The importance of an ensemble forecast for NYC water supply

A shift in the operational decision making approach

Adao Matonse, Jim Porter, Jerry Mead, Jim Mangarillo

DEP BWS, System Operations

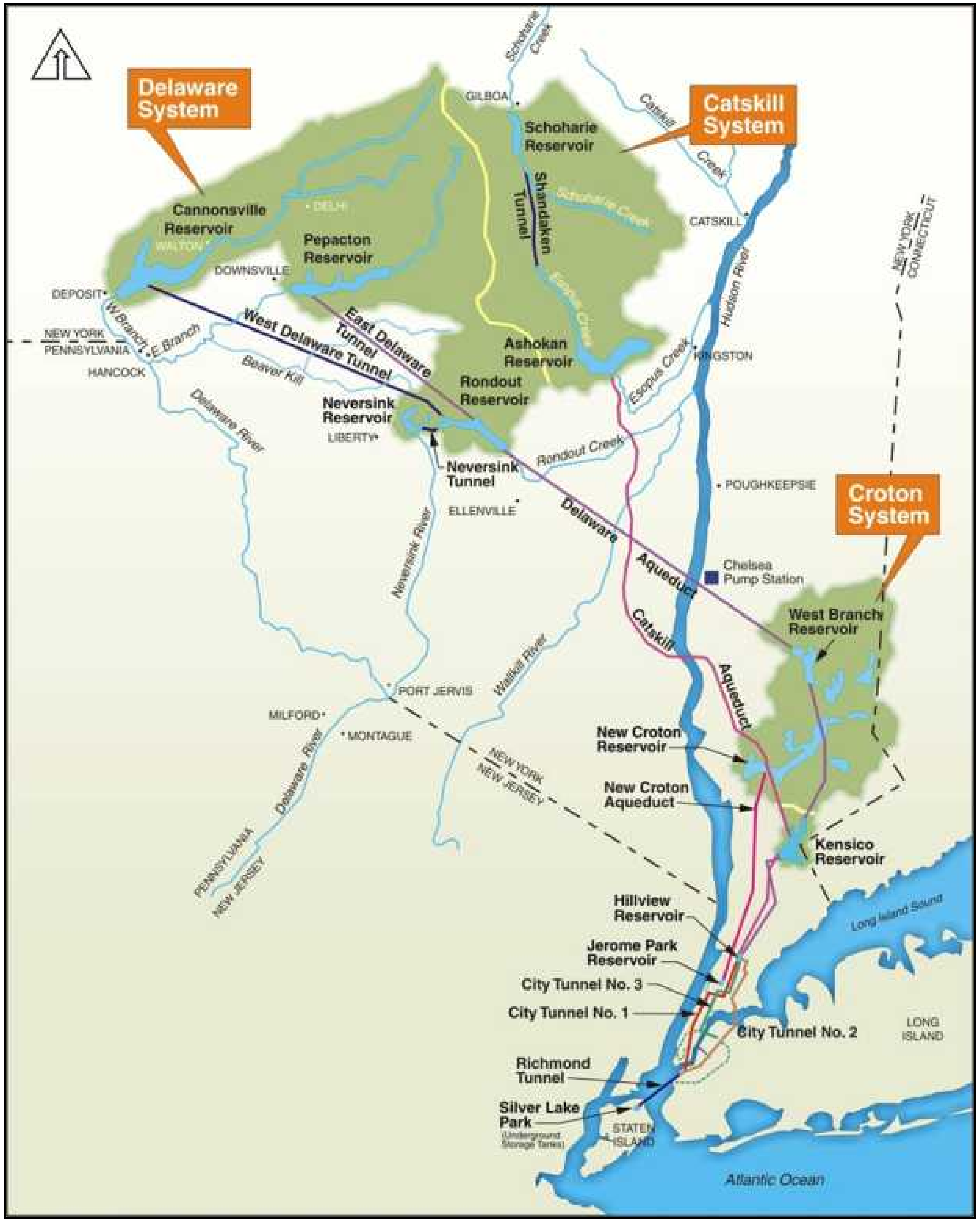
8th NCEP Ensemble Users Workshop

August 29, 2019

Presentation Outline

- New York City (NYC) water supply
- NYC Operations Support Tool (OST)
  - o Introduction
  - o Components
  - o Application
- The importance of an ensemble forecast
  - o OST application examples
- Our experiences and lessons learned
- NYC forecast support needs

New York City Water Supply

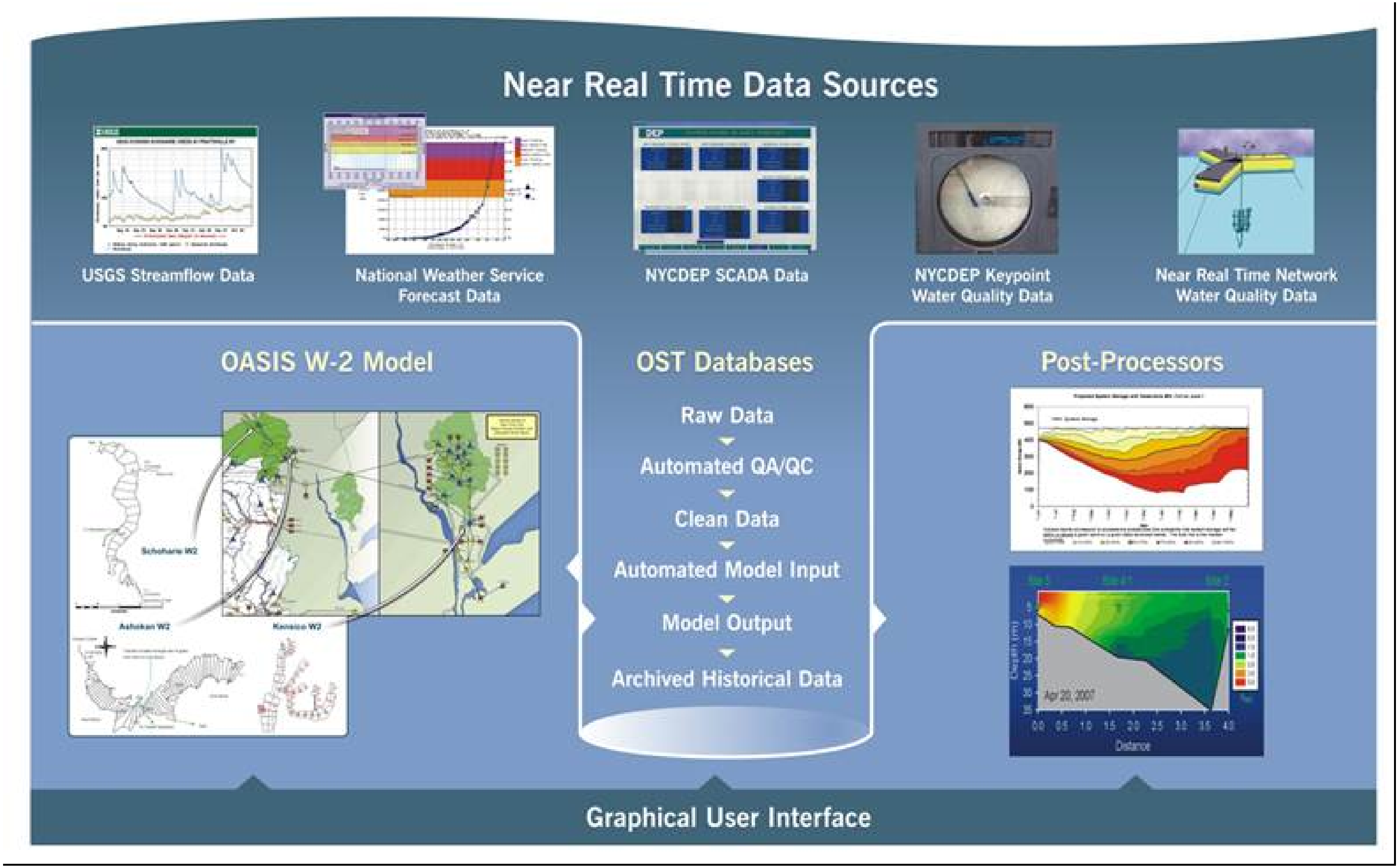


- Three Sub-systems
  - o Catskill, Delaware, Croton
- 19 reservoirs & 3 lakes
- 570 BG storage capacity
- Delivers 1.1 BG per day
- Serves 9 million people
- Unfiltered Surface Water Supply
- Managed by NYC DEP

Multiple Objectives and Challenges

- Supply reliability
- Drinking water quality regulations
- EPA Filtration Avoidance Determination (FAD)
- Tail water fisheries
- Ecological flows
- Regulated releases and diversions
- Spill mitigation
- Long-term supply/demand
- Climate change impact
- Extreme events frequency
- Operating costs
- Hydropower

NYC's Operations Support Tool (OST)



Developed as one of the FAD deliverables

OST Application Modes

NYC Environmental Protection

POSITIONAL ANALYSIS (PA) MODE

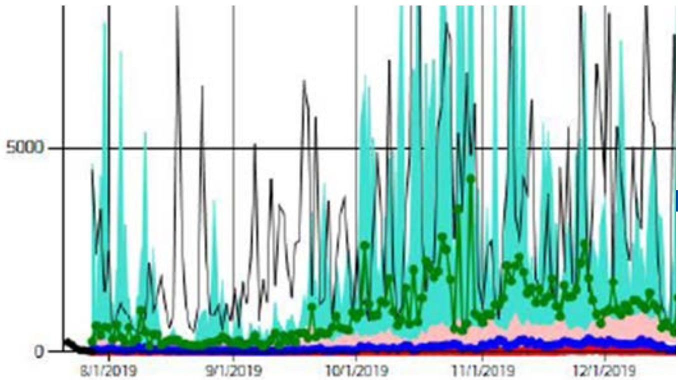
- 1-Year Long Simulation
  - Multiples traces
  - Support water supply operations
- Regular Runs
  - Open (Open)
  - Current Operations (CO)
- Test Operational Alternatives (TOA)
- Development Runs
  - Test New Rules (TNR)
  - Test New Infrastructure (TNI)

SIMULATION (SIM) MODE

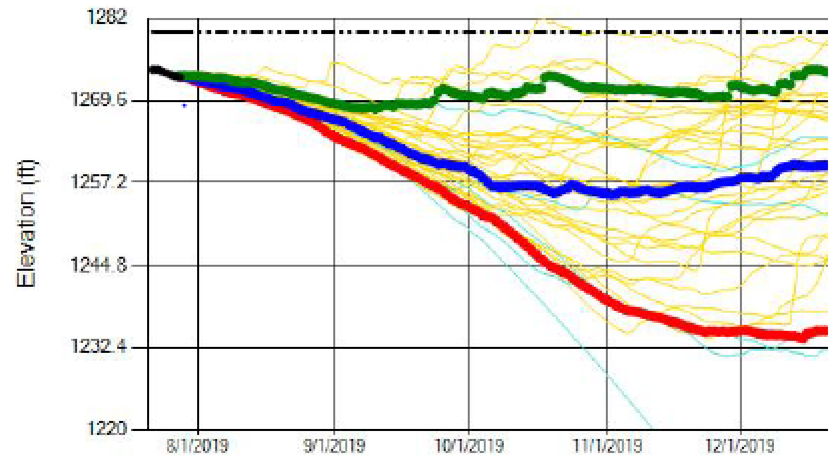
- Long-term simulation
  - 1 Trace
  - Multiple years
  - Support planning
  - Support policy development
  - Climate change impact assessment

OST Application – PA Mode

Ensemble of inflow forecasts



Probabilistic output metrics



OASIS – W2 Model

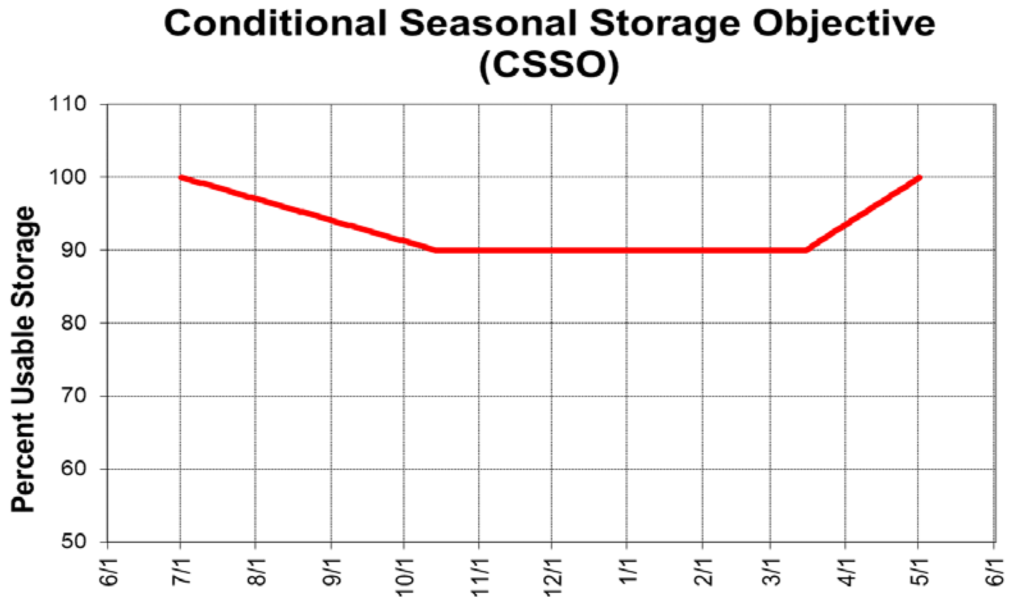
simulation scenario setup

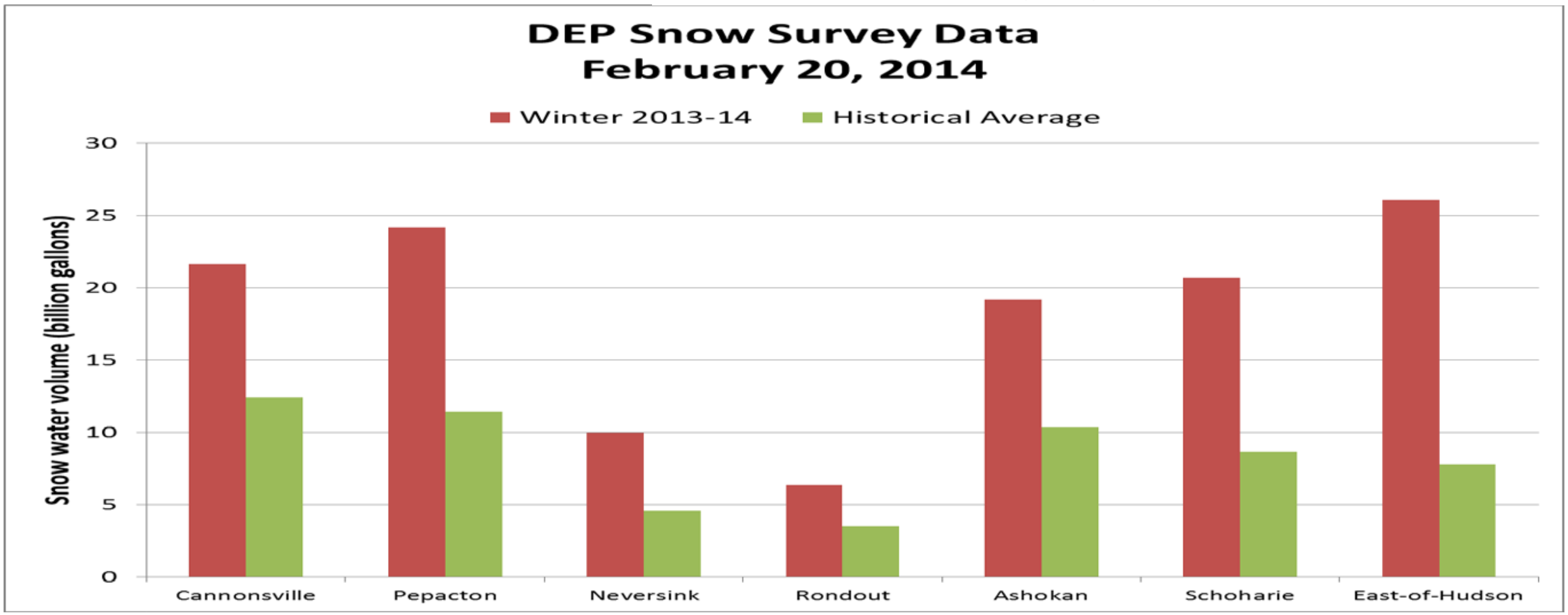
Current system status

Importance of Ensemble Forecasts

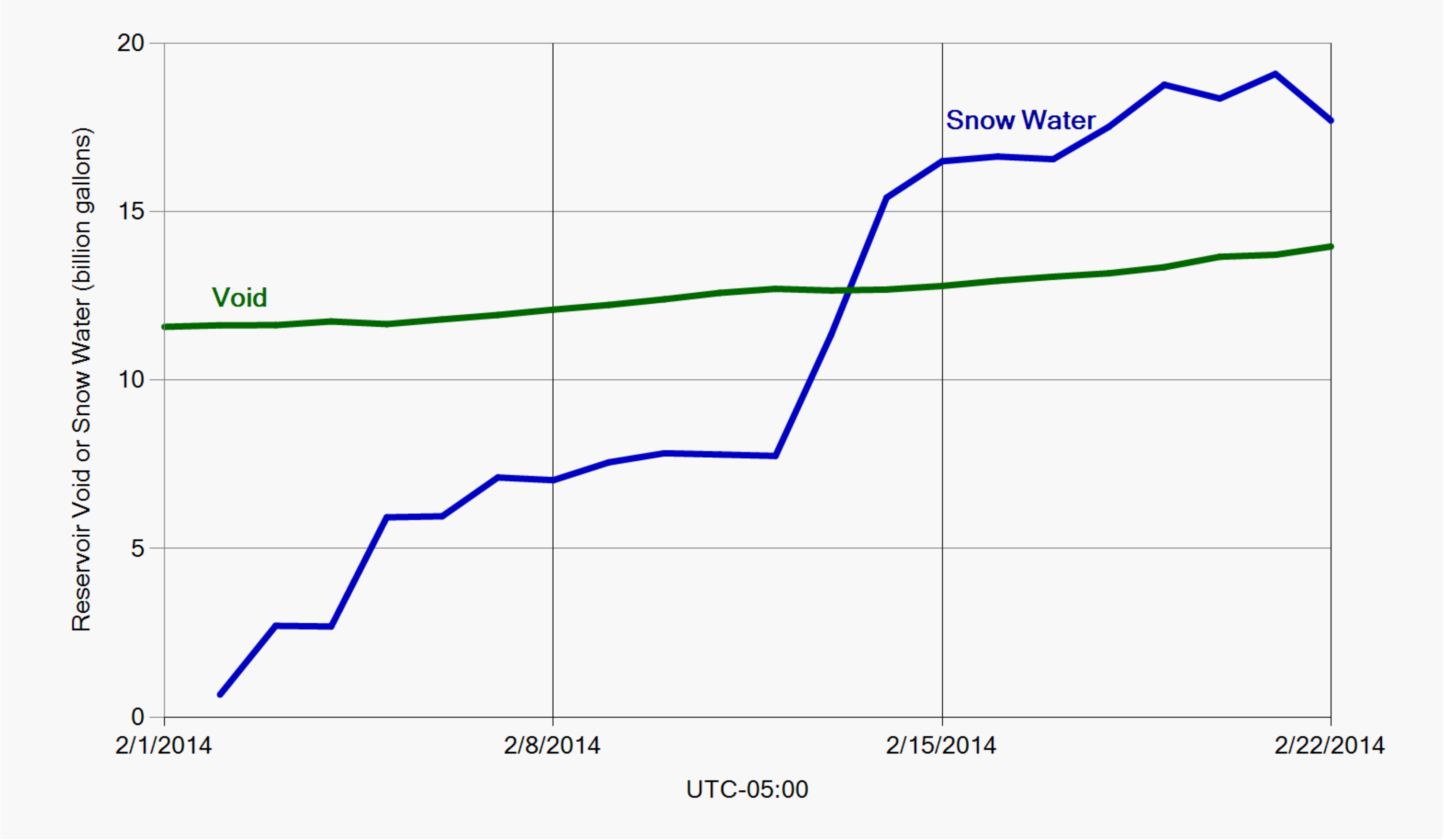
Example 1:

Winter 2013-2014: Spill mitigation by modeling alternatives for implementing a CSSO





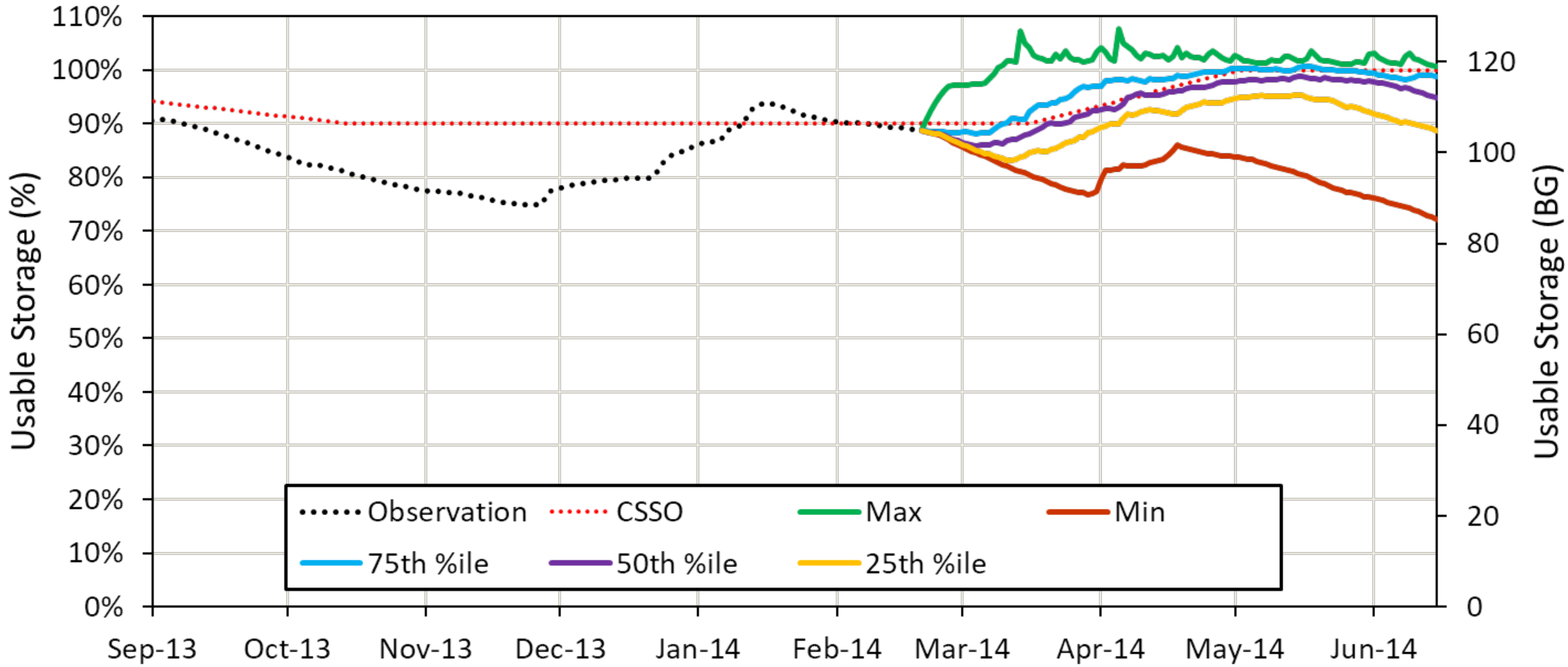
OST Application for CSSO Support



- By February 2014, there was a large amount of water stored as snowpack in the Ashokan Reservoir watershed
- OST was used to determine the most efficient way to minimize uncontrolled releases while maximizing reservoirs refill

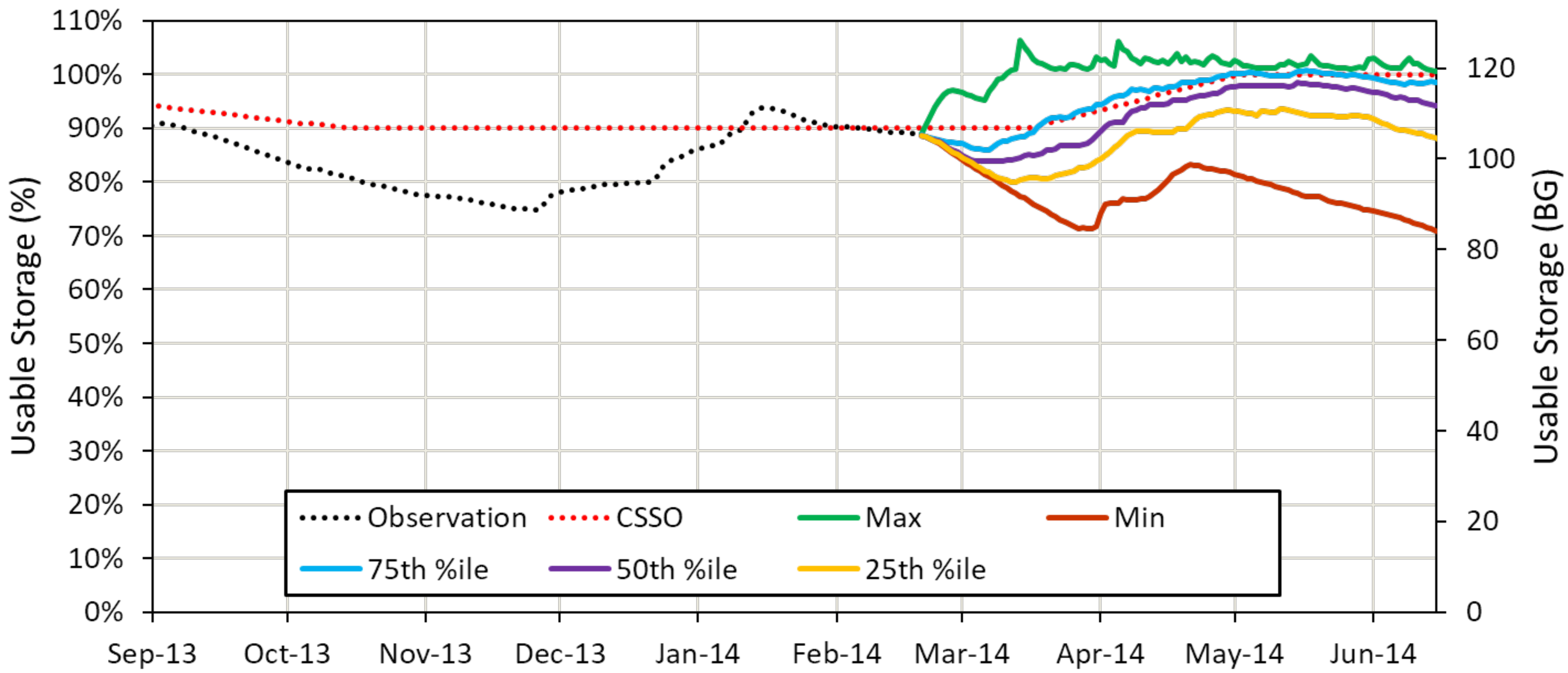
100 mgd release simulation scenario

NYC Environmental Protection

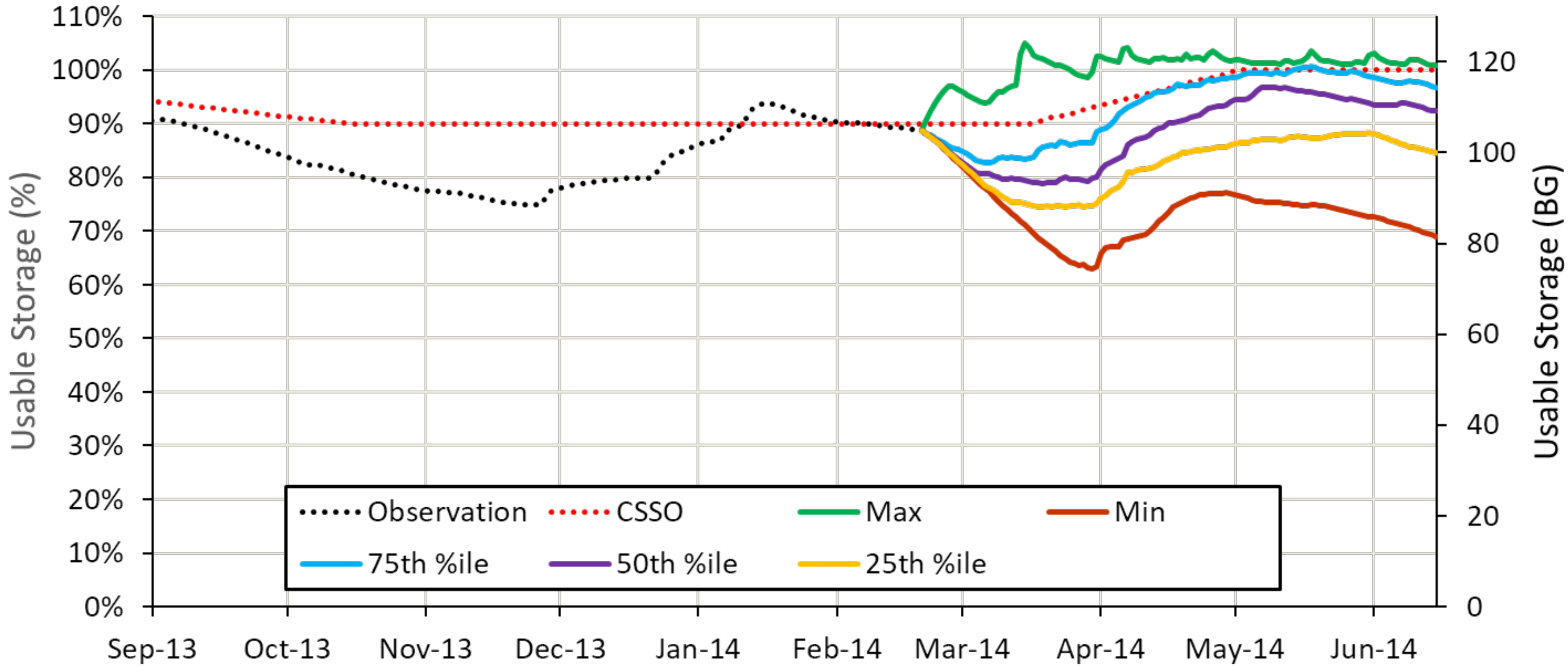


Water is released using the Ashokan Release Channel (ARC)

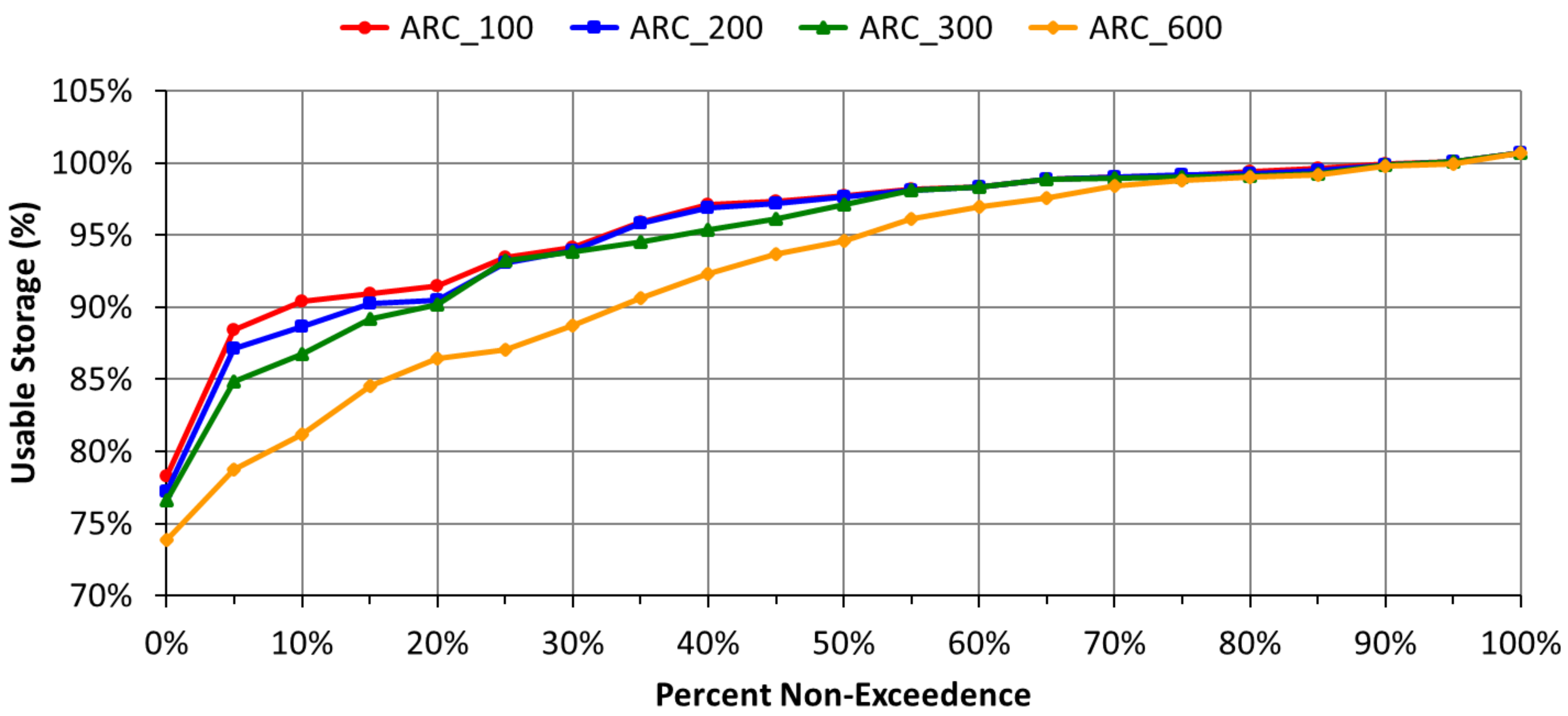
300 mgd release simulation scenario



600 mgd release simulation scenario

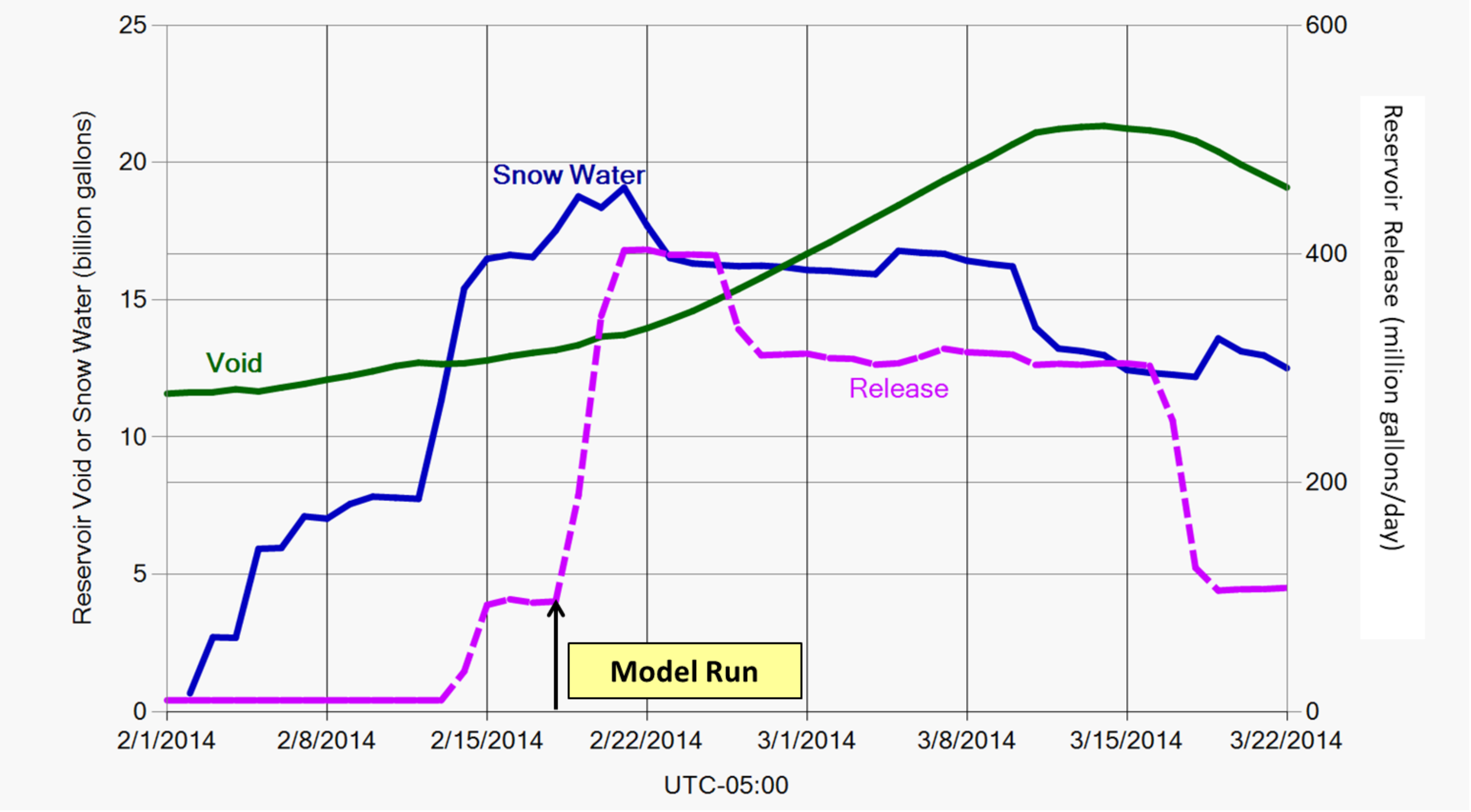


Impact on Jun 1st refill by Scenario



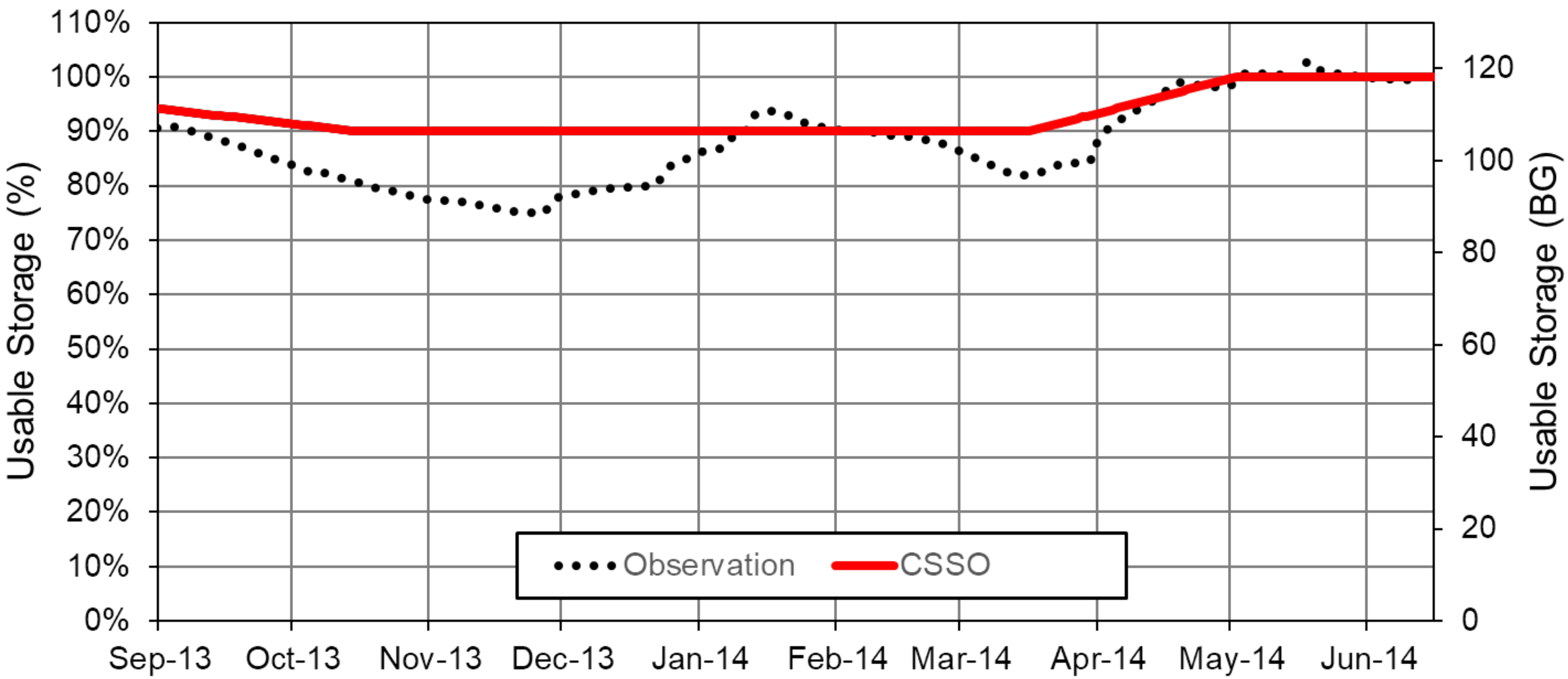
OST simulated alternative release impacted reservoir probability of refill by June 1st, differently

Reservoir Void, Release and Snow Water



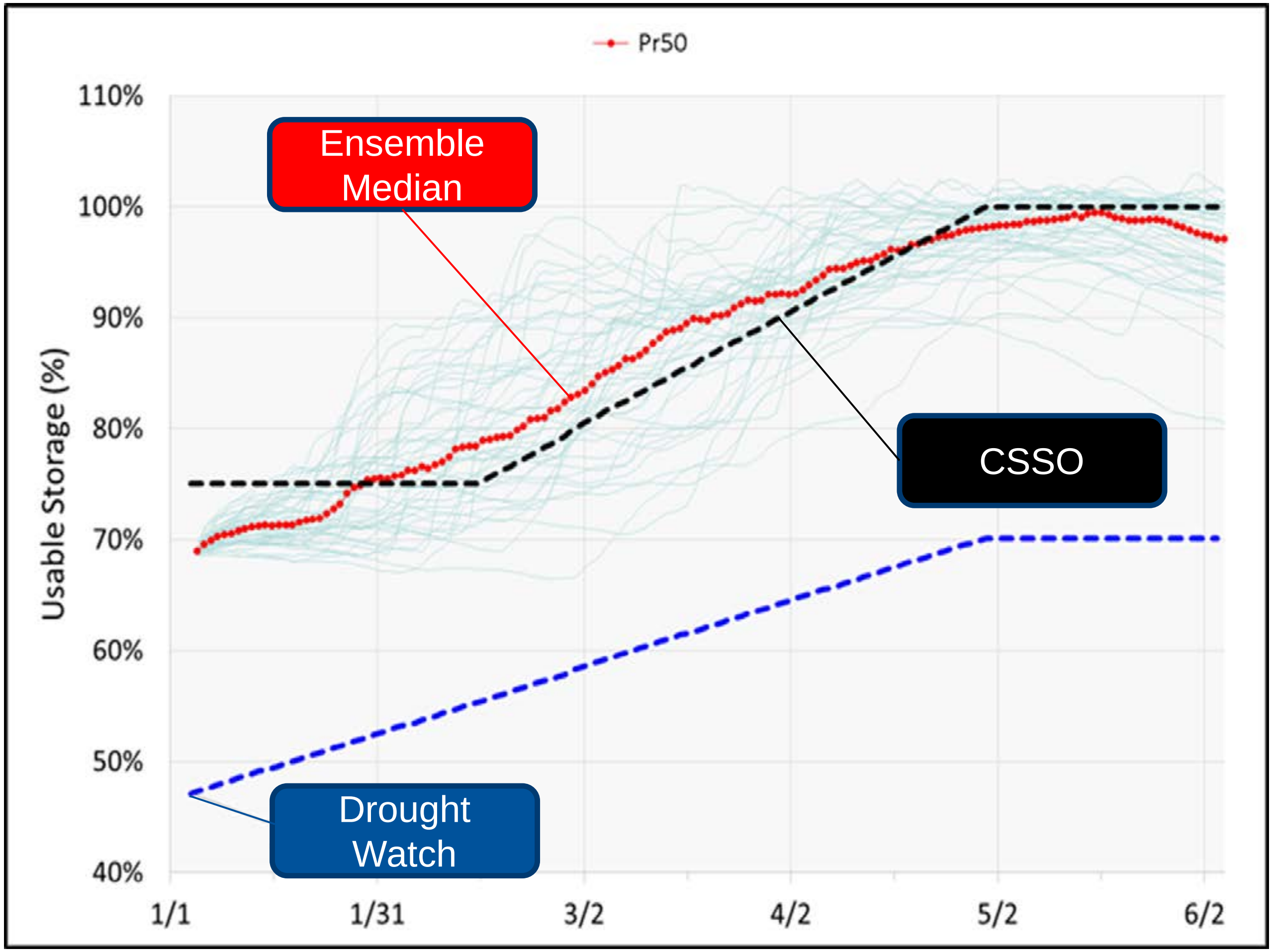
Repeated OST simulations provided valuable information to guide releases from Ashokan Reservoir

Implemented Operations



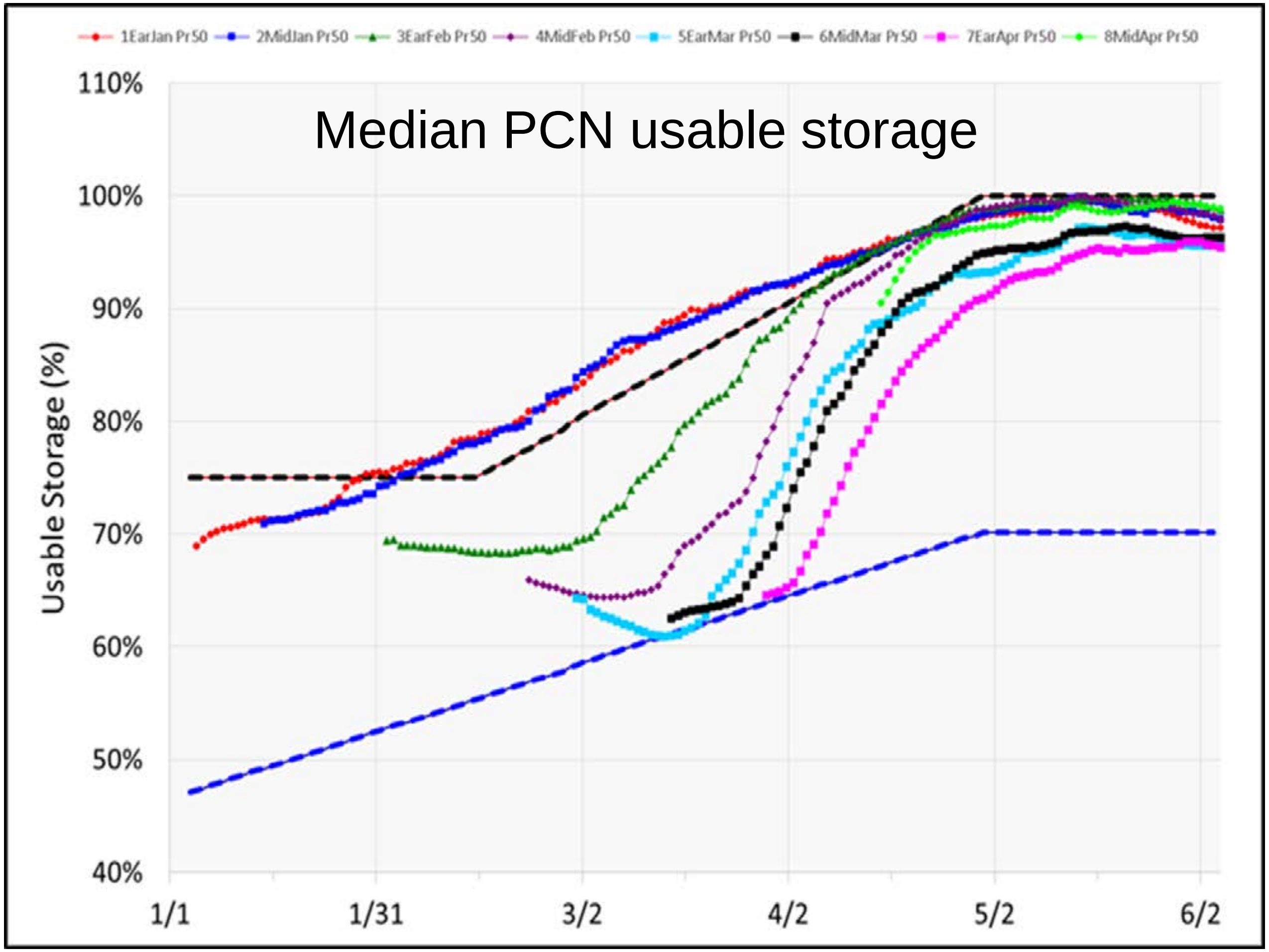
OST simulations helped operators meet spill mitigation objectives while ensuring reservoir refill

OST Application for Delaware Basin Operations



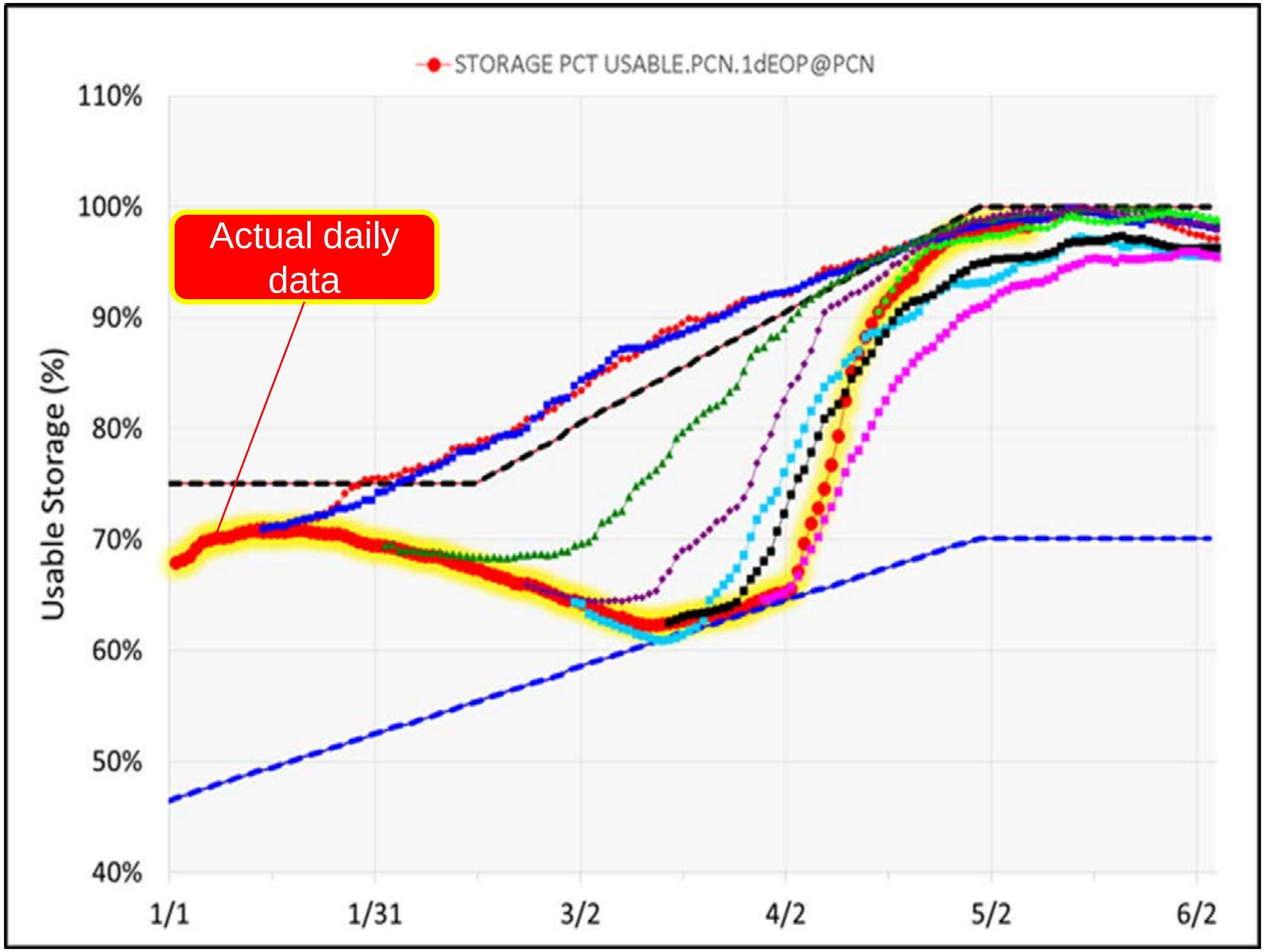
Example 2:

Winter/Spring 2015: Modeling support to prevent NYC's Delaware River basin reservoirs (Pepacton, Cannonsville and Neversink) from entering drought watch. Very cold temperatures, large snow accumulation



Each line represents a model simulation with a different starting date and ensemble forecast

Actual Storage



Flexible Flow Management Program

OST-2017 FFMP Release Summary
Decision Day: 8/14/2019

General Release Mass Balance		
Combined Pepacton, Cannonsville, and Neversink (PCN) Storage:	223,789	MG
+ PCN Inflow Forecast Accumulated to Jun 1:	387,697	MG
- Expected PCN Diverson Accumulated to Jun 1:	172,316	MG
-Jun 1 Storage Target:	267,460	MG
= Available Release Quantity Accumulated to Jun 1:	171,710	MG

Available Release Quantity Evenly Distributed to June 1		
Available Release Quantity Accumulated to Jun 1:	171,710	MG
/ Number of Days to Distribute Release Quantity:	292	days
Current PCN Release Target:	588	mgd
Current PCN Release Target:	910	cfs

Reservoir inflow accumulated through Jun 1 is used to calculate NYC Delaware basin reservoirs mass balance

Flexible Flow Management Program (cont.)

NYC Environmental Protection

Current Storage Zone for Schedule Selection

	Usable Storage	Usable Storage + Snow Storage	Zone
PCN	83.7%	*	L2
Pepacton	86.7%	*	L2
Cannonsville	77.4%	*	L2
Neversink	88.3%	*	L2

*Not applicable (snow storage is included in the forecast)

Use Release Target and Storage Zone to Select Release Schedule

	Storage Zone, Summer (cfs)			
	Pepacton	Cannonsville	Neversink	PCN
	L2	L2	L2	L2
Table-4a	100	190	75	380
Table-4b	110	245	80	435
Table-4c	115	300	90	505
Table-4d	125	360	95	580
Table-4e	135	415	100	650
Table-4f	140	460	110	710
Table-4g	150	500	115	765

Selected Schedule:Table(s) 4g

Mass balance is used to determine the release quantity from three NYC reservoirs to the Delaware River Basin

Experience and Lessons learned

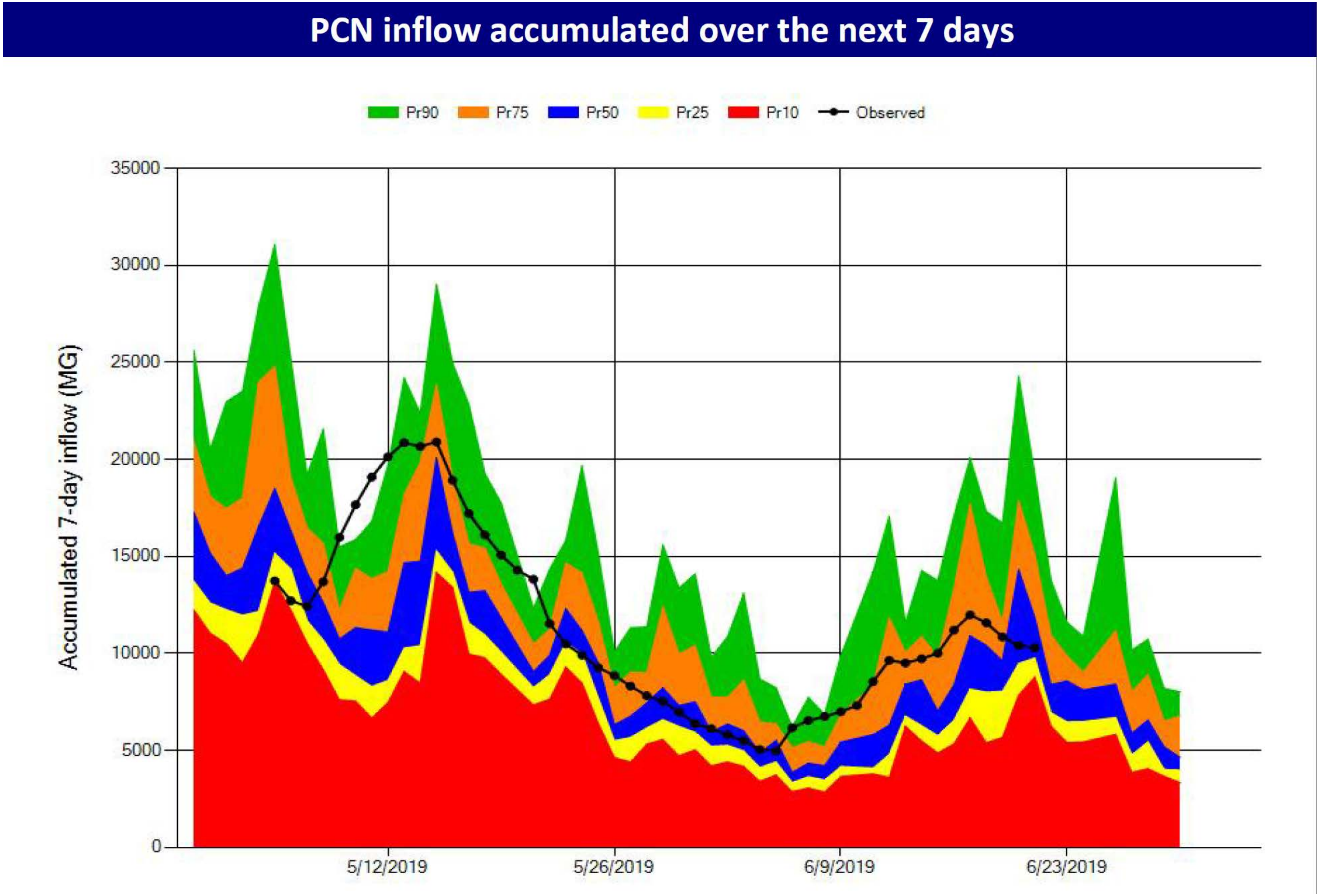
NYC Environmental Protection

Our experience with ensemble forecasts

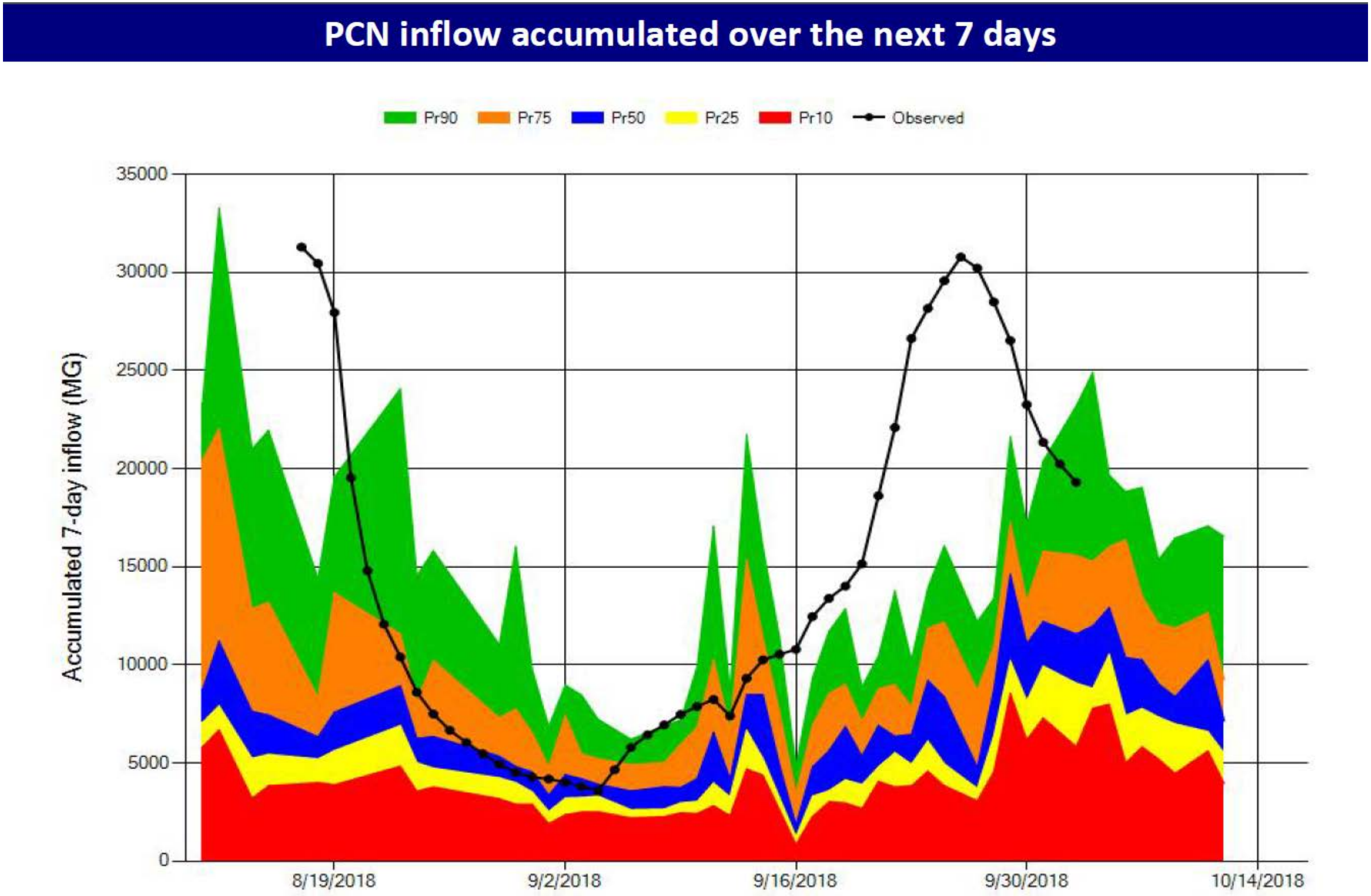
- Led to a shift in the way we operate the system
    - From deterministic to risk-based
- Initially challenging and difficult
    - How to interpret model results
    - How to display model output to better inform operators
    - Need to be pro-active
- It is dynamic process and involves continuous learning
    - Streamflow forecast performance changes frequently

Now that we have started using the new approach, it would be even more difficult to operate our system without it !

Inflow Patterns Change frequently

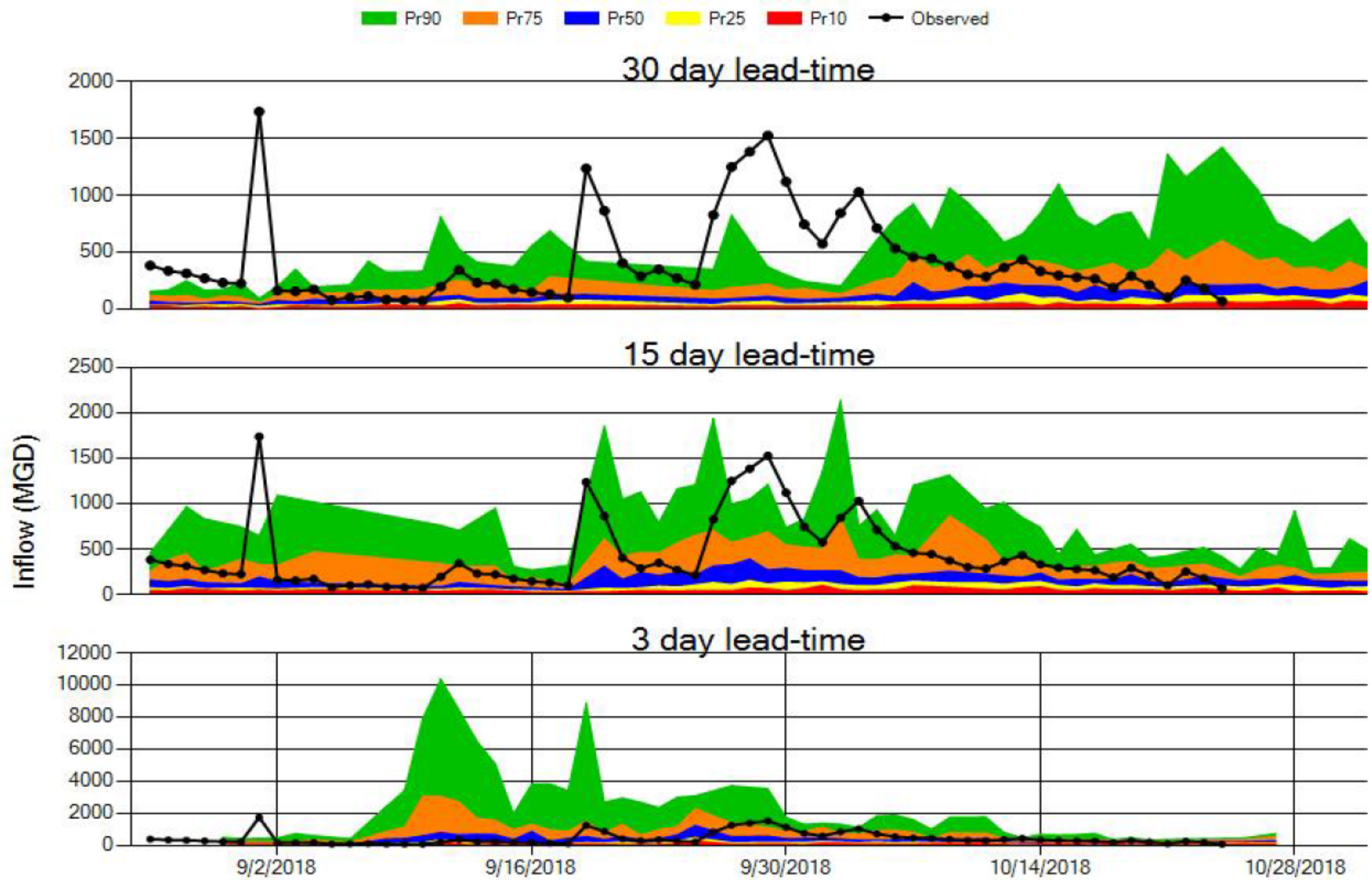


Affecting Forecast Performance

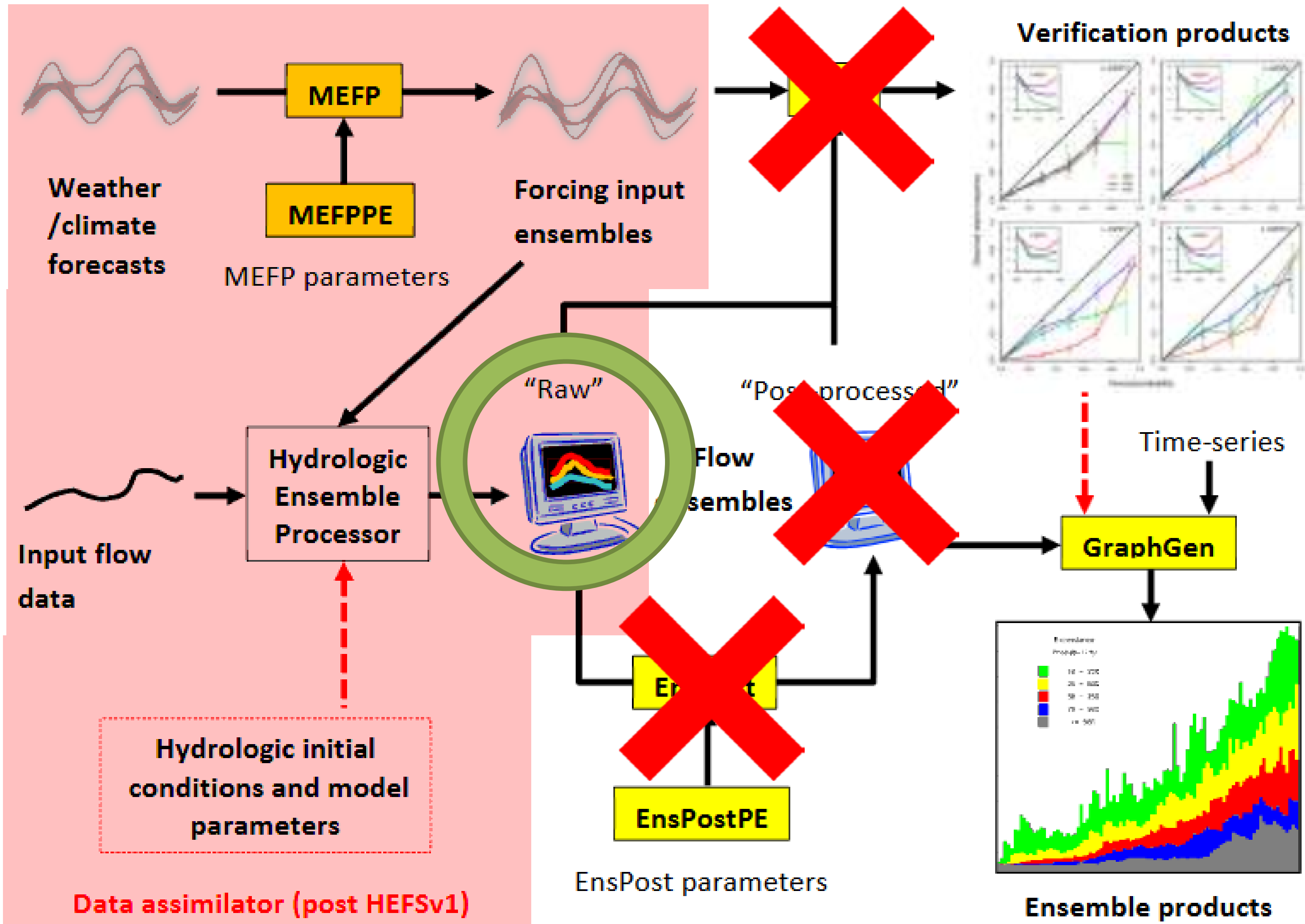


Uncertainty versus Lead Time

Schoharie inflow



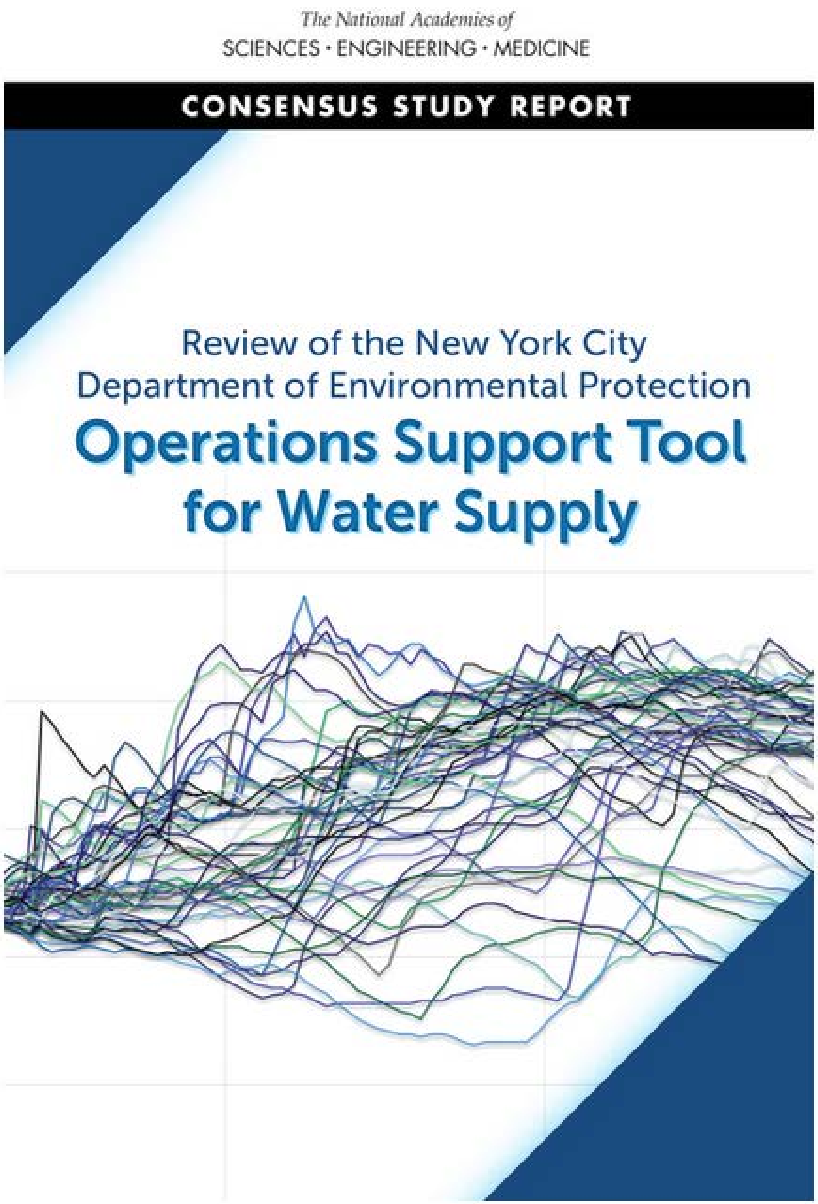
Current NWS Ensemble Product



NYC Forecast Support Needs

- Working with NWS to add EnsPost
  - o For all OST forecast locations
  - o Eliminate resources allocation for maintaining own post-processor
  - o Employ more resources for ensemble diagnostic
    - Develop diagnostic tools
    - Improve our understanding of ensemble forecasts performance
    - Need hindcasts to expand in-house analysis
- Improved forecast performance is very important
  - o Starting with the short-range forecast
  - o Under wet and dry hydrological conditions

OST Review by the NASEM Expert Panel



"One of the most advanced and complex support tools for water supply operations of its kind in the world." (NASEM)

Thank You!