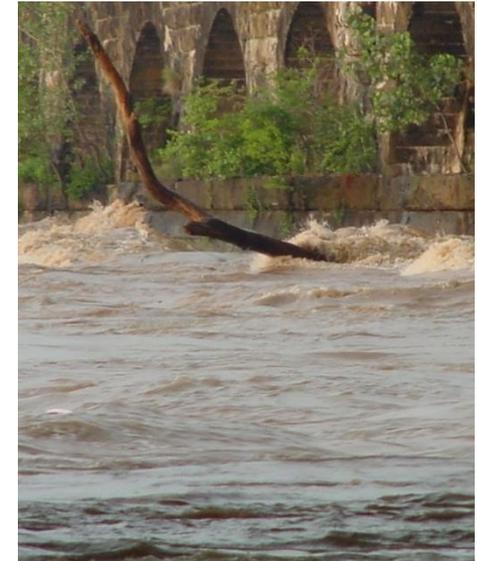


# Delaware River Basin Commission

## History and Practice of Flow Management in the Delaware River Basin

**Amy L. Shallcross, PE**  
**Manager,**  
**Water Resource Operations**

*Upstream, Downstream and the Turning Tide*  
Water Resource Association of  
the Delaware River Basin  
56<sup>th</sup> Annual Fall Conference  
October 16, 2017



**Delaware River Basin Commission**

DELAWARE • NEW JERSEY  
PENNSYLVANIA • NEW YORK  
UNITED STATES OF AMERICA

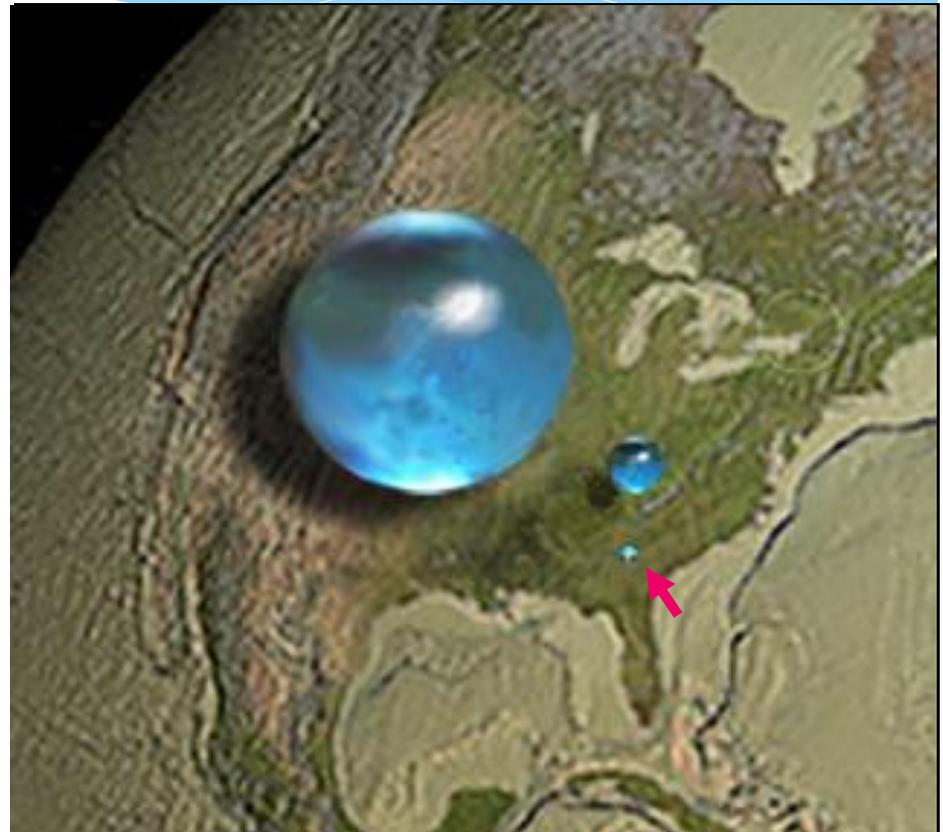
# Our Water Resources are FINITE!

## FRESH WATER

Spheres showing:

- (1) All water (sphere over western U.S., 860 miles in diameter)
- (2) Fresh liquid water in the ground, lakes, swamps, and rivers (sphere over Kentucky, 169.5 miles in diameter), and
- (3) Fresh-water lakes and rivers (sphere over Georgia, 34.9 miles in diameter).

Credit: [Howard Perlman](#), USGS; globe illustration by [Jack Cook](#), Woods Hole Oceanographic Institution (©); [Adam Nieman](#).

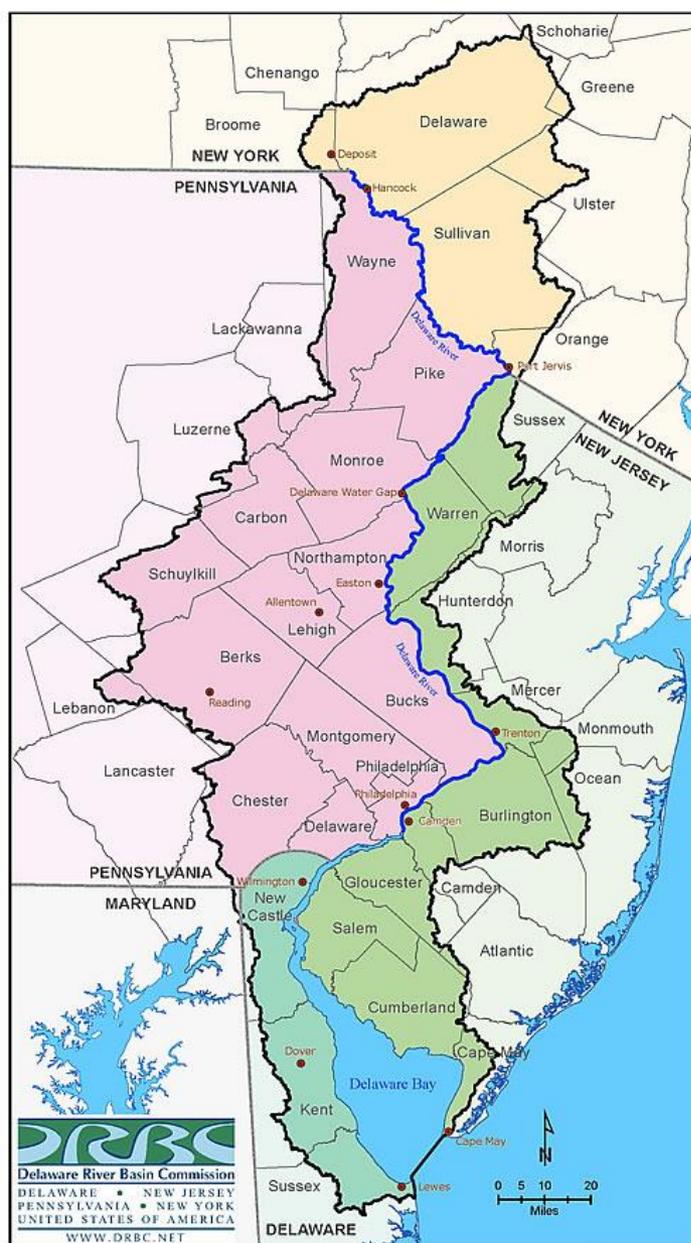


# Water Resource Management

- \* **Water Quantity/Flow Management**
  - \* **Storage – Drought and Flood Mitigation**
  - \* **Low Flow Augmentation**
  - \* **Flow Objectives**
  - \* **Allocations – Conservation**
- \* **Water Quality**
  - \* **Monitoring and Assessment**
  - \* **Permitting**
  - \* **Standards**

# Delaware River Basin

- \* Main Stem is 330 miles – no dams
- \* Forms interstate boundaries for DE, NJ, PA, NY
- \* 15 million people - 5 percent of the US population
- \* Drains 13,539 sq. mi. - 0.4 percent of US land area
- \* Contributes 21 BG in economic value to the region
- \* 8,280 mgd in SW and GW withdrawals
- \* 886 mgd consumptive use (11 percent evaporated or exported)



# Competing Objectives



- \* Drinking Water
- \* Aquatic Resources
- \* Assimilative Capacity
- \* Power generation
- \* Recreation
- \* Flood Mitigation

# Sources of Water

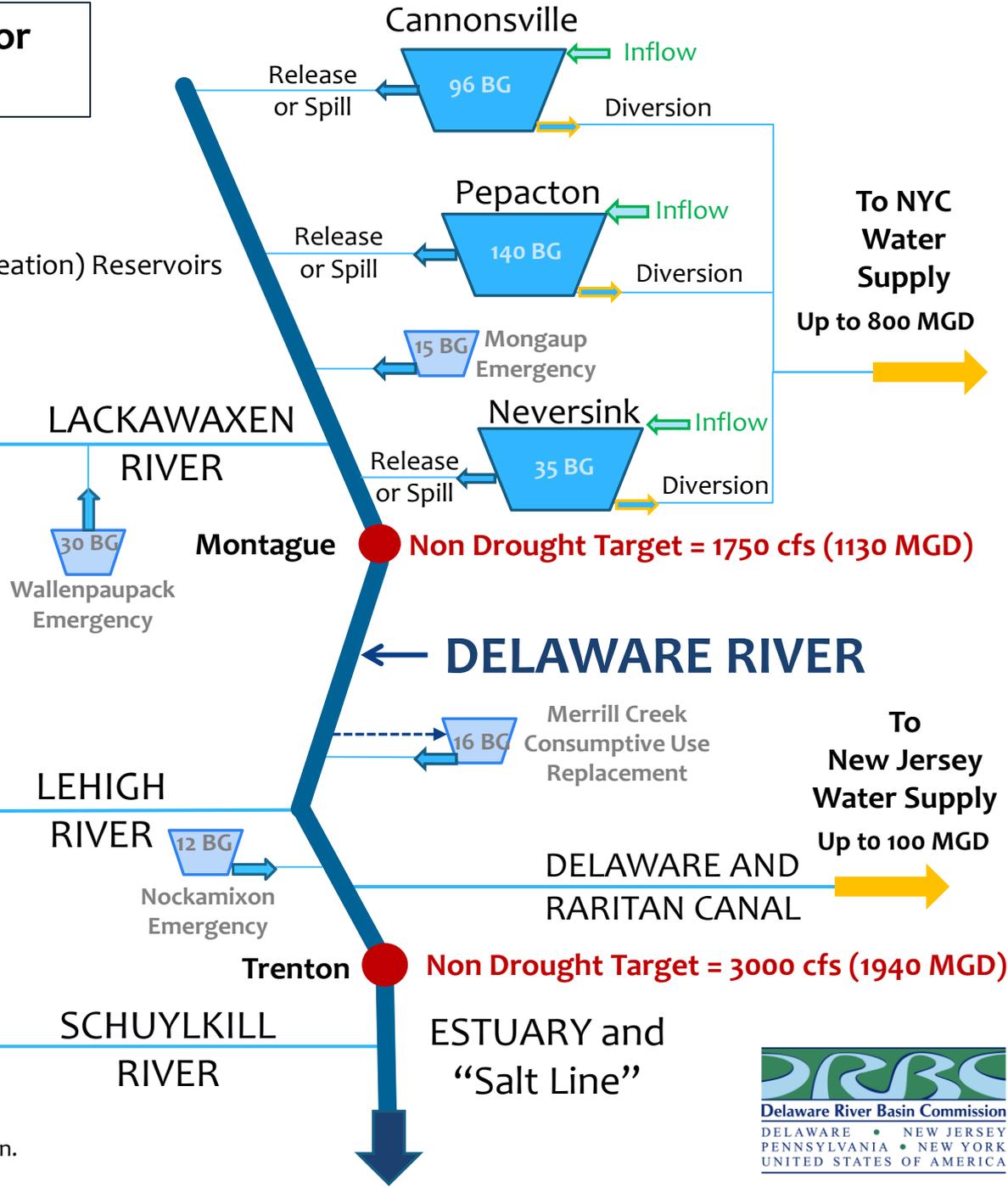
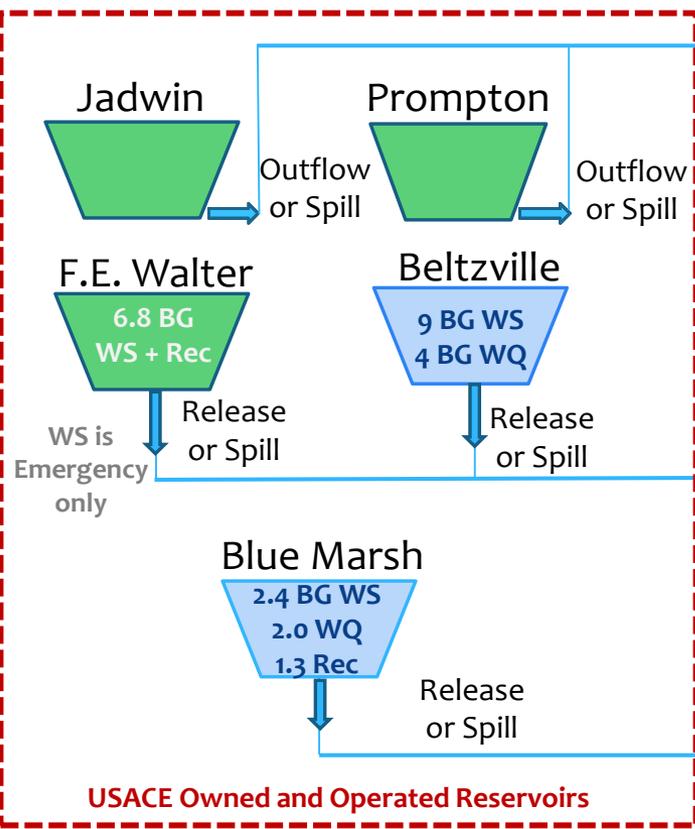
- \* Decree
- \* DRBC Storage in USACE Reservoirs
- \* Emergency
- \* Consumptive Use Make-Up
- \* Dockets



In very dry periods, flow at Trenton can be 60 percent or more from reservoir releases

# Water Management Schematic for the Delaware River Basin

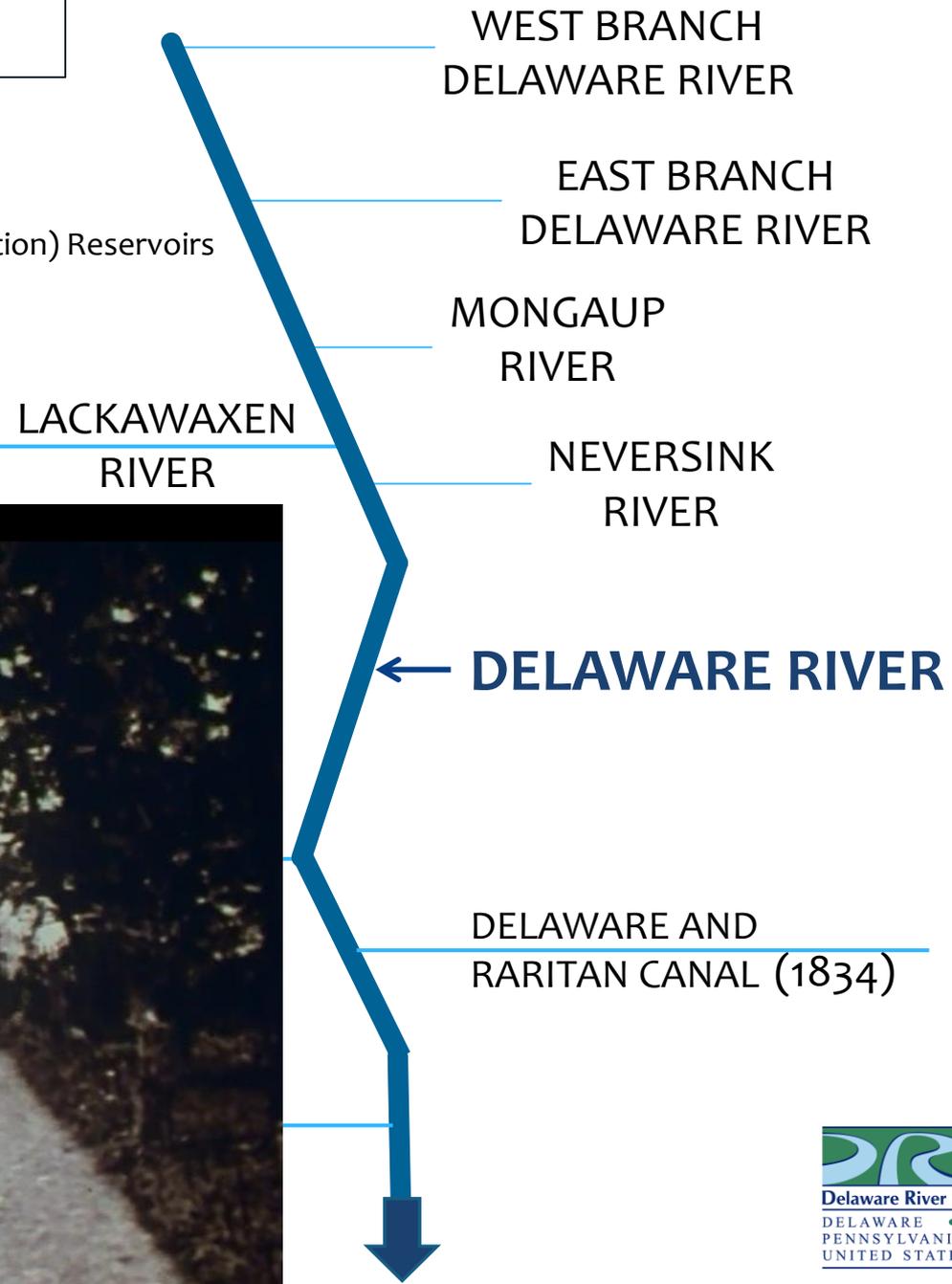
-  Out-of-Basin Diversion
-  Primarily Water Supply Reservoirs
-  Multi-Purpose (Flood/Power/WS/Recreation) Reservoirs
-  Primarily Flood Control Reservoirs
-  Flow Management Objective



Note: Not all reservoirs, tributaries, and diversions are shown.

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# Water Management Schematic for the Delaware River Basin

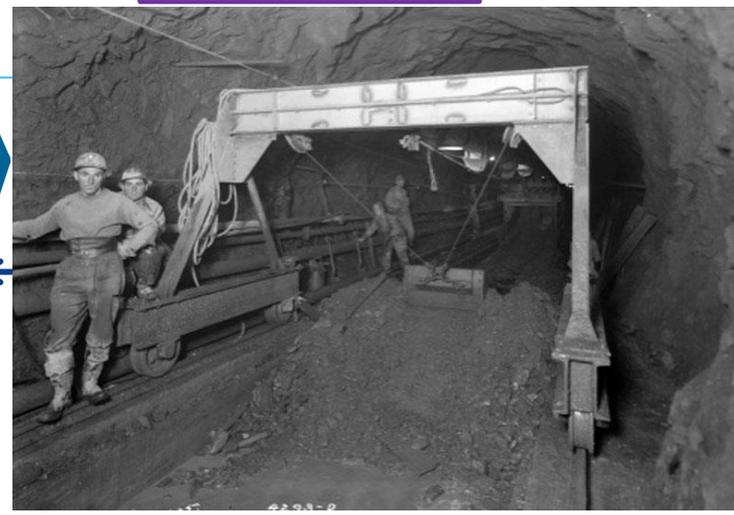
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## Hydropower Development

DELAWARE  
AQUEDUCT  
COMPLETED IN  
1945

To NYC  
Water  
Supply  


MONGAUP  
SYSTEM - 1927



DELAWARE AND  
RARITAN CANAL (1834)

LACKAWAXEN  
RIVER

LAKE WALLENPAUPACK - 1929

30 BG

15 BG

**1905:** NEW YORK CITY LOOKS WEST FOR MORE WATER  
**1915:** CATSKILL SYSTEM completed but not enough  
**1927:** DELAWARE BASIN Reservoirs approved by NYC Board of Water Supply  
**1931:** NYC sued by NJ (PA and DE Intervened) settled by SCOTUS

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## 1954 Supreme Court Decree

- NYC allowed to build 3 reservoirs (total)
- NYC may divert 800 mgd
- NYC must ensure **1,750 cfs** at Montague with Reservoir releases
- A quantity of NYC water made available for lower basin uses
- NJ may divert 100 mgd
- Office of the Delaware River Master
- Treatment of Wastewater from Port Jervis

LACKAWAXEN

1954 Neversink Completed



To NYC Water Supply  
Up to 800 MGD

 Non Drought Target = 1750 cfs (1130 MGD)

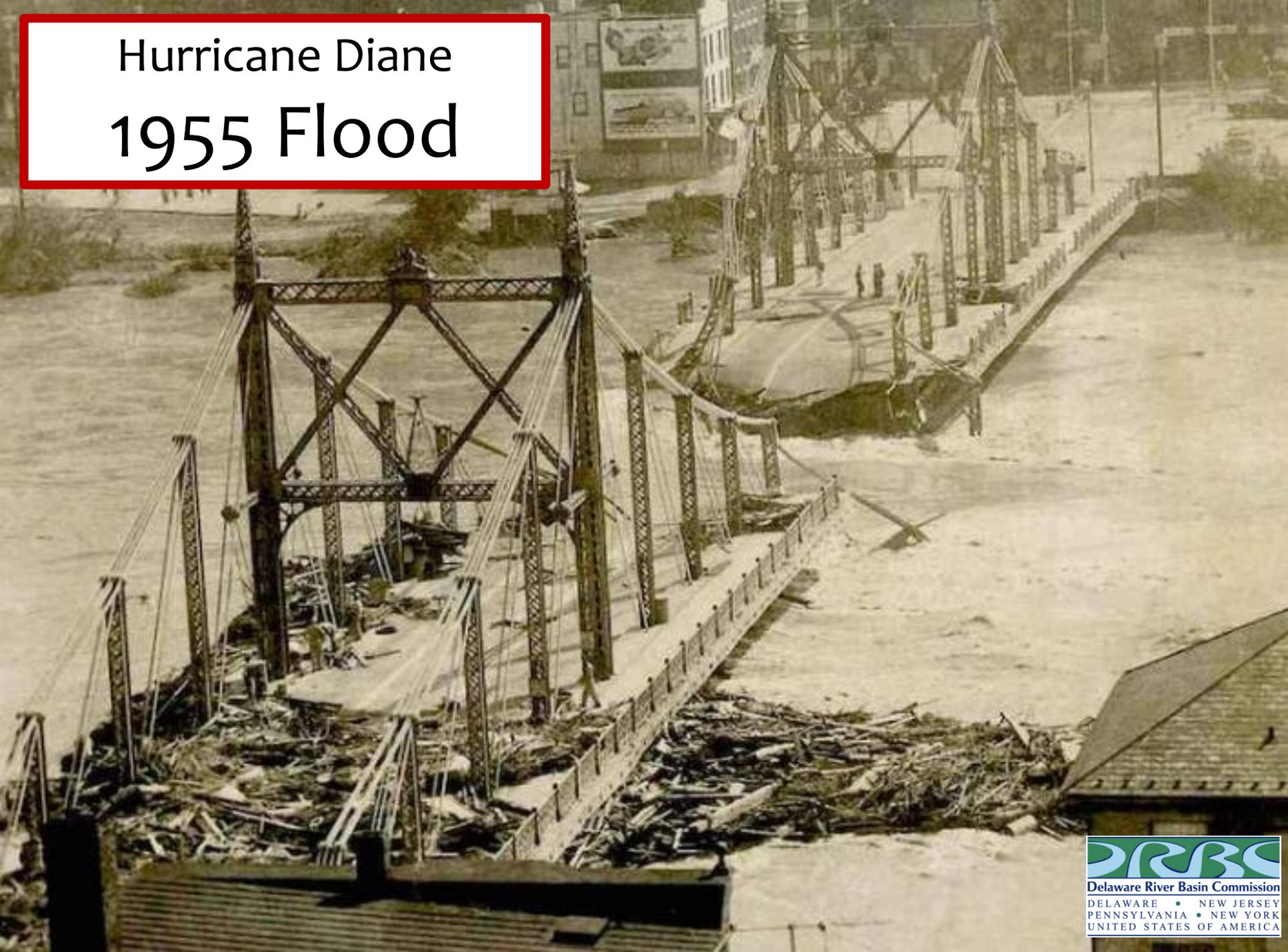
1950s NJ begins using canal for Water Supply

DELAWARE AND RARITAN CANAL

To New Jersey Water Supply  
Up to 100 MGD

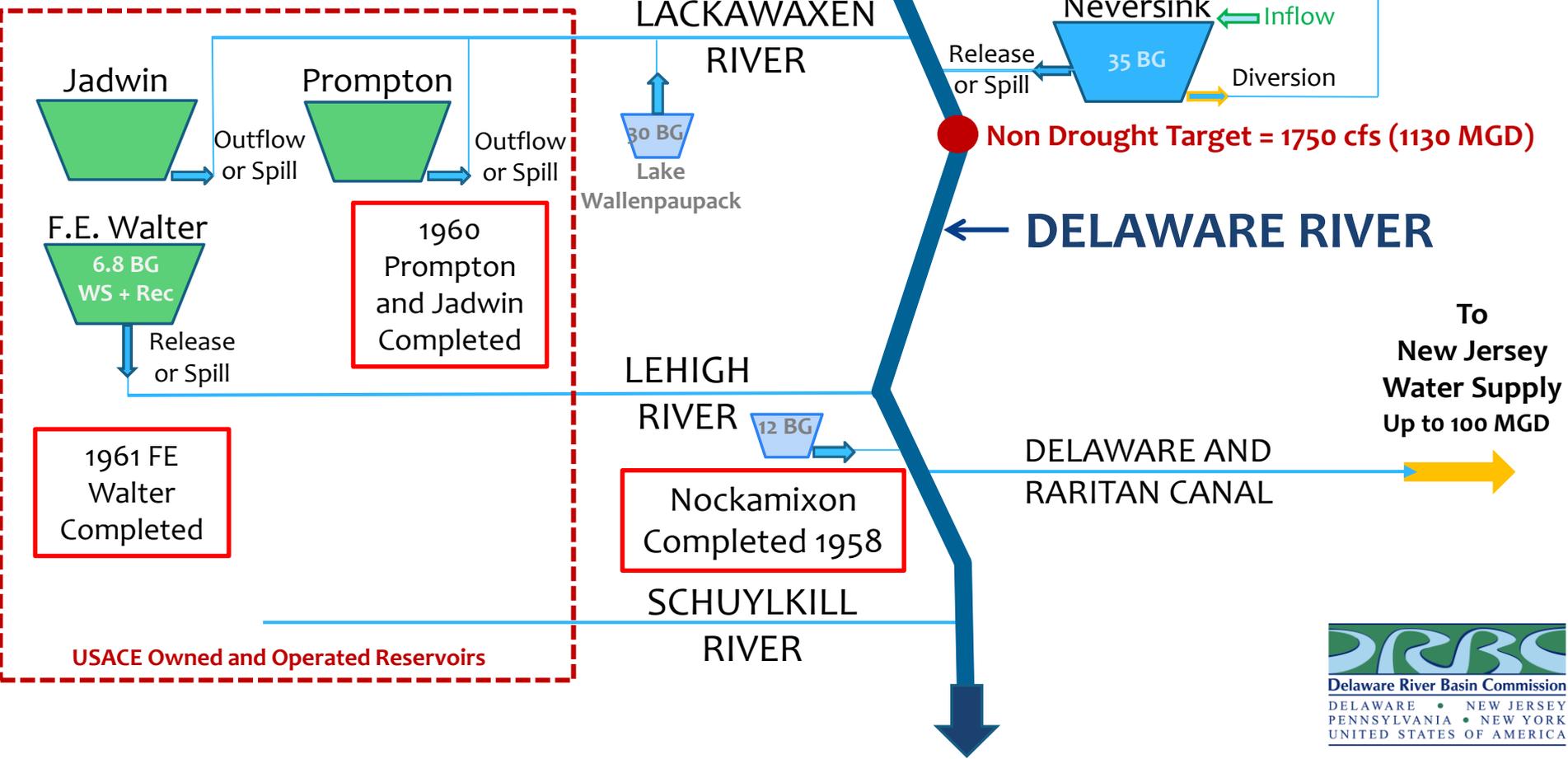
SCHUYLKILL RIVER

# Hurricane Diane 1955 Flood



# Water Management Schematic for the Delaware River Basin

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## FOUR STATES SIGN DELAWARE PACT

President Joins in Approving  
Vast Program for Basin  
Backed by Governors

COMMISSION IS SET UP

Developing of River Valley  
Will Use, Conserve and  
Protect Vital Supply

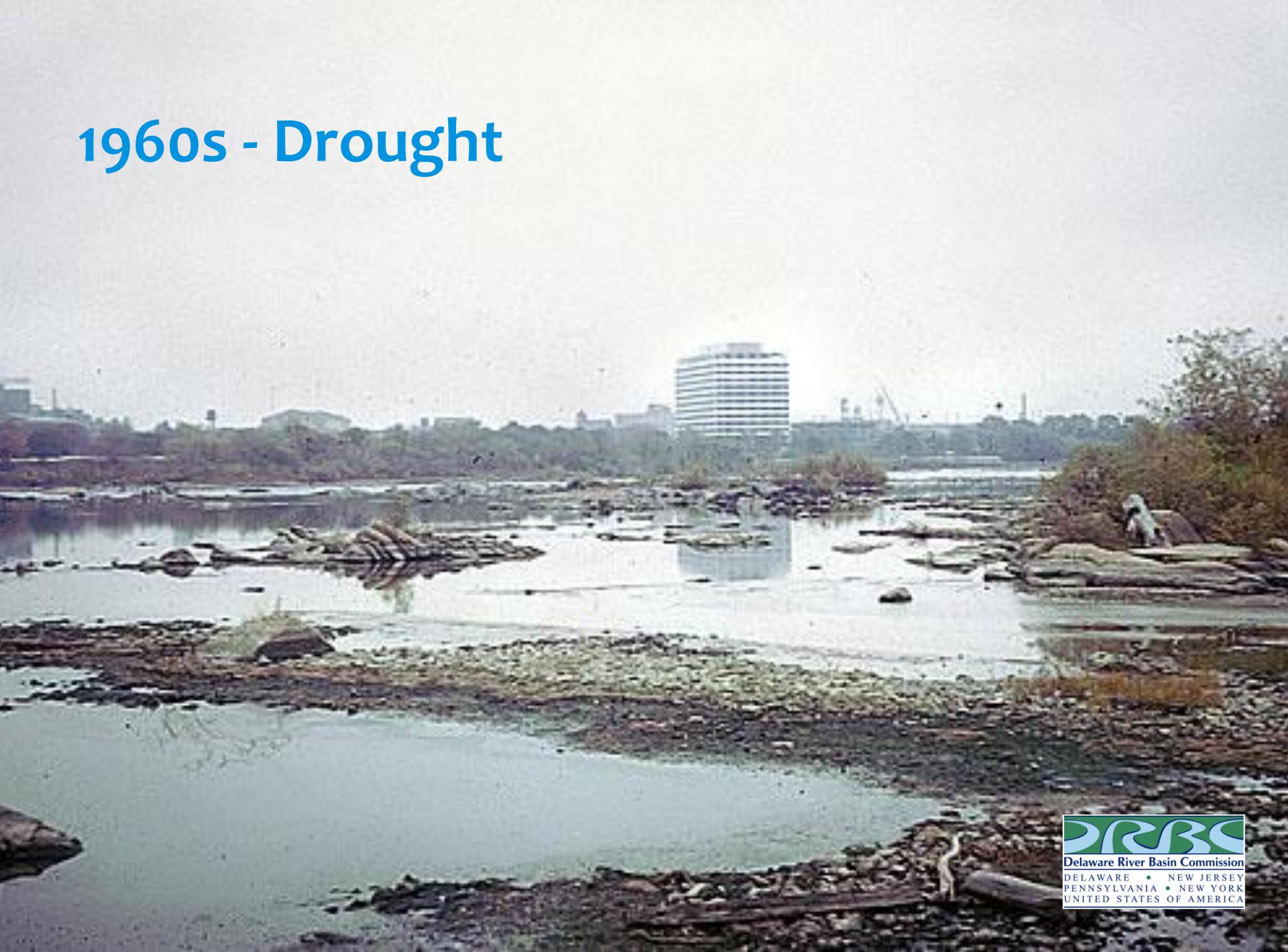
By **RUSSELL BAKER**  
Special to The New York Times.

*(seated left to right)* Governors Robert Meyner of New Jersey, Elbert Carvel of Delaware, and David Lawrence of Pennsylvania joined President John F. Kennedy at the White House on November 2, 1961, to participate in a ceremonial signing of the compact.

# Commission

- \* Established by Compact in 1961 to address:
  - \* Water supply shortages – venue for cooperation
  - \* Serious flooding
  - \* Severe pollution in the main stem and major tributaries
- \* Authorized to change provisions of the 1954 Supreme Court Decree only **WITH** the unanimous consent of the parties
- \* Required to cooperate and collaborate with States and Federal Agencies

# 1960s - Drought



# Water Management Schematic for the Delaware River Basin

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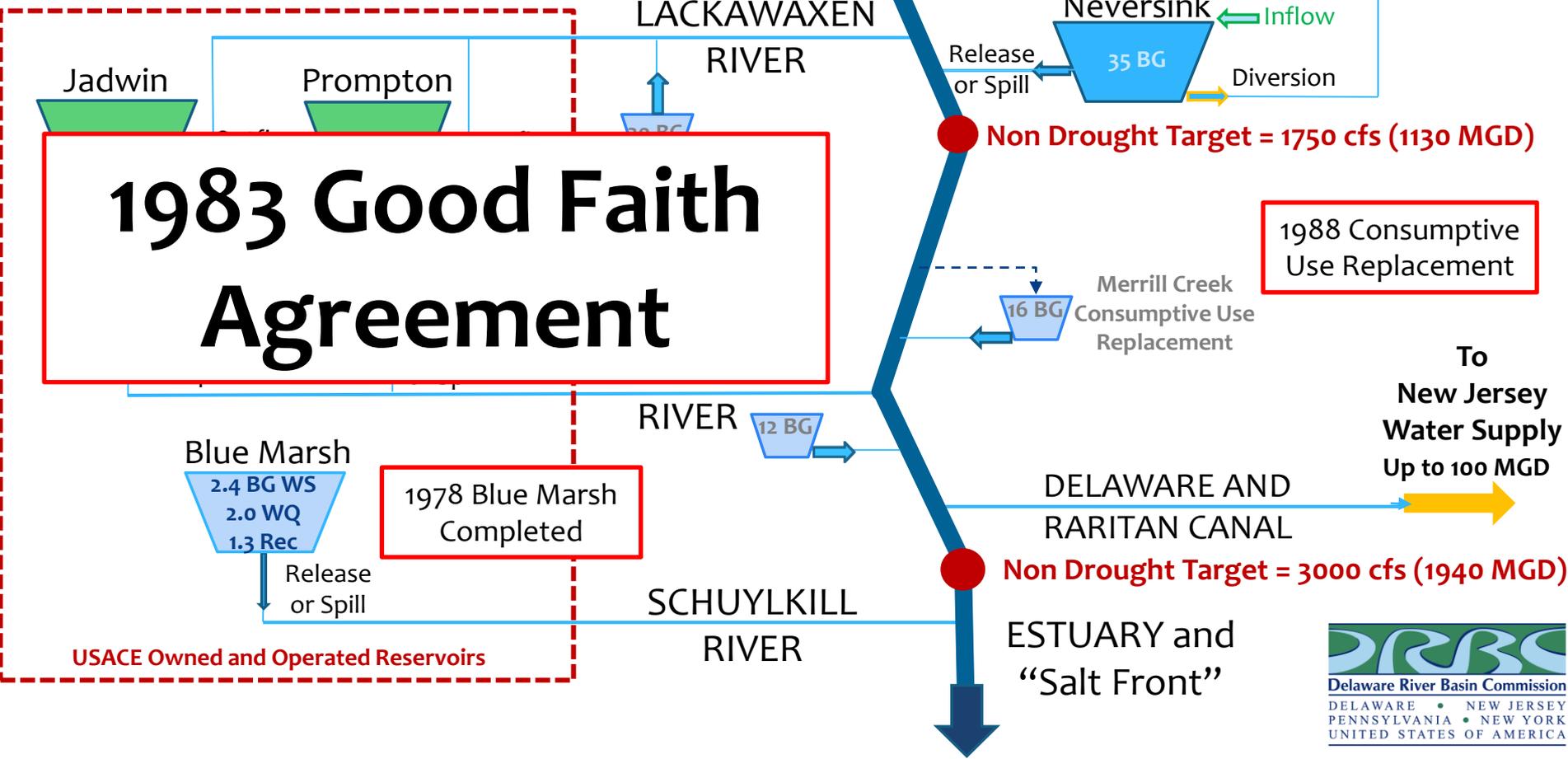
**Cannonsville Completed 1964**

**To NYC Water Supply Up to 800 MGD**

**1988 Consumptive Use Replacement**

**1983 Good Faith Agreement**

**1978 Blue Marsh Completed**



# Good Faith Agreement

- \* Phased reductions in out-of-basin diversions by New York and New Jersey based on reservoir storage
- \* Phased reductions in flow objectives
- \* A new flow objective at Trenton
  - \* Ensures freshwater flow into estuary
  - \* Varies seasonally
- \* Drought Management Plans

# Flexible Flow Management Program

- \* Bases the amount of water available for non-water supply purposes on current storage conditions and weather predictions from the national weather service.
- \* Beneficial uses include:
  - \* Enhanced releases for fisheries
  - \* Thermal mitigation
  - \* Spill mitigation

**Converts potentially spilled water into managed water.**

# Water Management Schematic for the Delaware River Basin

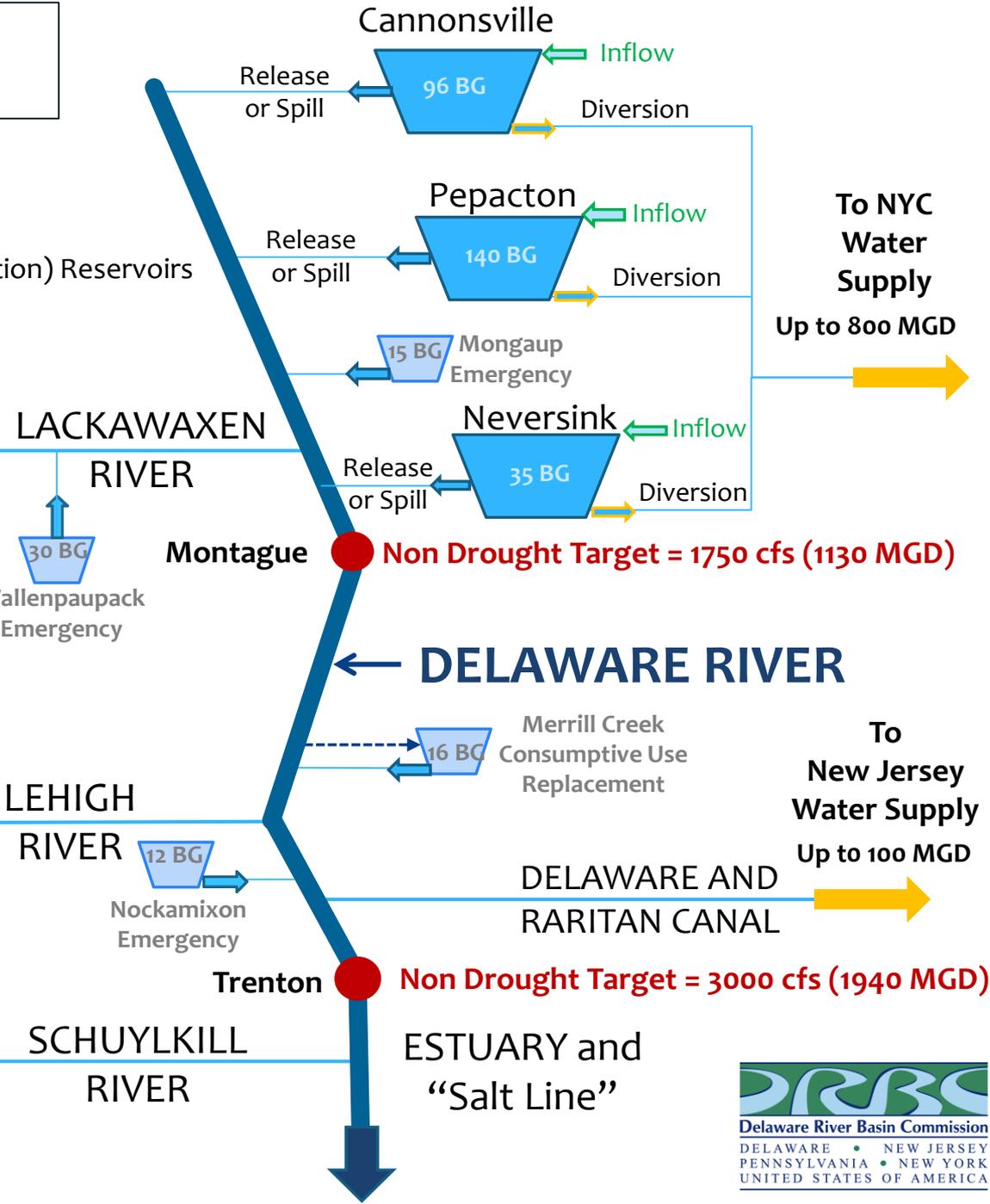
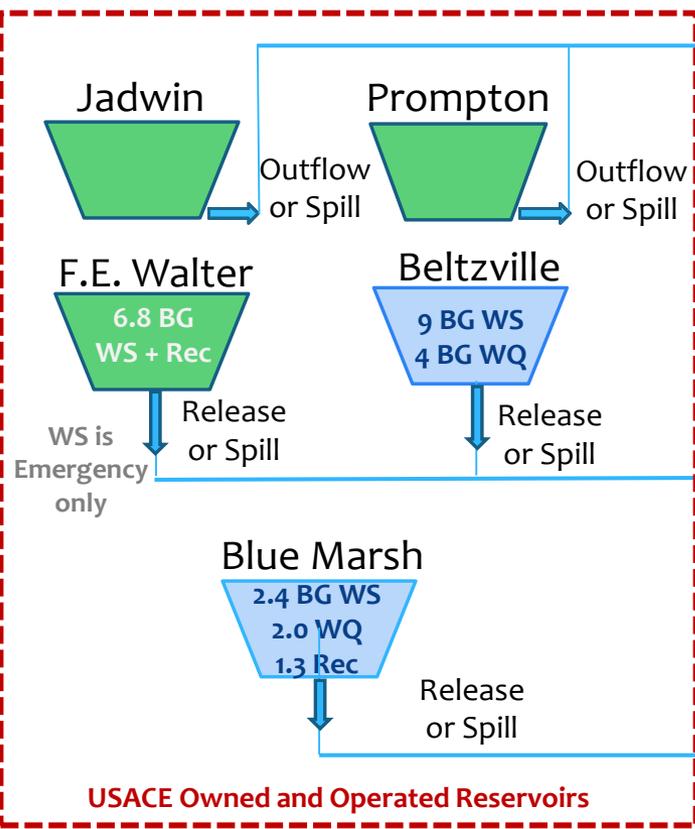
 Out-of-Basin Diversion

 Primarily Water Supply Reservoirs

 Multi-Purpose (Flood/Power/WS/Recreation) Reservoirs

 Primarily Flood Control Reservoir

 Flow Management Objective



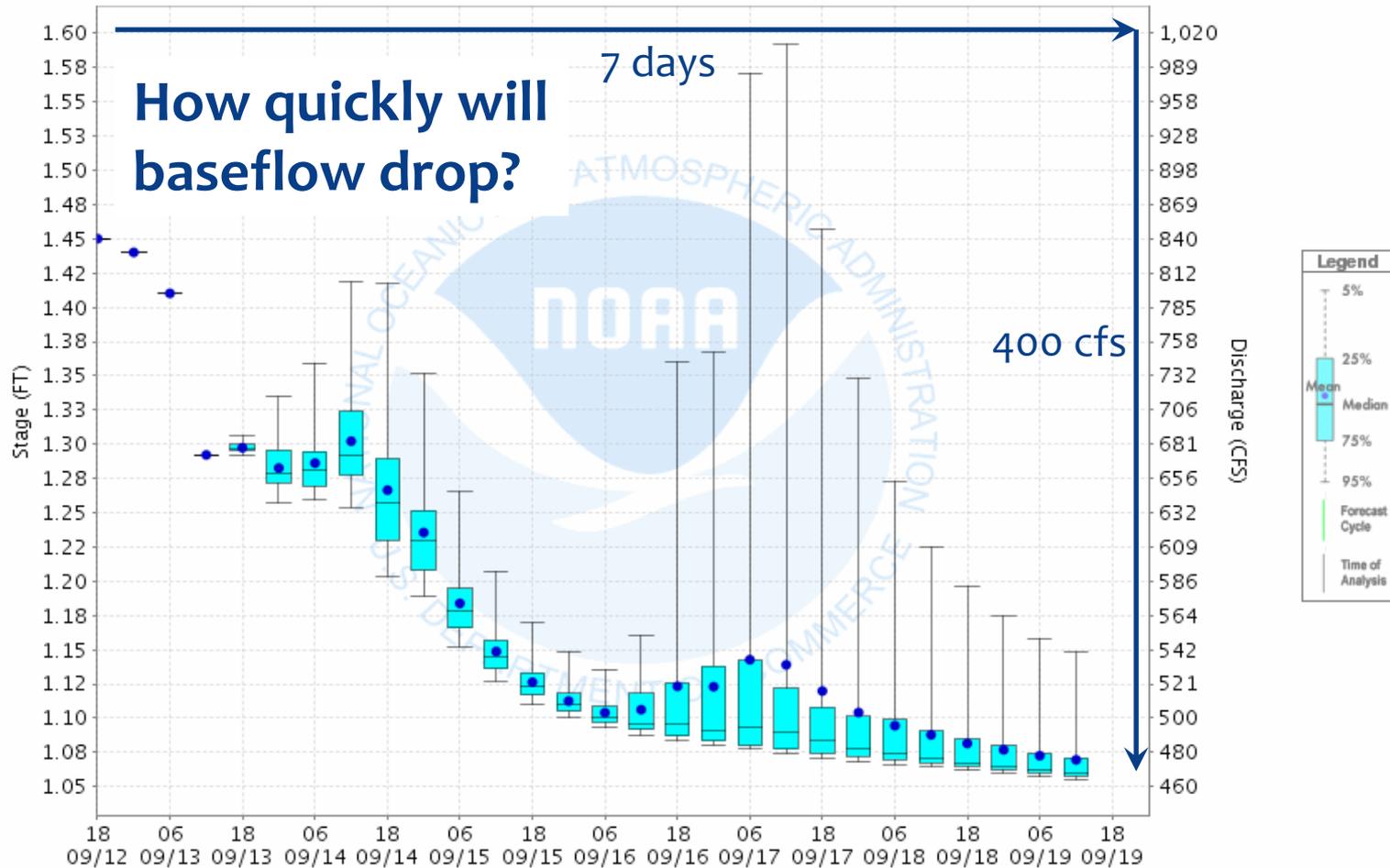
Note: Not all reservoirs, tributaries, and diversions are shown.

# Designing Reservoir Releases

- \* USGS Gages
- \* River Master's Office (Montague)
  - \* Balancing Adjustment (over/under adjustments)
  - \* Post-Release Montague Prediction
  - \* Hydropower changes to schedule
- \* Quantitative Precipitation Forecasts (Day 1, Day 2, Day 3, Days 1-2, Days 1-3, Days 4-5, Days 6-7 and 5- and 7-day totals)
- \* Observed Precipitation
- \* Meteorologic Model Ensemble River Forecasts (MMEFS)
  - \* Flow
  - \* Precipitation

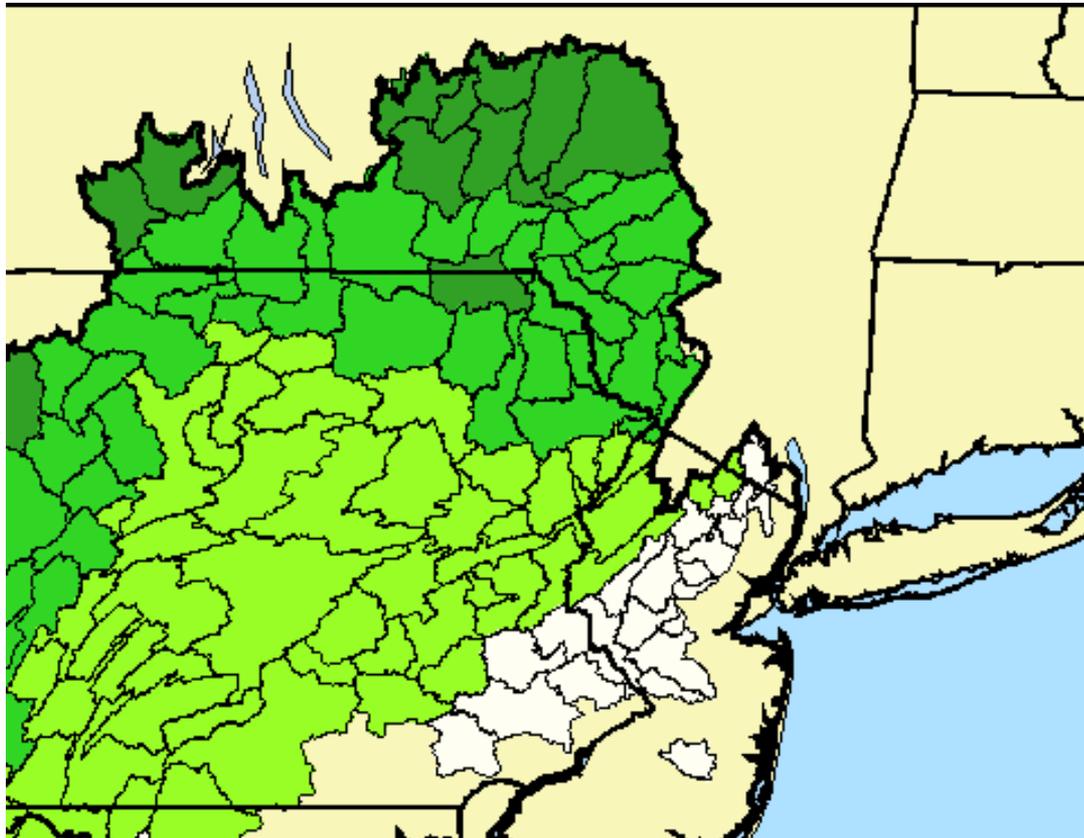
# Baseflow Recession

GEFS-based Stage Simulation Expected Value Plot  
Lehigh River at Bethlehem, PA (BETP1)  
Analysis for the period 09/13/2014 00 UTC - 09/19/2014 18 UTC



Forecast Cycle: 20140912 18 UTC  
(21 members; plot times UTC)

# Precipitation



Inches	
	Zero
	0.01 to 0.10
	0.10 to 0.25
	0.25 to 0.50
	0.50 to 0.75
	0.75 to 1.00
	1.00 to 1.25
	1.25 to 1.50
	1.50 to 1.75
	1.75 to 2.00
	2.00 to 2.00

# Runoff



Photo Credit: University of Nebraska

If you do not see water flowing into storm drain, it will not make it into the river.

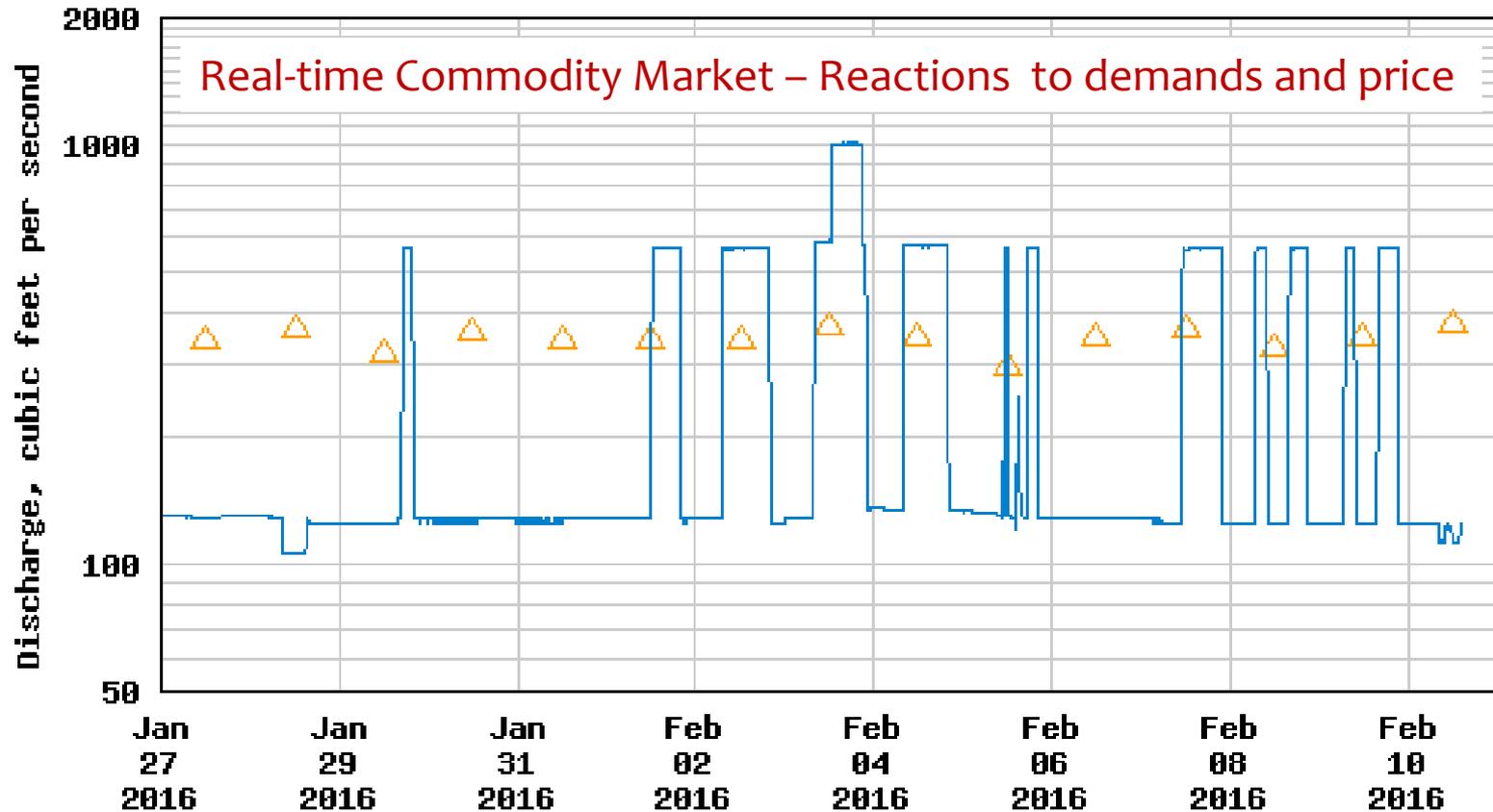
# Travel Times



Reservoir	To Montague	To Trenton
Cannonsville	48 hours	96 hours
Pepacton	60 hours	108 hours
Neversink	33 hours	84 hours
Prompton	48 hours	96 hours
Wallenpaupack	16 hours	64 hours
Mongaup	8 hours	56 hours
FE Walter		60 hours
Beltzville		48 hours
Merrill Creek		24 hours
Nockamixon		12 hours
Blue Marsh		38 hours (Estuary)

# Hydropower

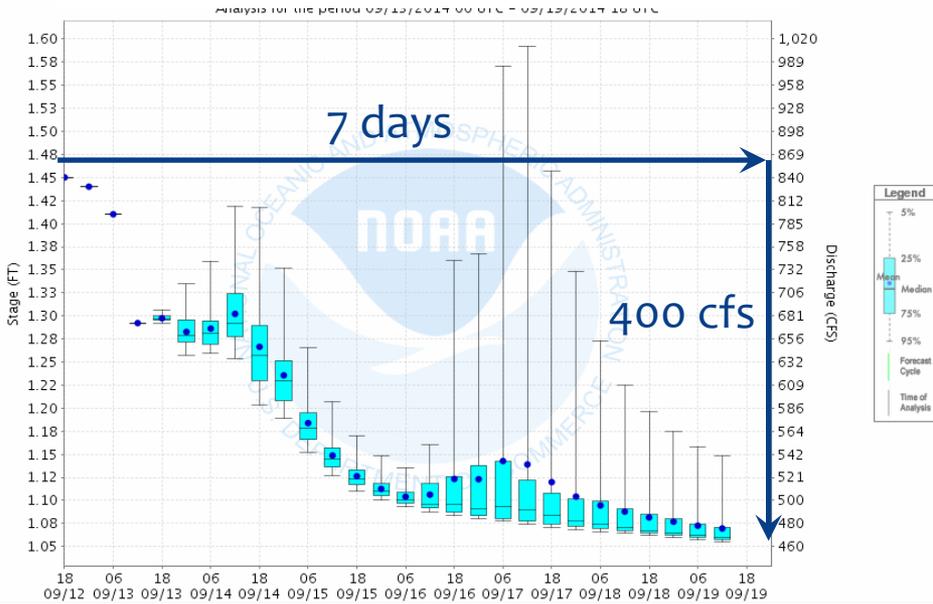
USGS 01433500 MONGAUP RIVER NEAR MONGAUP NY



----- Provisional Data Subject to Revision -----

△ Median daily statistic (57 years) — Discharge

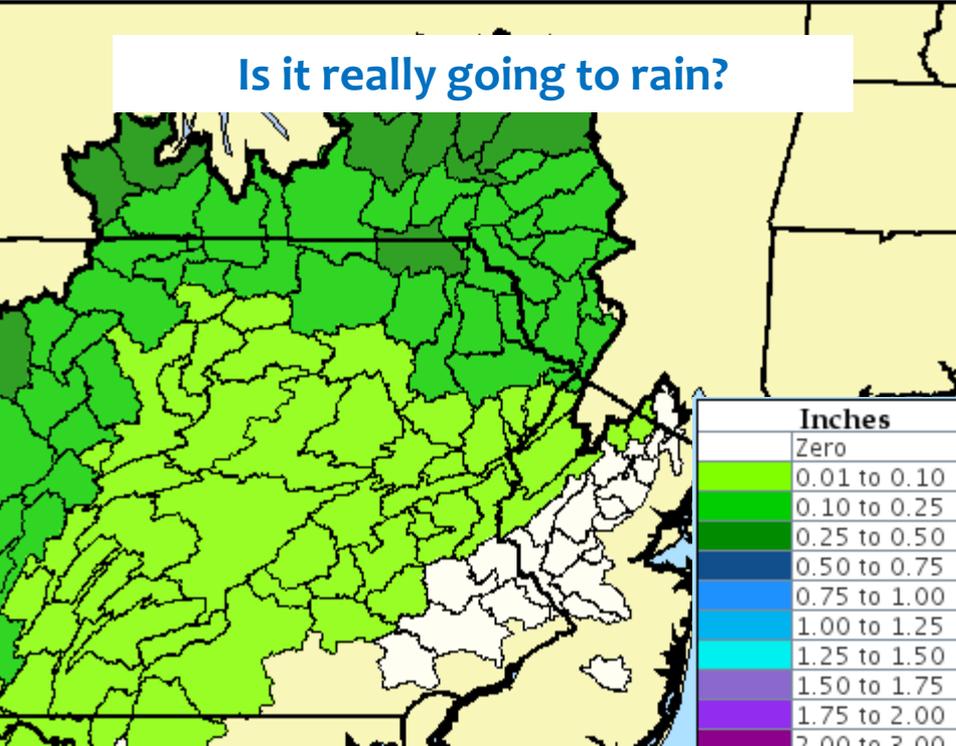
# How quickly will baseflow drop?



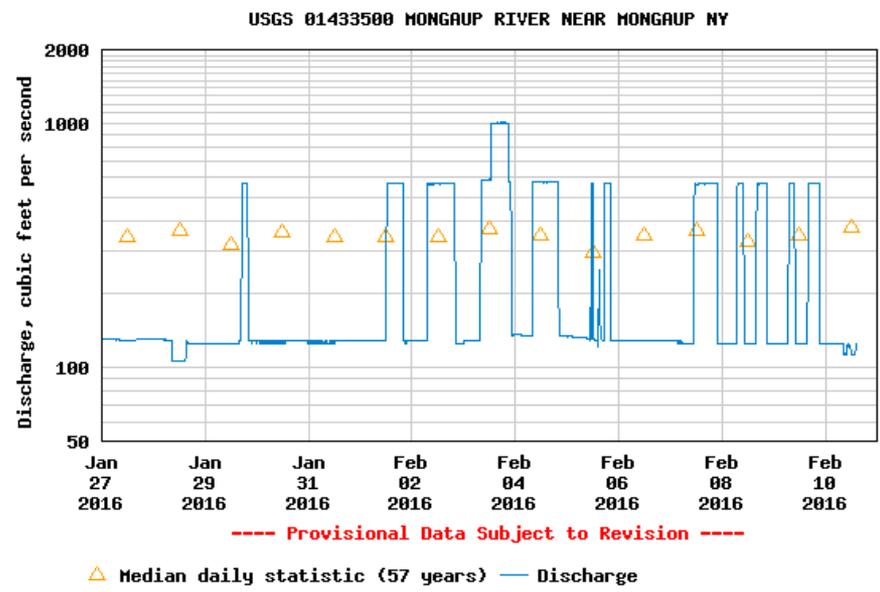
# Will it get there on time?

Approximate Travel Times During Low Flow Conditions				
	Hours		Days	
	Montague	Trenton	Montague	Trenton
Cannonsville	48	96	2	4
Pepacton	60	108	2.5	4.5
Neversink	33	84	1.4	3.5
Wallenpaupack	16	64	0.7	2
Rio	8	56	0.3	2
Merrill Creek		24		1
FE Walter	44	60		2.5
Beltville		32		2
Nockamixon		12		0.5
	<b>Philadelphia</b>			
Blue Marsh		38		

# Is it really going to rain?



# Will scheduled hydropower release occur?



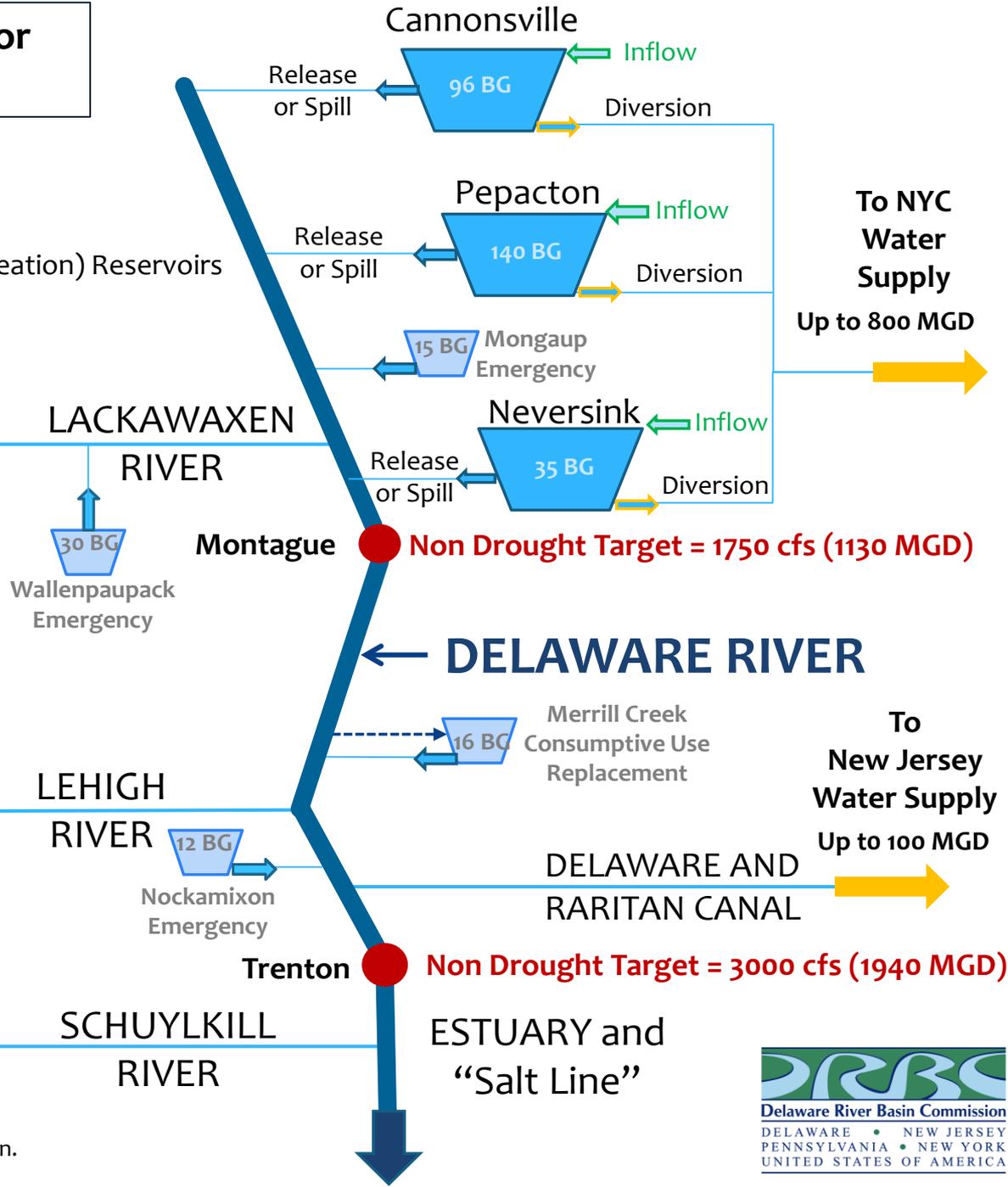
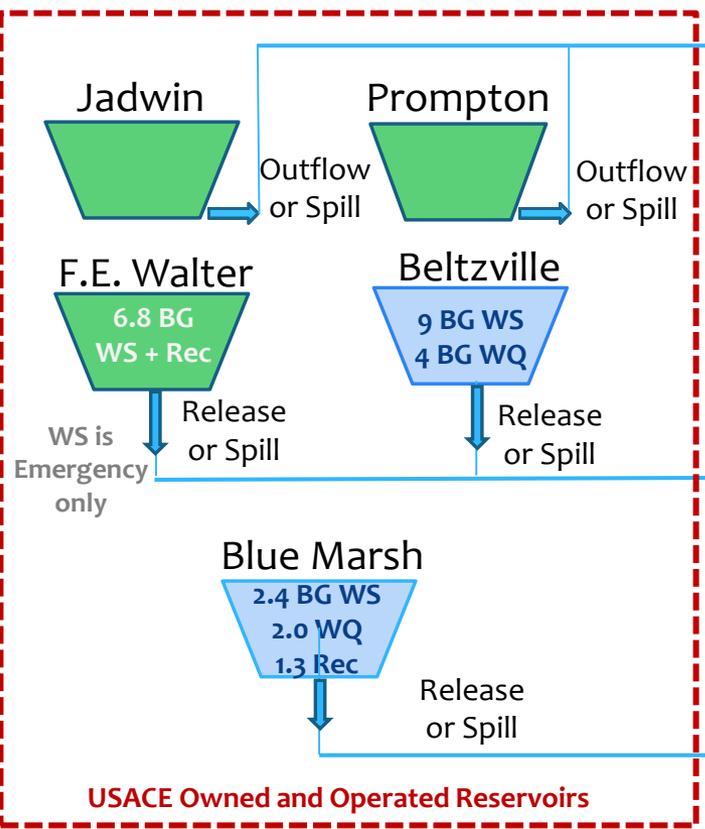
# Water Resource Management

in the DRB

- \* System developed over a long time with competing objectives
- \* Finite resources (water and storage)
- \* Operations can be designed to:
  - \* Use the resource when available
  - \* Conserve the water when becoming scarce
  - \* Be more drought resilient
- \* Uncertainties in real-time management – some irreducible
- \* Future uncertainties: *today could be the first day of the next drought of record*

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# Questions

Amy Shallcross

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DRBC.net