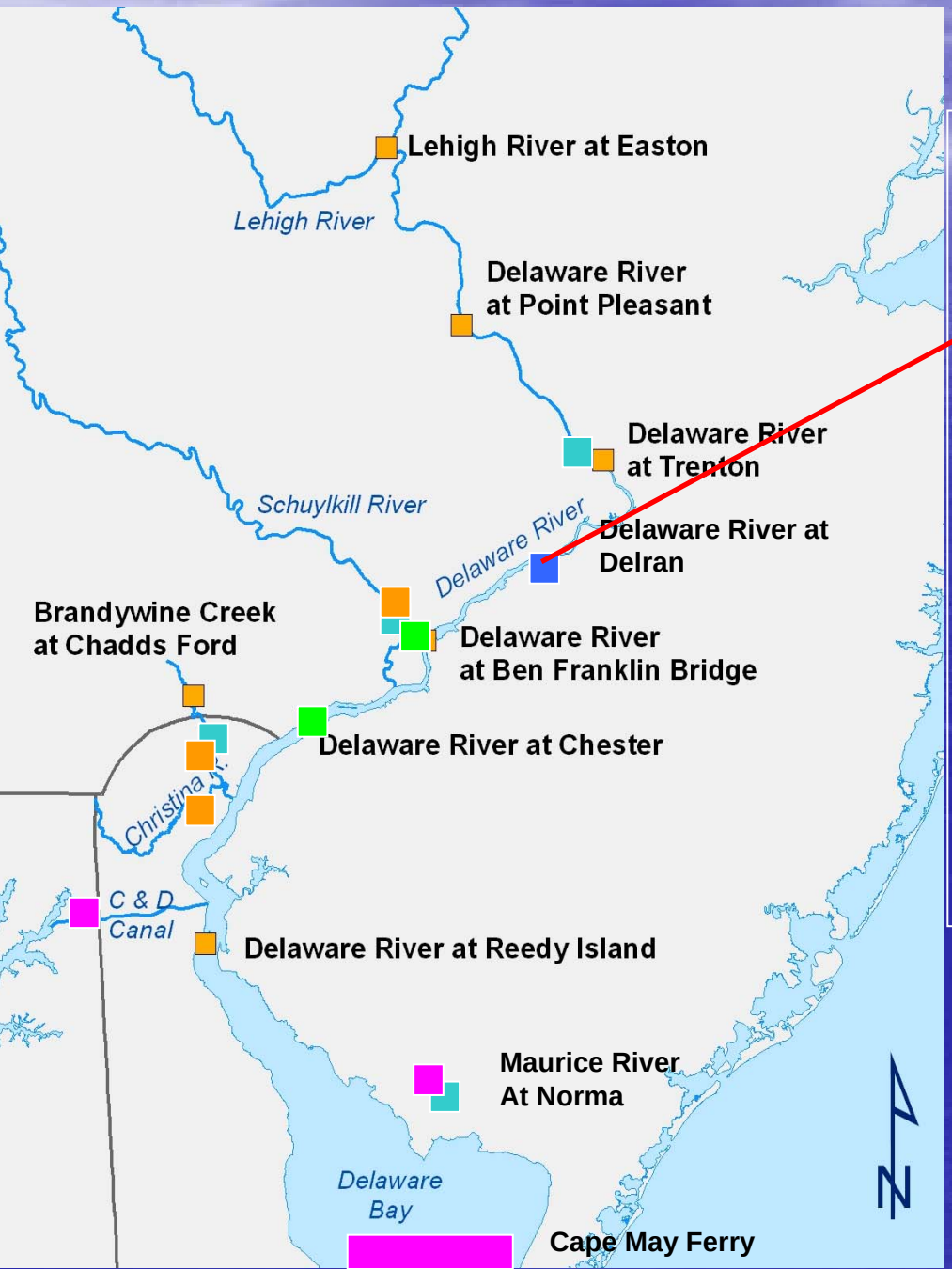
Google Earth

Surface water



Ground water

USGS NWQMN Sensor and Discrete Monitoring Network in the Delaware Demonstration area



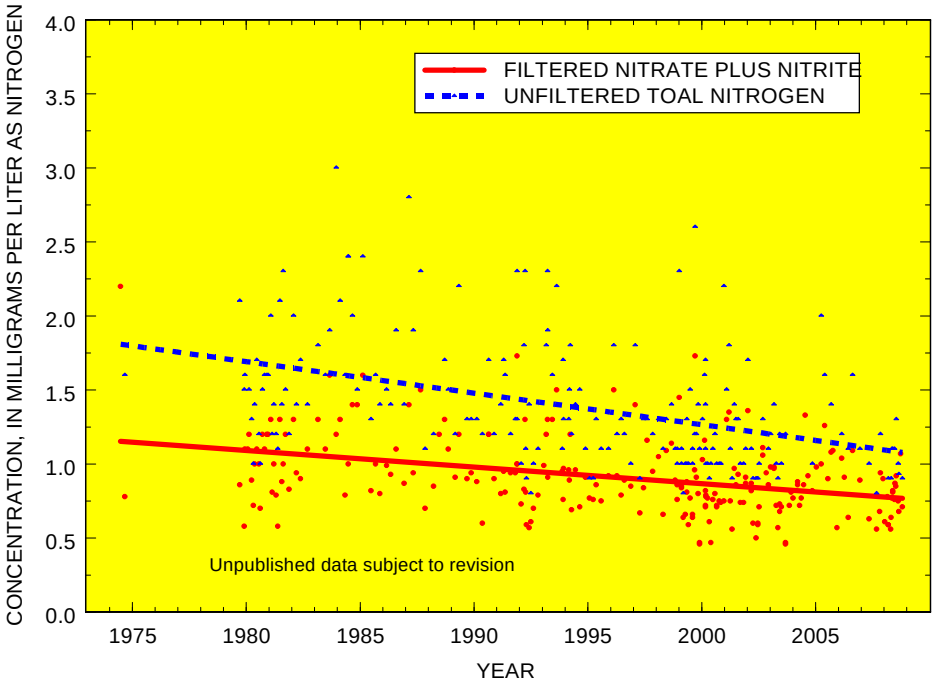
- Existing 4 or 5 parameter real-time sensors
- New 5 parameter real-time sensor
- Upgraded to 5-parameter real-time sensor with turbidity
- Possible real-time sensors
- DEL-NMN discrete monitoring sites for nutrients and carbon

USGS Improvements to Monitoring in the Delaware River Basin to Meet the Needs of the National Monitoring Network for U.S. Coastal Waters and Their Tributaries

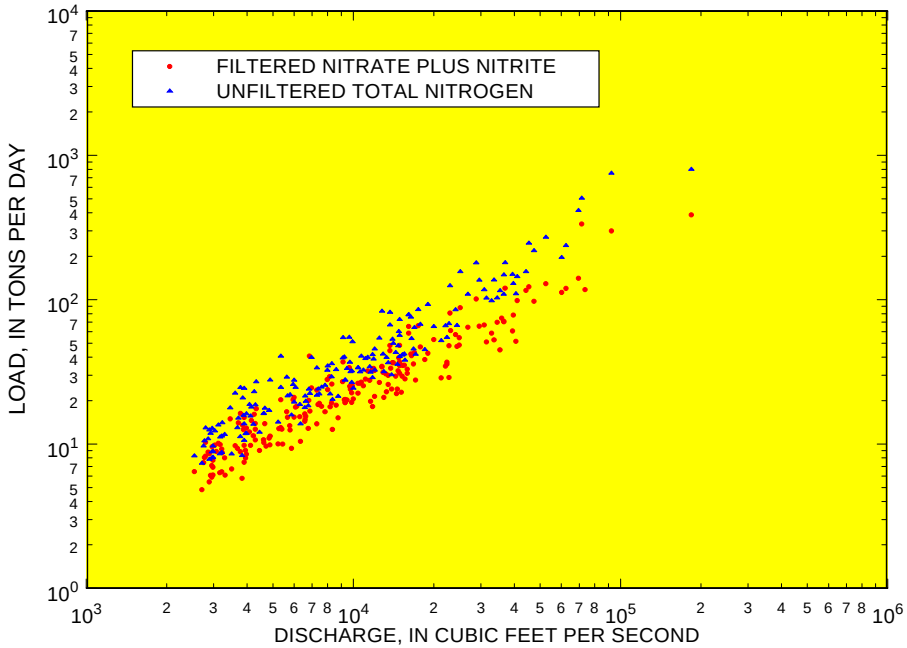
Objectives FY08-09

- Improve real-time monitoring along river and estuary
  - New site at Delran T, SC, pH, DO and turbidity
  - upgrade other stations to include turbidity
- Improve nutrient and carbon analyses as per Nutrient Work Group recommendations
  - Major head of tide stations in the basin (Delaware River at Trenton, Schuylkill, Maurice, Christina/Brandywine)
  - Estuary Boat Run sites
- Delaware River at Trenton upgraded to a “temporary” USGS NASQAN site

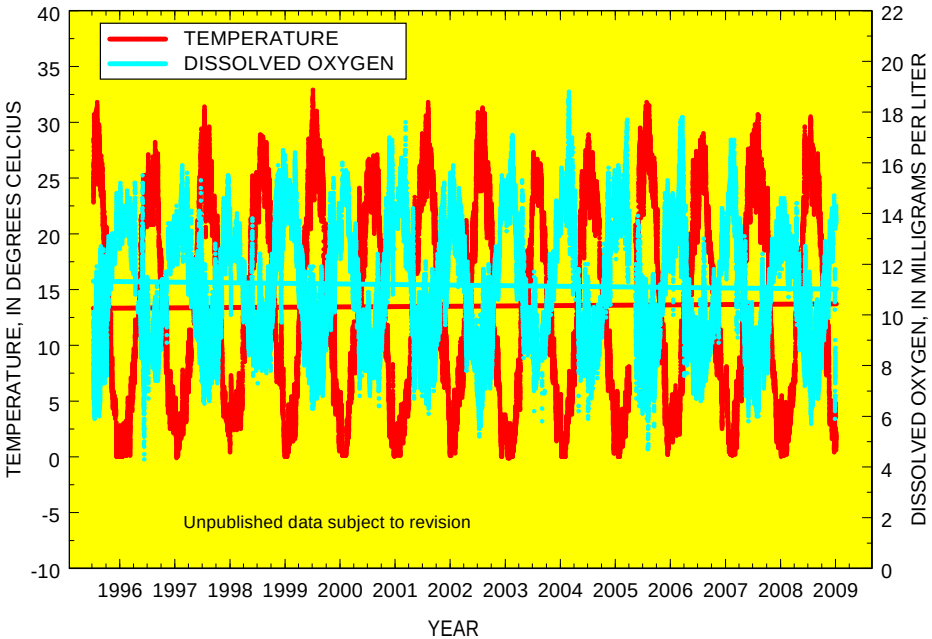
DELAWARE RIVER AT TRENTON--TRENDS IN CONCENTRATIONS FILTERED NITRATE PLUS NITRITE AND TOTAL NITROGEN



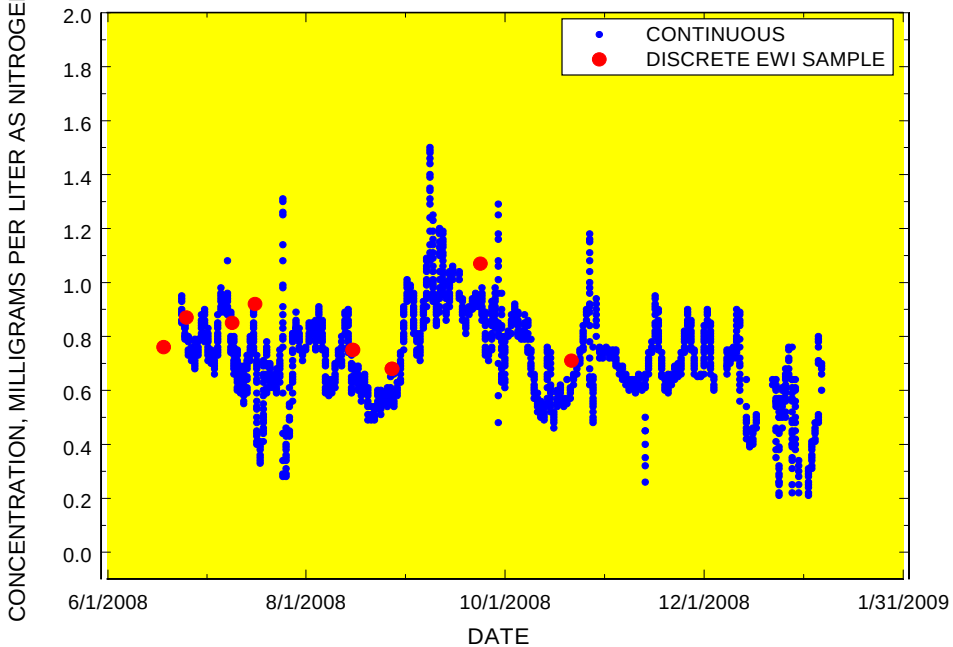
DELAWARE RIVER AT TRENTON--LOADS FILTERED NITRATE PLUS NITRITE AND TOTAL NITROGEN



DELAWARE RIVER AT TRENTON--WATER TEMPERATURE vs. DISSOLVED OXYGEN

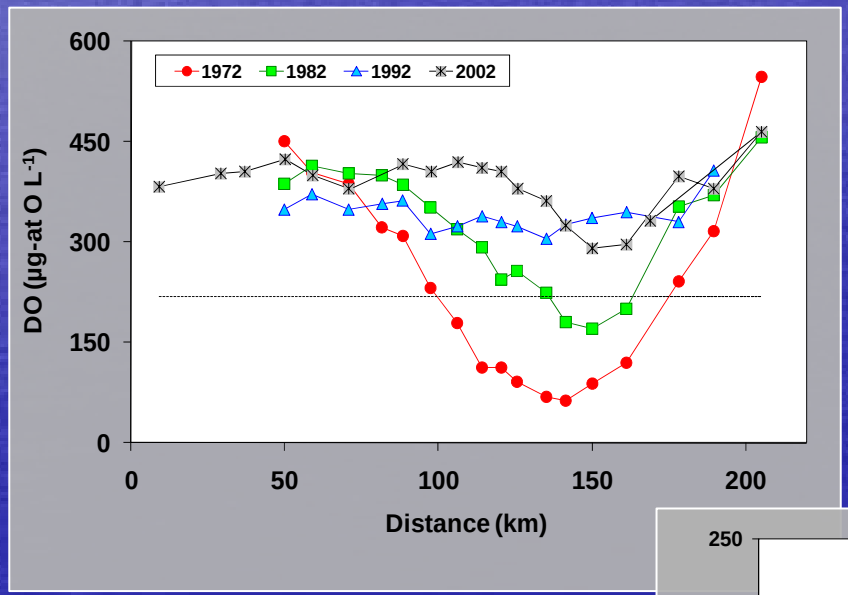


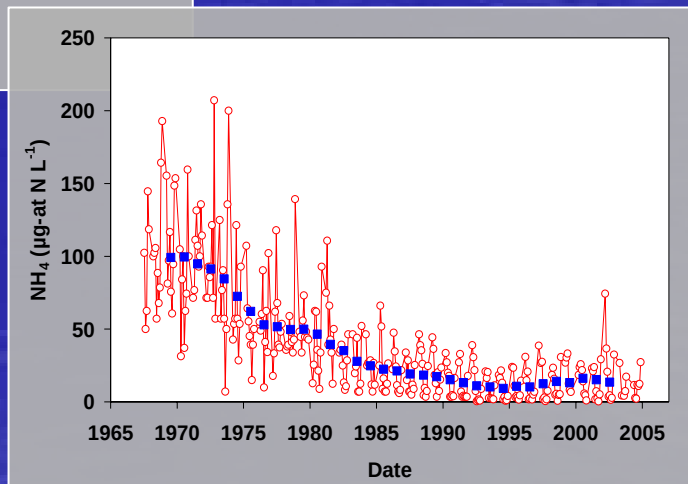
DELAWARE RIVER AT TRENTON--NITRATE PLUS NITRATE USING CONTINUOUS vs. DISCRETE EWI SAMPLES



Delaware Estuary Boat Run Network with DRBC and DNREC

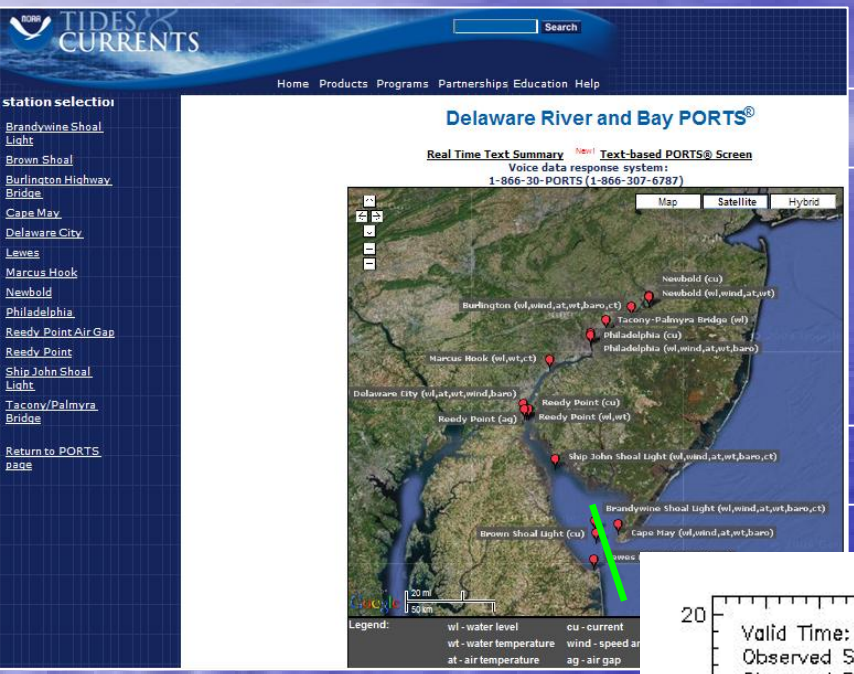
- Data collected since early 1970's
- 22 sites along estuary spine sampled 16 times per year on same day
  - Nutrients Carbon Other
  - Bacteria VOCs



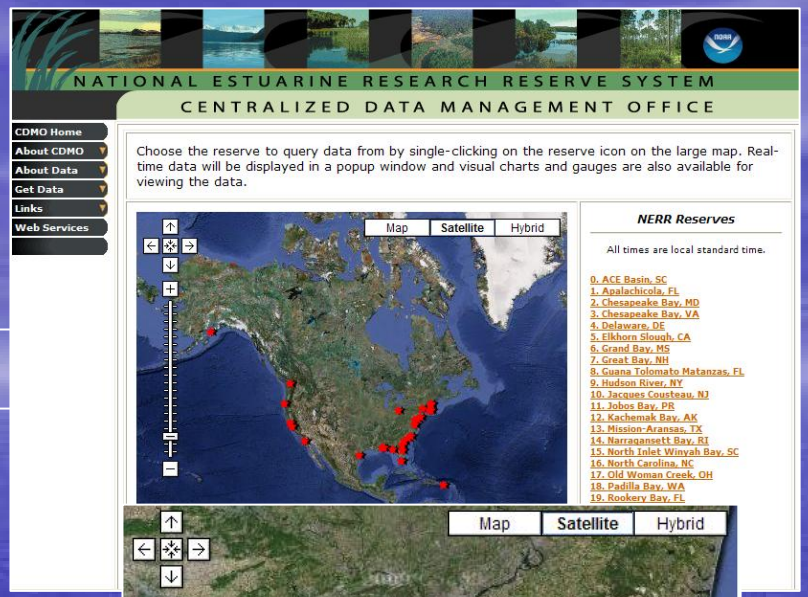


http://cdmo.baruch.sc.edu/QueryPages/googlemap.cfm

NOAA Monitoring



NOAA NEERS



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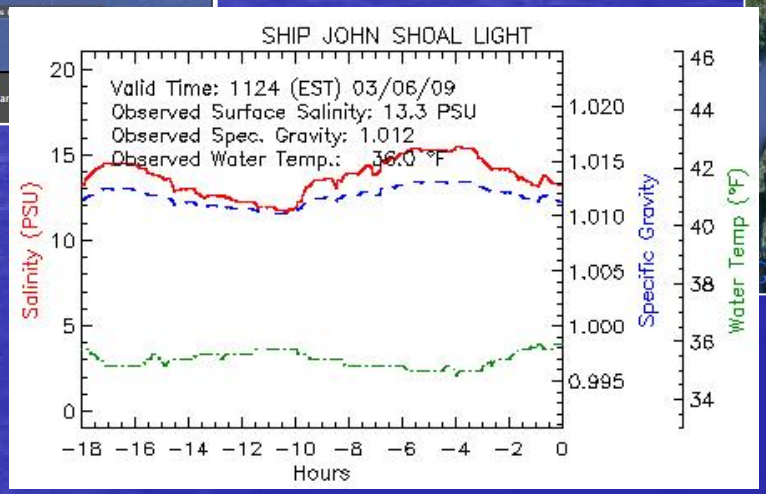
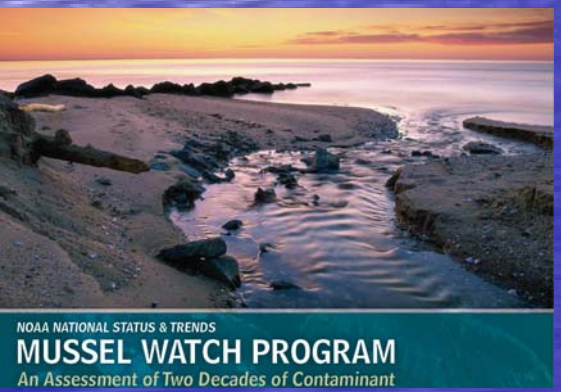
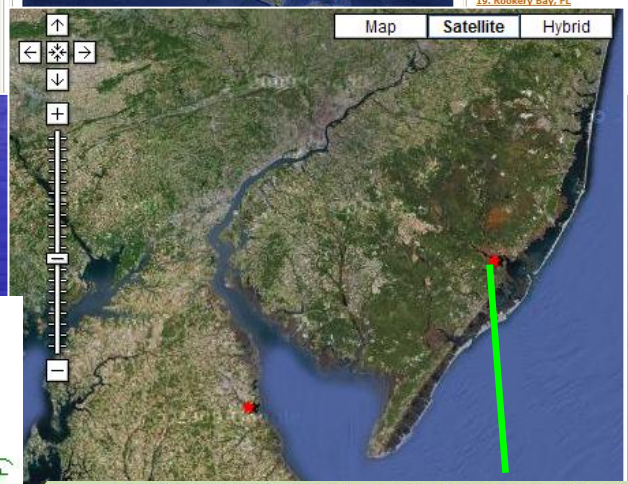
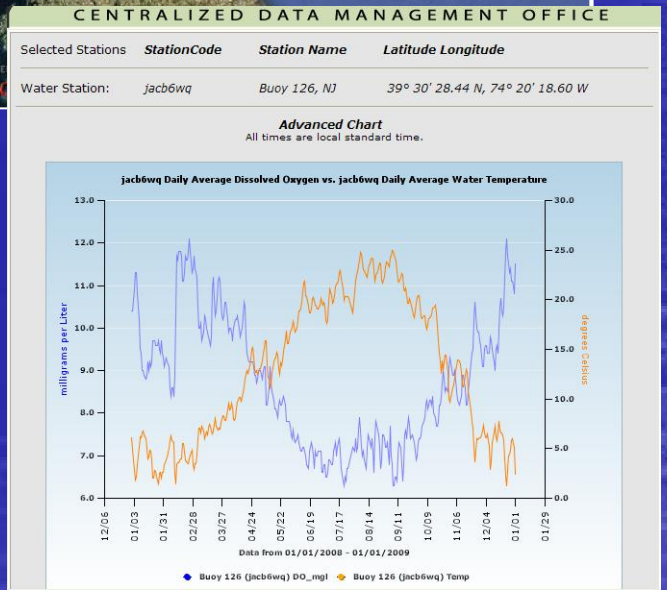


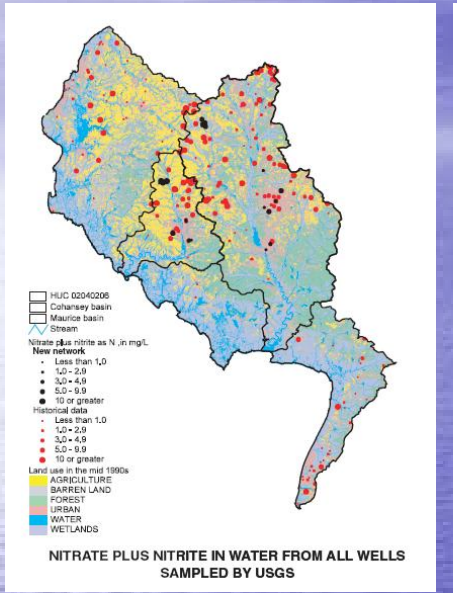




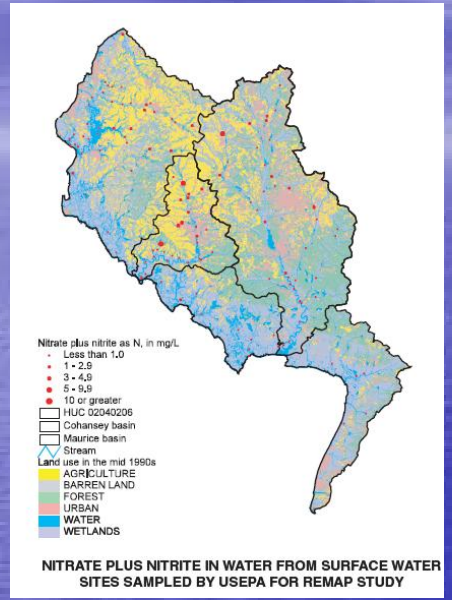


http://tidesandcurrents.noaa.gov/dbports/

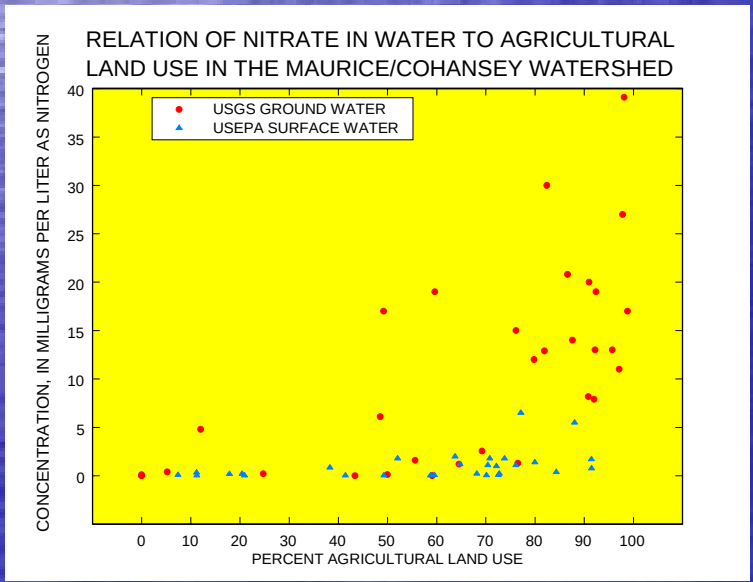
USEPA Monitoring



NITRATE PLUS NITRITE IN WATER FROM ALL WELLS SAMPLED BY USGS

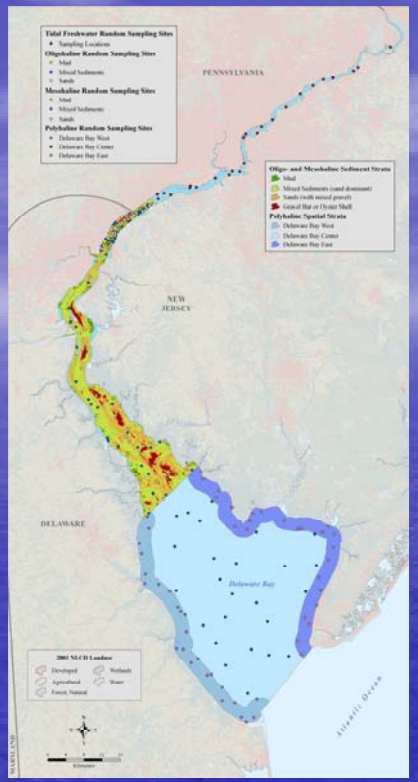


NITRATE PLUS NITRITE IN WATER FROM SURFACE WATER SITES SAMPLED BY USEPA FOR REMAP STUDY

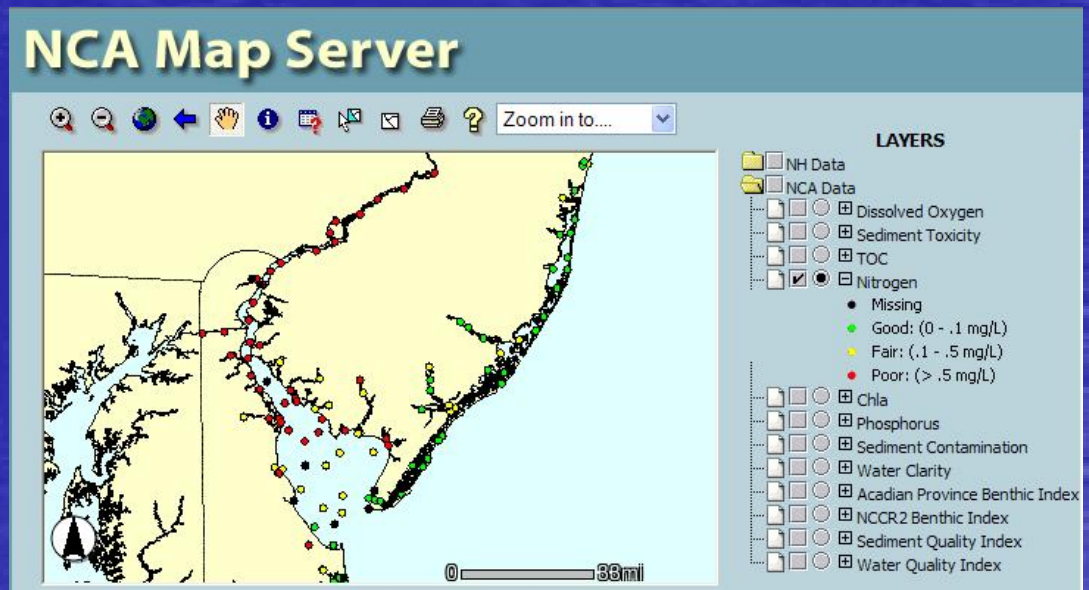


Maurice-Cohansey Watershed Inventory

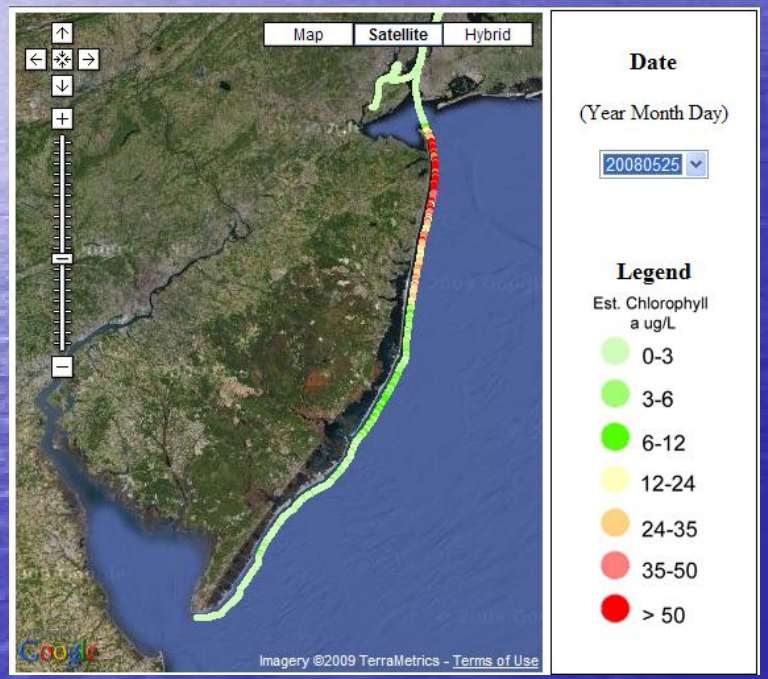
Delaware Benthic Inventory



National Coastal Assessment Estuary Inventory



Selected State and other monitoring networks



Issues: State of the Delaware Basin Environmental Indicators

- Land use/landscape
  - Population, land use, impervious cover, tidal wetlands, tidal wetland buffers, total wetlands, forests, Superfund sites, riparian corridors,
- Water quantity/hydrology
  - Water supply and demand, streamflow, ground-water quantity, flooding, dams
- Water quality
  - Physical (DO, temperature, pH)
  - Chemical
    - Inorganic (N, P, TSS, Cu, PB, Zn, Hg
    - Organic (PCBs, pesticides, atrazine, metoloclor, emerging contaminants)
    - Fish consumption advisories, Sec. 303(d) Designated uses/impaired waters, salt line
- Living resources
  - Macroinvertebrates
  - Shellfish (oyster beds, horseshoe crabs, blue crab, fw mussels, zebra mussels),
  - Fisheries (American shad, brook trout, stripped bass, Atlantic sturgeon, weakfish, summer flounder)
  - Amphibians, reptiles, red knot

http://dspace.udel.edu:8080/dspace/bitstream/19716/3808/1/StateoftheDelRiverBasin08.pdf

Methods Board internal - Windows Internet Explorer

http://wi.water.usgs.gov/methodsboard/workgroups/sensors/index.htm

Methods Board internal

Methods and Data Comparability Board

Workgroup - Sensors

Challenge: Environmental sensor technology for field applications is rapidly evolving. The development of standard operating procedures (SOPs) for many of these technologies and applications has not kept pace and gaps have emerged that hinder the inter-comparability of data and collaboration. The result is degraded data quality and reduced productivity in the field. There is also no central repository available for users to access SOPs for field measurements compare sensing technologies, performance specifications, deployment guidelines, and greenness profiles.

Objectives: To convene a workgroup of experts on sensors to consider efforts to address these challenges in one or more of the following ways:

- Develop SOPs for the calibration, quality assurance and quality control, maintenance, and the deployment of field based environmental sensors
- Make recommendations for the creation of a data base to store relevant information on sensors to allow potential users to make informed decisions on the use of sensors for their projects
- Recommend types of sensors that are appropriate for the National Monitoring Network in freshwater, estuarine and coastal environments

The purpose of these pages will be to assist the workgroup in organizing its work, to share documents and ideas, and to begin the process of building a Web site for eventual public consumption.

NEW -- Field Monitoring Quality Assurance Initiative

NEW -- "Who's doing what in the Sensors world" database

Minutes of past meetings

- Oct. 13 QA/QC conf. call
- Nov. 3, 2008 conference call
- Oct. 2, 2008 QA/QC subgroup conf call

http://wi.water.usgs.gov/methodsboard/workgroups/sensors/index.htm

Watershed

Manager Database*

DRBC (1991)

Honda (1976)

NOAA NS&T Bioeffects Assessment (1997)

Christina River QM Database**

| National Status & Trends

Sediment (Benthic Surveillance)

Mussel Watch

vare Watersheds

kill Valley

Schuylkill

Estuary

Lower Delaware

Crosswicks-Neshaminy

Estuary

Brandywine-Christina

are Bay

Cohansey-Maurice

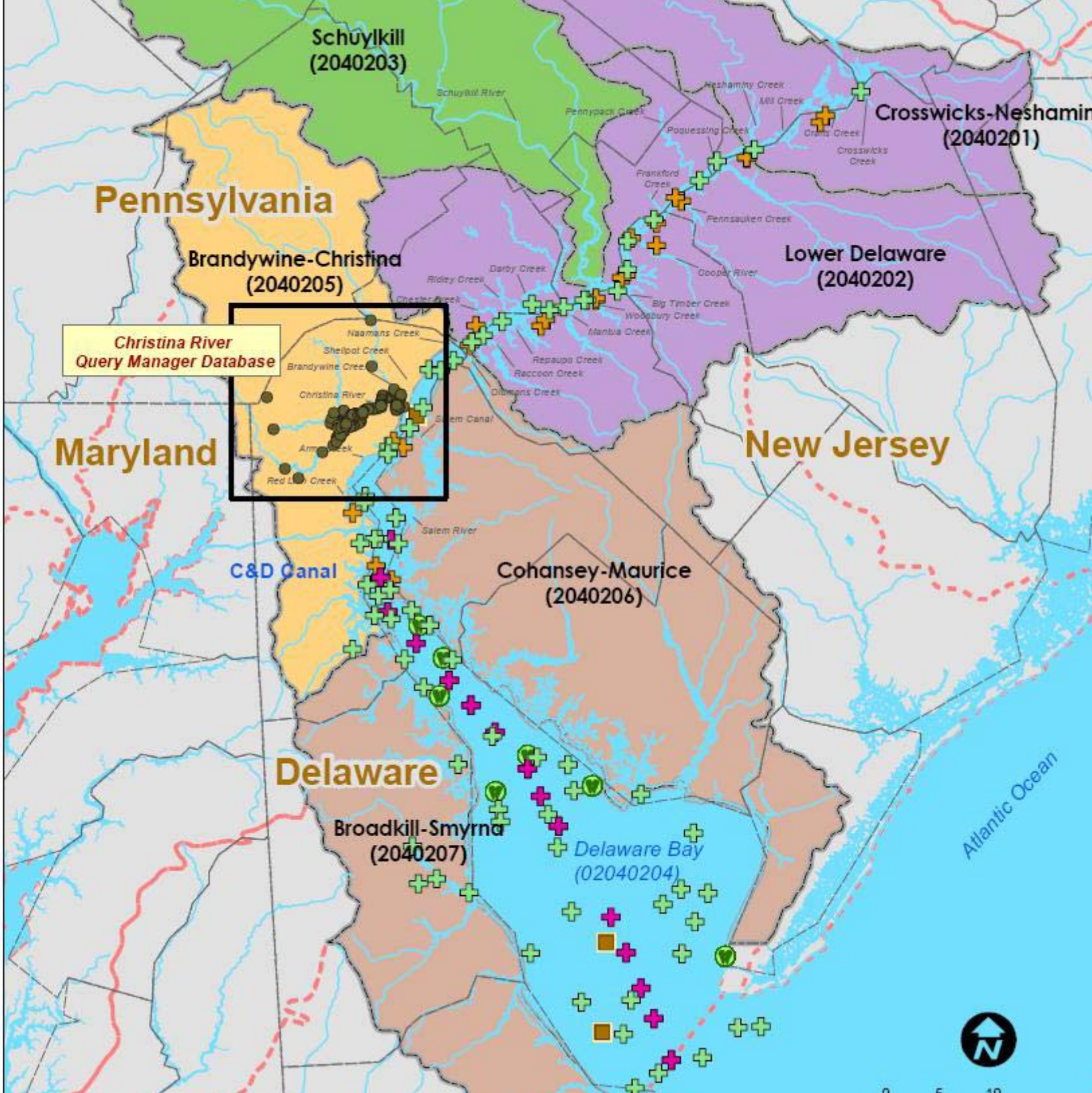
Broadkill-Smyrna

8 digit USGS HUCs

Counties

d Boundaries:USGS 8 Digit HUC
AA, USGS
anager Sediment & Bioeffects Database
data from NOAA Status and Trends and
ompiled by DuPont
a River Query Manager database updated
vailable for download NOAA OR&R website

e Estuary Watershed
e and Mapping Project



Delaware Estuary Watershed: OR&R Waste Sites*

OR&R Waste Sites

Delaware Watersheds

Schuykill Valley

- Schuylkill

Upper Estuary

- Lower Delaware
- Crosswicks-Neshaminy

Lower Estuary

- Brandywine-Christina

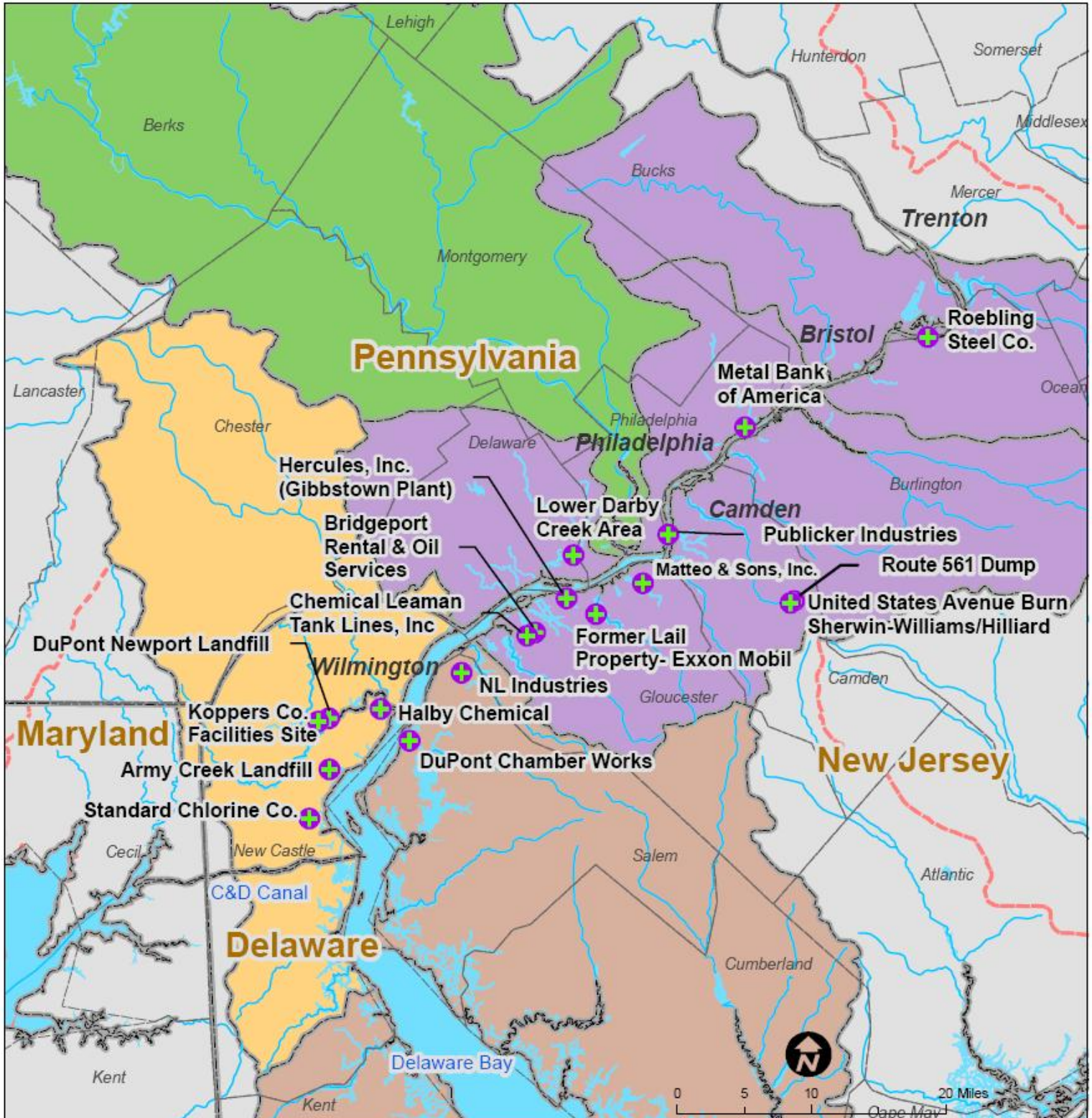
Delaware Bay

- Cohansey-Maurice
- Broadkill-Smyrna
- 8 digit USGS HUCs
- *Counties*

Notes:
Watershed Boundaries:USGS 8 Digit HUC
ESRI, NOAA, USGS
Waste Sites: OR&R Database Sept. 2006
*Site names may not reflect ownership or official designation

Delaware Estuary Watershed Database and Mapping Project

B.Shorr NOAA Assessment & Restoration Division 02/17/2007



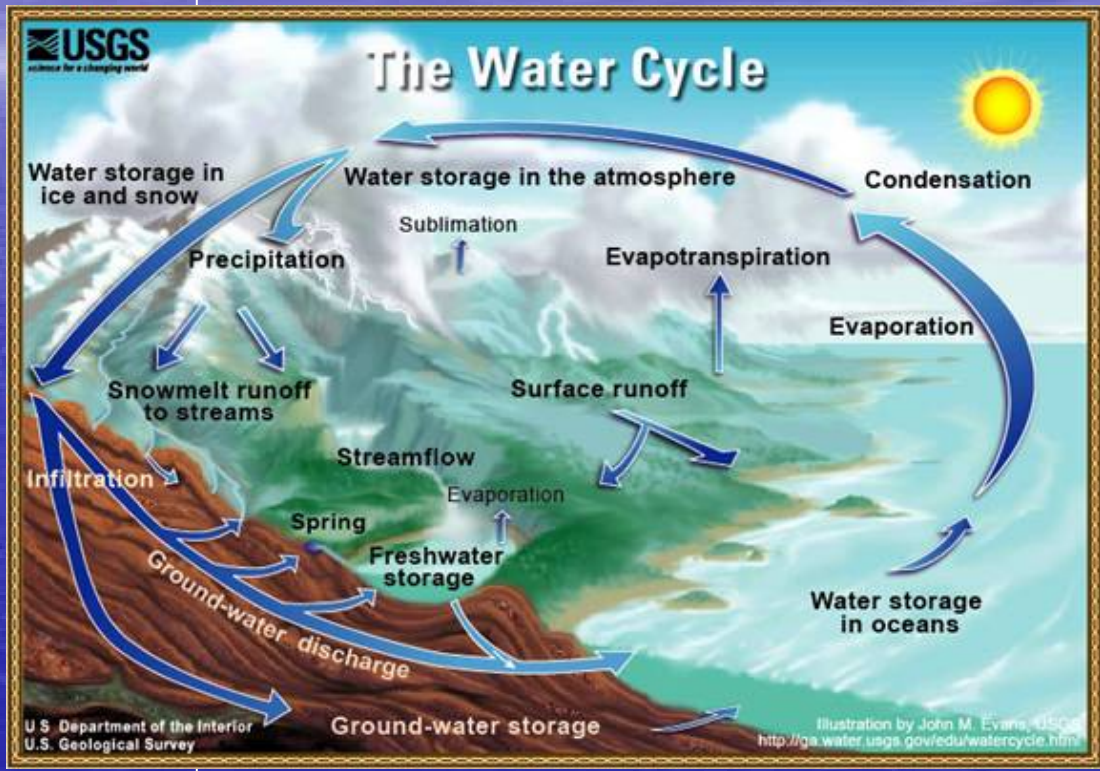
Issues: from 2006 White Paper

Top Ten Technical Needs for the Delaware Estuary
1. **Contaminants** (forms, sources, fates & effects for different classes)
2. **Tidal Wetlands** (status, trends and relative importance of different types)
3. **Ecologically Significant Species & Critical Habitats** (benthos, reefs, horseshoe crabs)
4. **Ecological Flows** (effects of base and episodic flows on salt balance & biota)
5. **Physical-Chemical-Biological Linkages** (e.g., sediment budget effects on toxics & biota)
6. **Food Web Dynamics** (key trophic connections among functional dominant biota)
7. **Nutrients** (forms, concentrations and relative balance of macro- and micronutrients)
8. **Ecosystem Functions** (assessment and economic valuation of ecosystem services)
9. **Habitat Restoration and Enhancement** (science & policy)
10. **Invasive Species** (monitoring, management & control)

Source: 2006 "White Paper on the Status and Needs of Science in the Delaware Estuary"

Resource compartments being addressed

- Estuaries
- Near-shore waters
- Off-shore waters
- ~~Great Lakes~~
- Coastal beaches
- Wetlands
- Flow and flux from
  - Rivers and streams
  - Ground water
  - Atmospheric deposition



Delaware River

STATE OF THE BASIN REPORT

2008

SUMMARY

How clean are the water resources of the Delaware River, its tributaries and Bay?

Do we have enough water for drinking and commerce?

Is it safe to drink?

Are our waters "swimmable"?

Are fish abundant and safe to eat?

How are other living resources faring?

Is critical habitat being protected?

Are years of management and stewardship yielding good results?

Are we prepared to meet the issues we might face in the future?

Responding to these questions requires environmental managers to set goals for the protection and improvement of resources, to efficiently assess issues and trends, and to monitor the success of implemented management strategies—all of which require high-quality data, scientific information, and an effective feedback system. You can't manage what you don't measure.

This State of the Basin Report 2008 is designed to serve as a benchmark of current conditions and a point of reference for gauging progress toward management goals. It also provides a platform for measuring and reporting future progress in water resource management, and a guide for adjusting monitoring and assessment programs. Finally, it is intended to communicate our understanding of the health of the Basin, to increase public involvement in Delaware River Basin and Estuary Program activities, and to build consensus on a broad array of actions that can be taken to continue to improve water quality, water availability, and enhance the living resources of the Delaware River Basin.

Delaware River Basin Commission
P.O. Box 7360, West Trenton, NJ 08628-0360
Phone (609) 883-9500; Fax (609) 883-9522
www.DRBC.net

DELAWARE RIVER NEAR HANCOCK, NY. D. SOETE

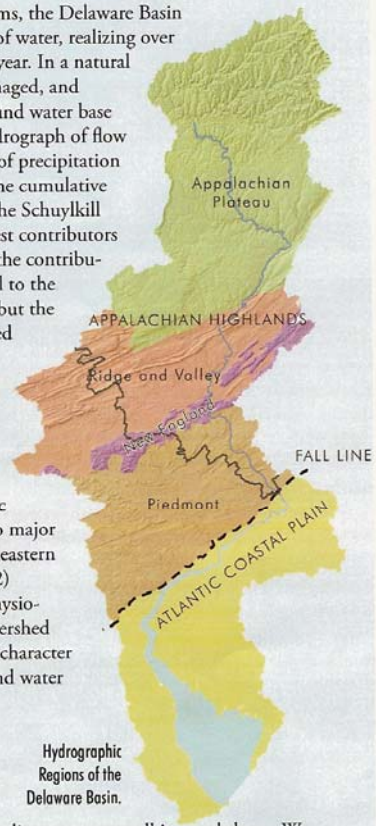
CATEGORY I • HYDROLOGY

INDICATOR	STATUS	PRESENT CONDITION	TREND	
Flows at Trenton	○	**Good**: Flow target maintained 95% of the time.	◆	Stable
Salt Line Location	○	**Very good**: Fluctuations within acceptable range. Drinking water intakes effectively protected.	◆	
Water Use Efficiency	◐	**Fair**: Per capita use ranges from 90 to 190 gal. per capita per day.	◆	
Water Use	○	**Good**: Human needs being met; instream needs being studied.	◆	
Water Supply Sources	○	**Good**: Multiple potable supply sources available in many areas.	◆	Stable
Areas of Ground Water Stress	◐	**Fair**: New problem areas identified.	◆	Stabilizing with conjunctive use.
Flood Damage	●	**Poor:** Increasing repetitive claims in recent years.	◆	

Compared to many other river systems, the Delaware Basin is blessed with a relative abundance of water, realizing over 45 inches of rainfall on average in a year. In a natural system flows are variable, but unmanaged, and dependent on precipitation and ground water base flows. Flow regimes, tracked as a hydrograph of flow volumes over time, reflect the effect of precipitation on streams. Flows on the River are the cumulative effects of flow from the tributaries; the Schuylkill and Lehigh Rivers are the two greatest contributors to Delaware River flows. Generally, the contribution of each tributary is proportional to the land area it drains—its watershed—but the magnitude of flows is also determined by the geology and soils of the watershed.

Hydrographic Regions of the Basin

The Delaware River Basin lies in two significantly different hydrologic regions which correspond to the two major physiographic divisions in the northeastern US: 1) the Appalachian Highlands 2) the Atlantic Coastal Plain. While physiographic provinces do not follow watershed boundaries, they do help define the character of watersheds and influence flows and water quality.



Hydrographic Regions of the Delaware Basin.

Hydrology Summary. Hydrologic indicators are overall in good shape. We are meeting the flow targets that are the foci of management efforts, meeting human demand for water, using resources with some degree of efficiency, making headway in water use and protection, and working to improve flood losses. The potential for increased climatic variation may challenge adaptive management efforts in the future.

CATEGORY II • WATER QUALITY

Major Influences on Stream and River Quality -

- *Runoff and point-source discharges from agricultural and urban areas*
- *Persistent contaminants associated with past human activities: mining, industry, urban development and agriculture*
- *Impoundments and diversions of water*

Major influences on Ground Water Quality -

- *Use of pesticides, nutrients and VOCs in urban and agricultural areas*
- *Physical properties of soils and aquifers, and chemical properties of contaminants*
- *Naturally occurring radon and arsenic*

2004 USGS Circular #1227

Water Quality Summary. Metrics indicate that water quality overall is *Fair.* Dissolved oxygen, nutrients and clarity appear to be good and generally meeting criteria in the tributaries and the river mainstem. However, toxics remain a problem. Lack of criteria for some parameters make evaluation problematic, and deficiencies in monitoring hinder robust assessments of others.

Stream monitoring for macroinvertebrates.

INDICATOR	STATUS	PRESENT CONDITION	TREND	
Nutrients	◐	**Fair**: Concentrations high compared to other systems, but harmful effects not evident.	◆	Stable
Dissolved Oxygen	○	**Good**; stable. DRBC and state DO standards being met; upper basin DO is better than lower basin.	◆	Stable
Water Clarity	○	**Good**: Naturally turbid estuary; non-tidal river generally clear except after storm events.	◆	
Copper	◐	**Fair**: Dissolved copper below but near water quality criteria.	◆	
Fish Consumption	●	**Poor**: Advisories for at least one species on many tributaries and River for mercury and/or PCBs.	◆	
Toxics: Pesticides	◐	**Fair**: Presence throughout basin, esp. historic agricultural use areas; atrazine concentrations below drinking water standard.	◆	
Toxics: PCBs	●	**Poor**: PCBs persist in water, sediments and fish tissue, esp. in the tidal river/estuary.	◆	Possibly improving.
Support of Designated Use: Tributaries	◐	**Fair**: 37% of assessed tributary miles do not support designated uses.	◆	
Tributary Water Quality Trends (DO, N, P, TSS)	○	**Good**	◆	Stable in Upper & Central watersheds; some declines in Lower and Bay watersheds.
Support of Designated Use: Delaware River	◐	**Fair**; conditions range from poor to good depending on use designation.	◆	

CATEGORY III • LIVING RESOURCES

INDICATOR	STATUS	PRESENT CONDITION	TREND	
Benthic Macro-invertebrates	◐	**Fair**: Conditions range from poor to very good. All regions show impacts	◆	
Freshwater Mussels	●	**Very poor:** More than 75% have special conservation status due to habitat and water quality degradation.	◆	
Oysters	●	**Poor**: Populations are low but seed beds are being carefully managed.	◆	Recent trend positive.
Horseshoe Crabs	◐	**Fair**: Egg densities affect shore birds.	▶	Reduced breeding populations are improving.
Red Knot	●	**Very poor:** Vulnerable to loss of food source and climate impacts.	◀	Populations may be crashing.
Louisiana Waterthrush	◐	**Fair**: Sensitive to polluted waters and loss of forested riparian habitat.	◆	
Bald Eagle	○	**Good**	▶	Generally improving.
Striped Bass	○	**Good:** Restored.	◆	Stability uncertain.
Weakfish	◐	**Fair**	◀	Recent declines.
Atlantic Sturgeon	●	**Poor**	◀	Declining
Shad	◐	**Fair**: improved with DO and fish passage, but recent declines evident.	◆	
Brook Trout	●	**Poor**: Population extirpated or severely reduced in many watersheds.	◆	

The past history of the river's anoxic (zero dissolved oxygen) zone, the introduction of water quality regulations, and subsequent improvements in water quality is a success story. The positive change is most dramatically evident in the restoration of living resources, especially fin fish populations and most notably shad.

Water quality criteria for the support of aquatic life have been adopted for a number of parameters, and are being considered for more. All of the waters of the basin are designated for the support of aquatic life. The key water parameter of concern has been dissolved oxygen (DO) because it is necessary for nearly every aquatic resource and is essential for overall ecosystem health. In addition to water quality, healthy living resources are affected by flow, temperature, natural predation, harvesting by humans, disease, and habitat loss.

Living Resources Summary. This category includes species of concern that are affected by changes in water quality and hydrology, e.g., the "endpoints" of changing biological, chemical and physical conditions in waterways and water-related landscapes. The overall condition assessment for this category is *Fair* with a significant number of indicators having a *Poor* rating. Selection of additional indicators may be advised for subsequent reports to include additional species that are of ecological or economic importance.

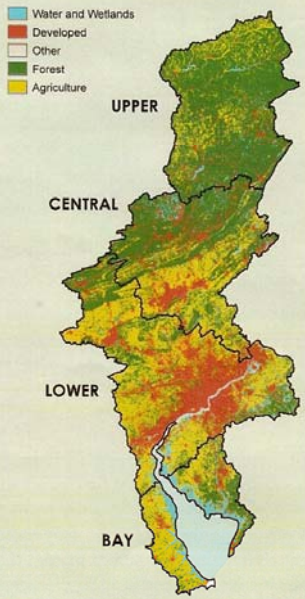
CATEGORY IV • LANDSCAPE

INDICATOR	STATUS	PRESENT CONDITION	TREND	
Population Growth and Distribution	NR	Basin population 7.8 million, up 6% (1990-2000).	NR	
Population Density	NR	Basin average is 603 p/mi². Ranges from <10 to >2,000 p/mi².	NR	
Land Use 2001	NR	Developed area increased by 71 mi² in 5 years at expense of forest and agricultural land.	NR	
Land Consumption	●	Poor: Per capita rate of developed land has increased.	◀	Increasing
Dams	●	**Poor**: 1550 tributary dams disrupt natural hydrology and fish passage.	▶	
Forests	◐	**Fair:** Decreasing by size of 1 football field every two hours. 48 mi² of forest lost in 5 years	◀	Decreasing
Wetlands	◐	**Fair:** Assessment of functional integrity needed.	◀	Losses occurring at a slower rate.
Tidal Wetland Buffers	●	**Poor**: Upper Estuary. **Fair**: Lower Estuary and Bay regions.	◆	

Landscapes and Water Resources

Natural landscapes and human alteration of that landscape—measured as land cover and land use—play a crucial role in water resource condition. Human use of land and changes to its physical state can be major factors in the alteration of ecological processes at both local and global scales. Many if not most physical and chemical changes in waterway systems are linked to land use, although some of the linkages are complex and difficult to quantify. USGS has found significant relationships between landscape condition and the health of aquatic communities. The 2003 Final Report of the New Jersey Comparative Risk Project identified landscape change as "lying at the heart of many environmental problems," and when compared to an array of known or perceived threats, land use change, in the view of the experts, "produced by a wide margin the largest negative ecological and socio-economic impacts" including: habitat loss and fragmentation; permanent ecosystem destruction; increases in stormwater flows and flooding; skewed employment patterns and property values detrimental to older communities; traffic congestion; and public health impacts.

Map of Basin Land Use 2001



Landscapes Summary. Indicators in the landscape category include factors that contribute to impacts in the other three categories. Improvements in data quality, availability and timeliness are essential for improved reporting. The functional linkages between landscape change and other indicators are not always well quantified nor well represented through indicators. Additional metrics to help bridge this gap should be considered for the next report.