CWMS Implementation
for the Delaware River Basin

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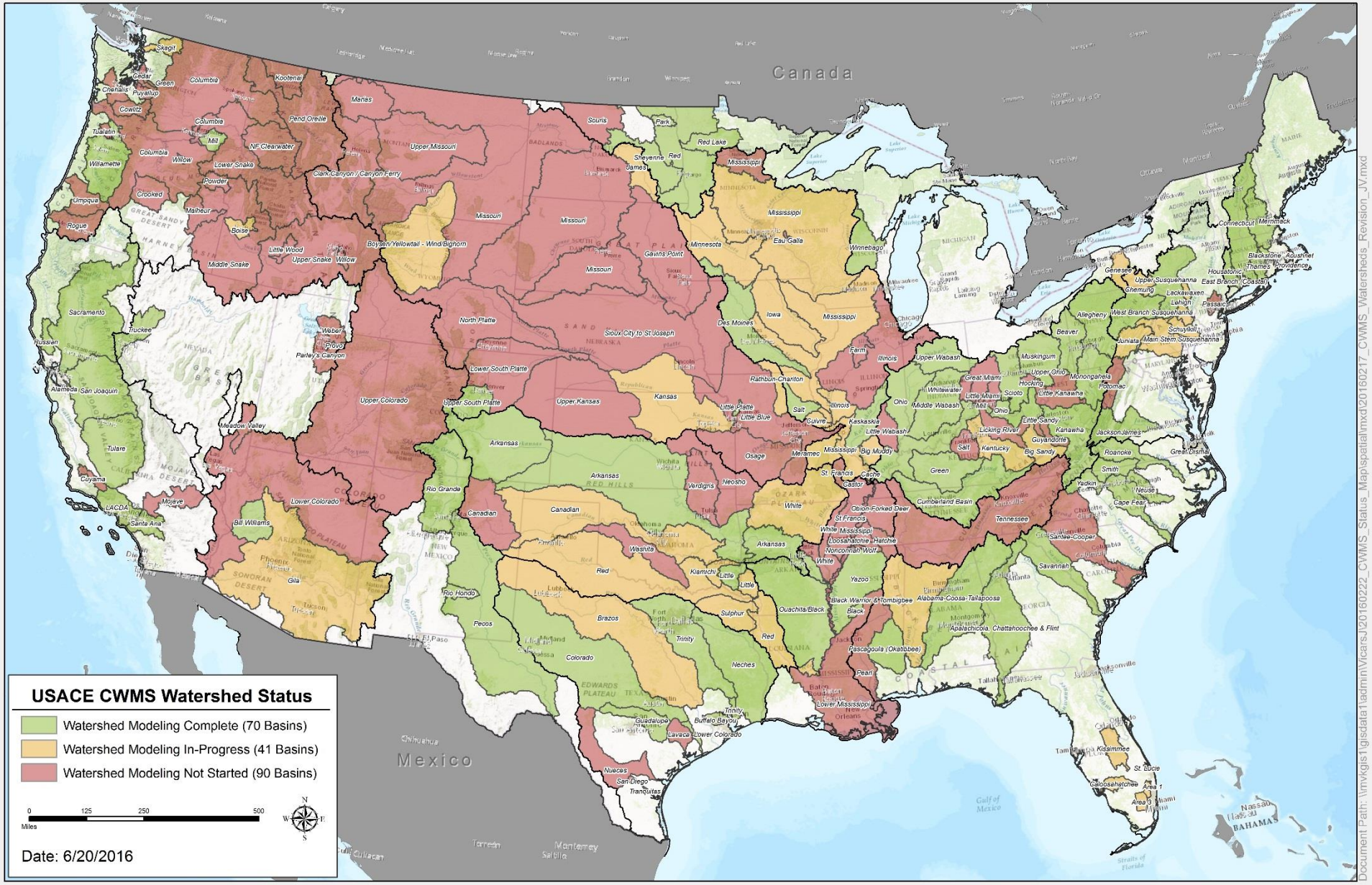
Vision / Goals

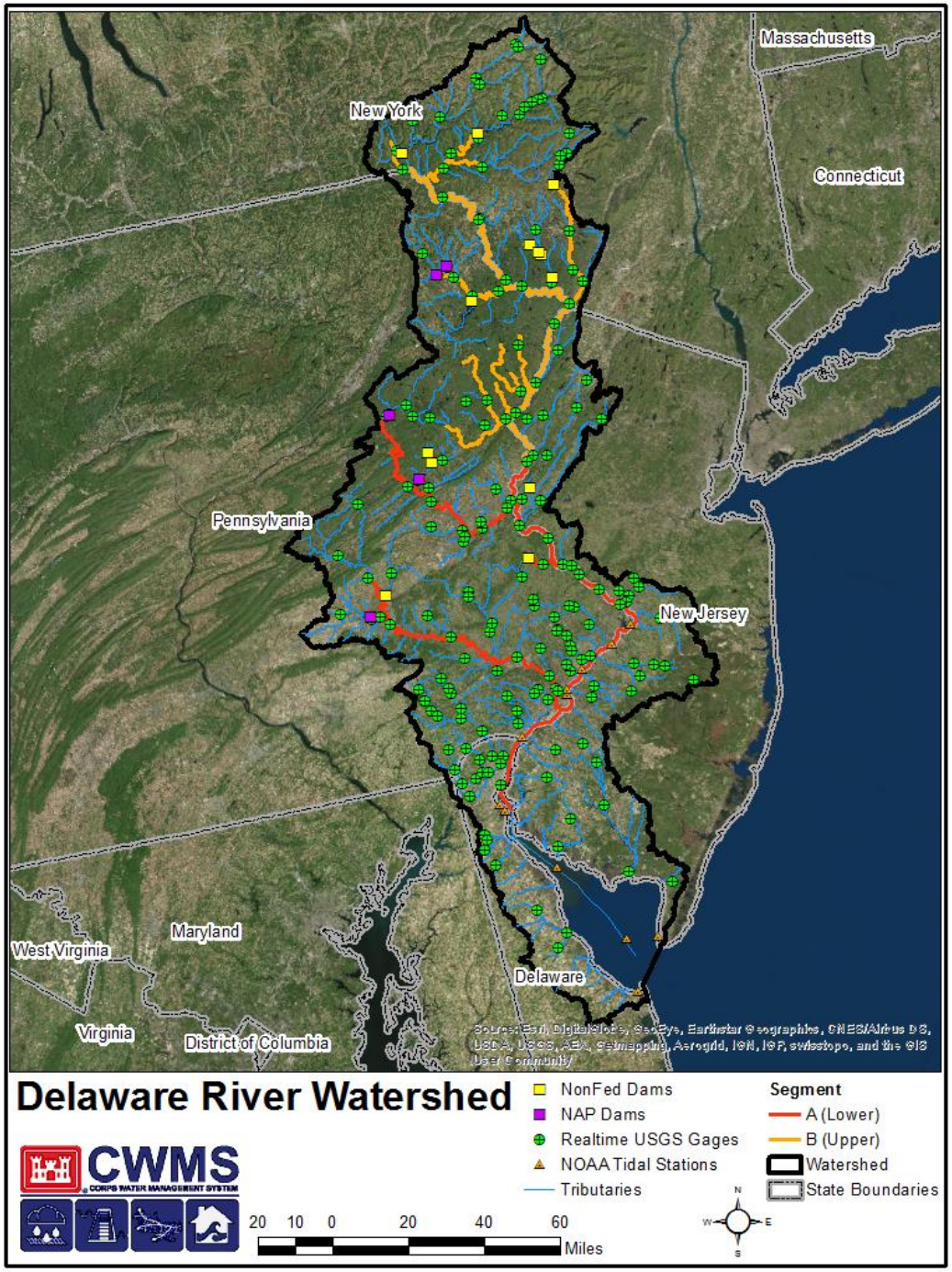
All USACE managed watersheds fully modeled within CWMS with models operated daily to provide decision support to Water Managers and results automatically consolidated to standardized briefing tools within CorpsMap for executive and public use.

CWMS Implementation Status



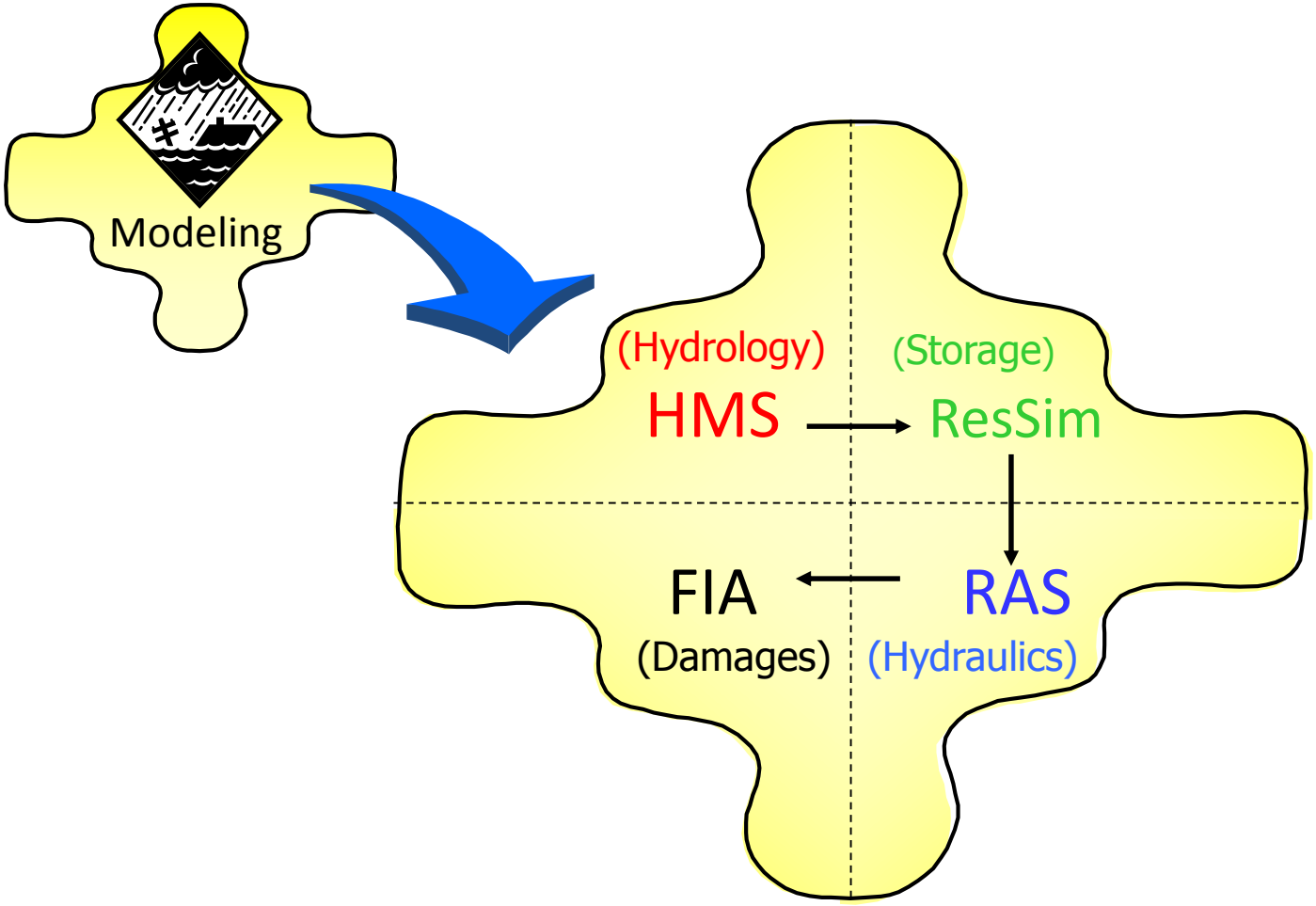
DRB CWMS Objectives

- Estimating stream flows in both controlled and uncontrolled subbasins within the Delaware River watershed during both high and low flow conditions.
- Determining the potential impacts of various release scenarios on reservoir elevation and storage, local flood protection projects and downstream flows, especially in major damage centers.
- Identifying additional opportunities for system-wide operation to take maximum advantage of the existing infrastructure for Delaware River flood risk management
- Identifying additional opportunities to take maximum advantage of existing infrastructure for Delaware River low flow augmentation.



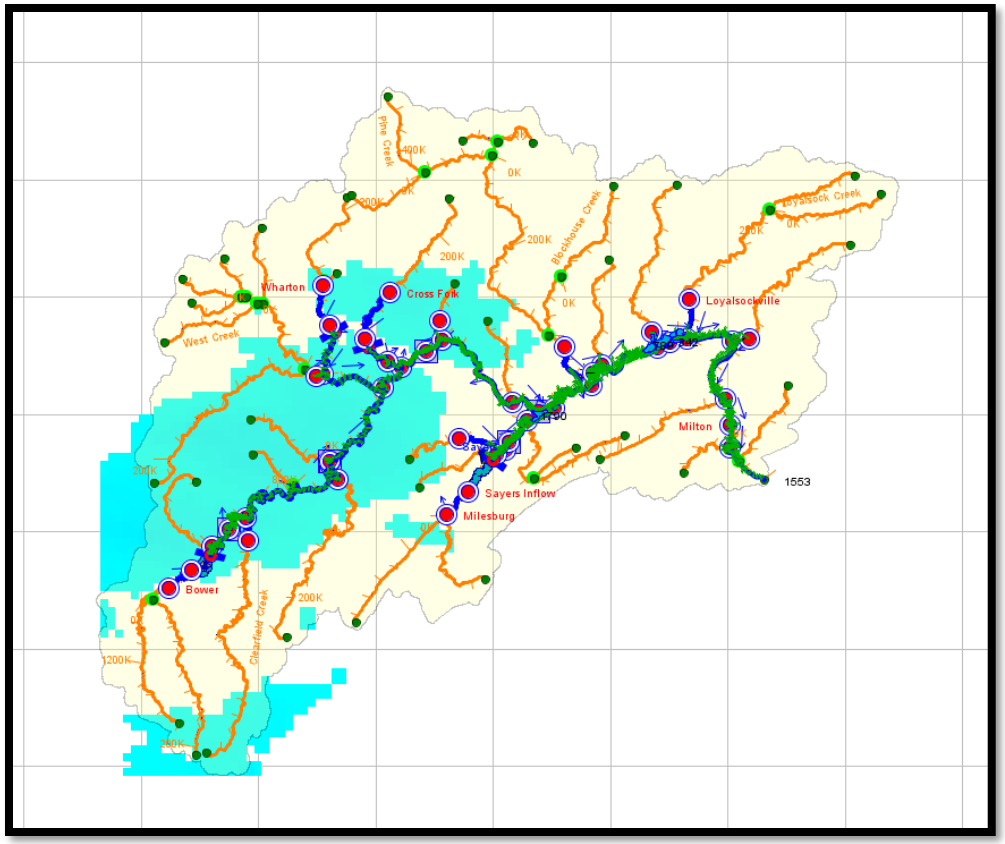
- Real-time data streams integrated into the interface from 200+ USGS gages and 13 NOAA tidal stations.
- Considers the entire 13,539 sq mile watershed
- Calibrate to several high flow events and one low flow event
- Considers all 5 USACE dams and several non-federal dams
- Considers mainstem and major tributaries

Watershed Modeling for Decision Support



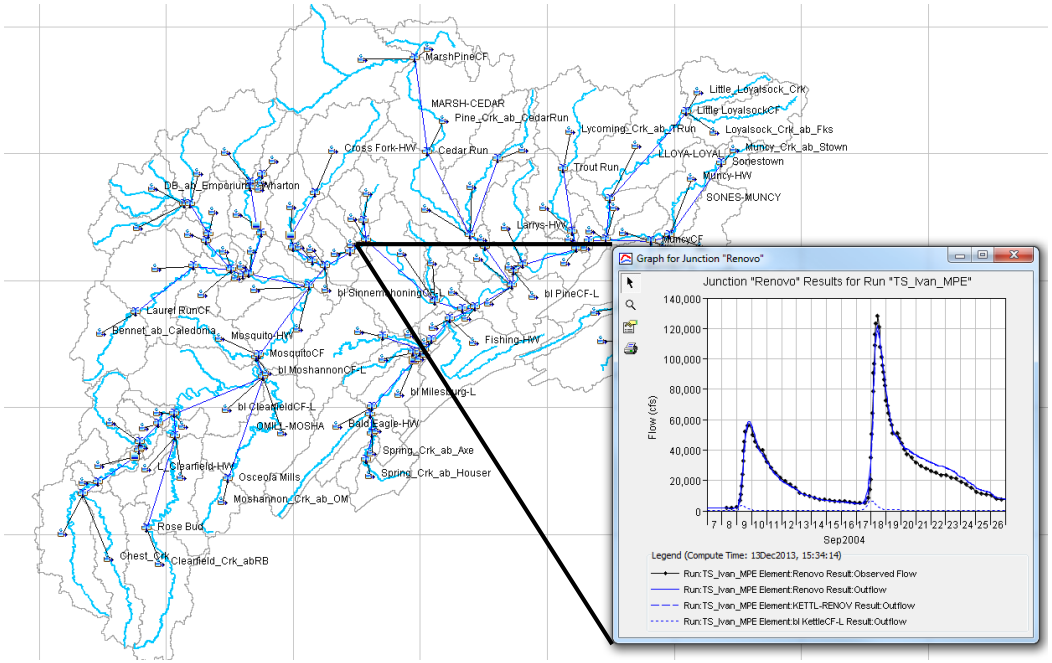
MFP - Precipitation Analysis

Meteorological Forecast Processor



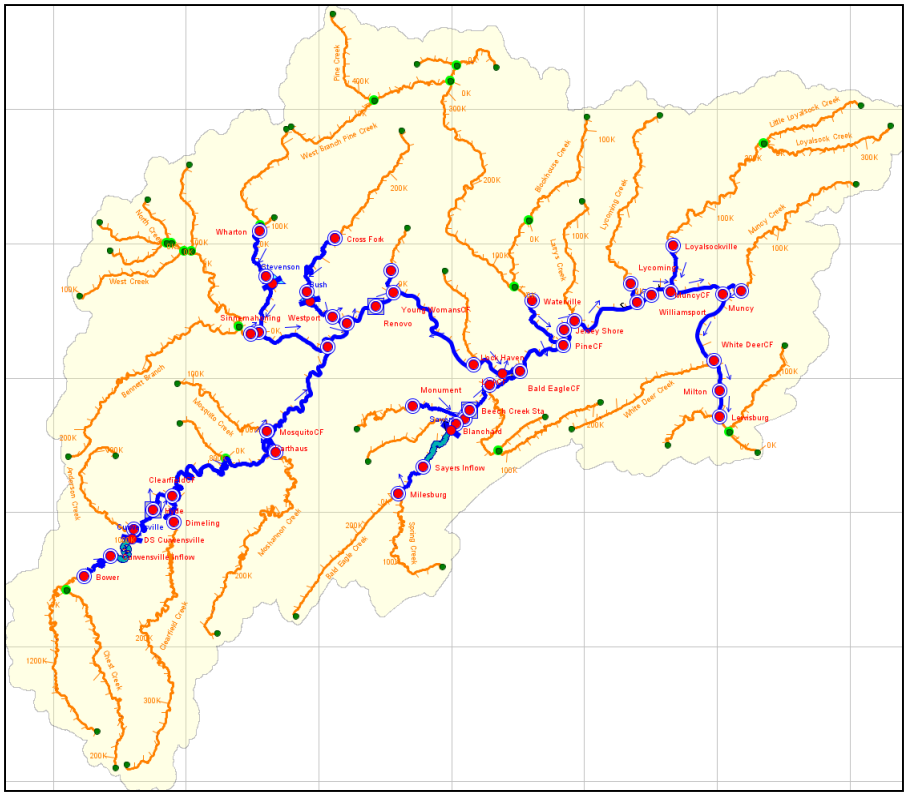
- Precipitation processed on a grid basis.
- Observed data from NEXRAD or interpolated from gages.
- Future Precipitation Scenarios:
  - NWS Quantitative Precipitation Forecasts (QPF)
  - Multiples of the QPF
  - Manual-entry or standard scenarios (What if?)
    - Timing
    - Location (watershed “zones”)

Hydrologic Modeling (HEC-HMS)



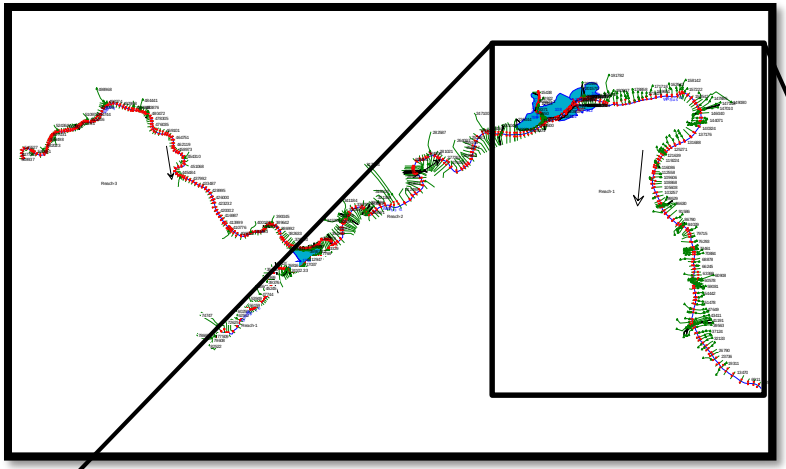
- Computes runoff from observed data and future precipitation scenarios
- Processes:
  - Deficit and Constant or Green Ampt
  - ModClark UH Transform
    - Grid Cell sizes are 2km x 2km
  - Recession Baseflow
  - Channel Routing
    - Muskingum-Cunge
    - Muskingum
    - Modified Puls
- Include entire 13,539 sq miles
- Calibrate/validate to several historic events

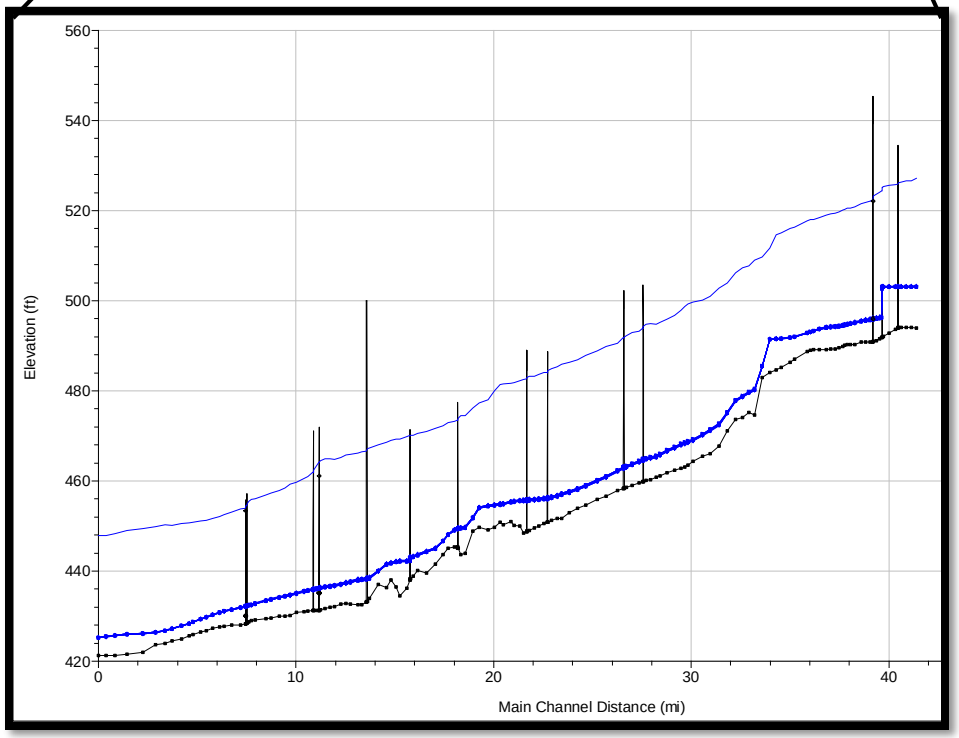
Reservoir Operations with HEC-ResSim



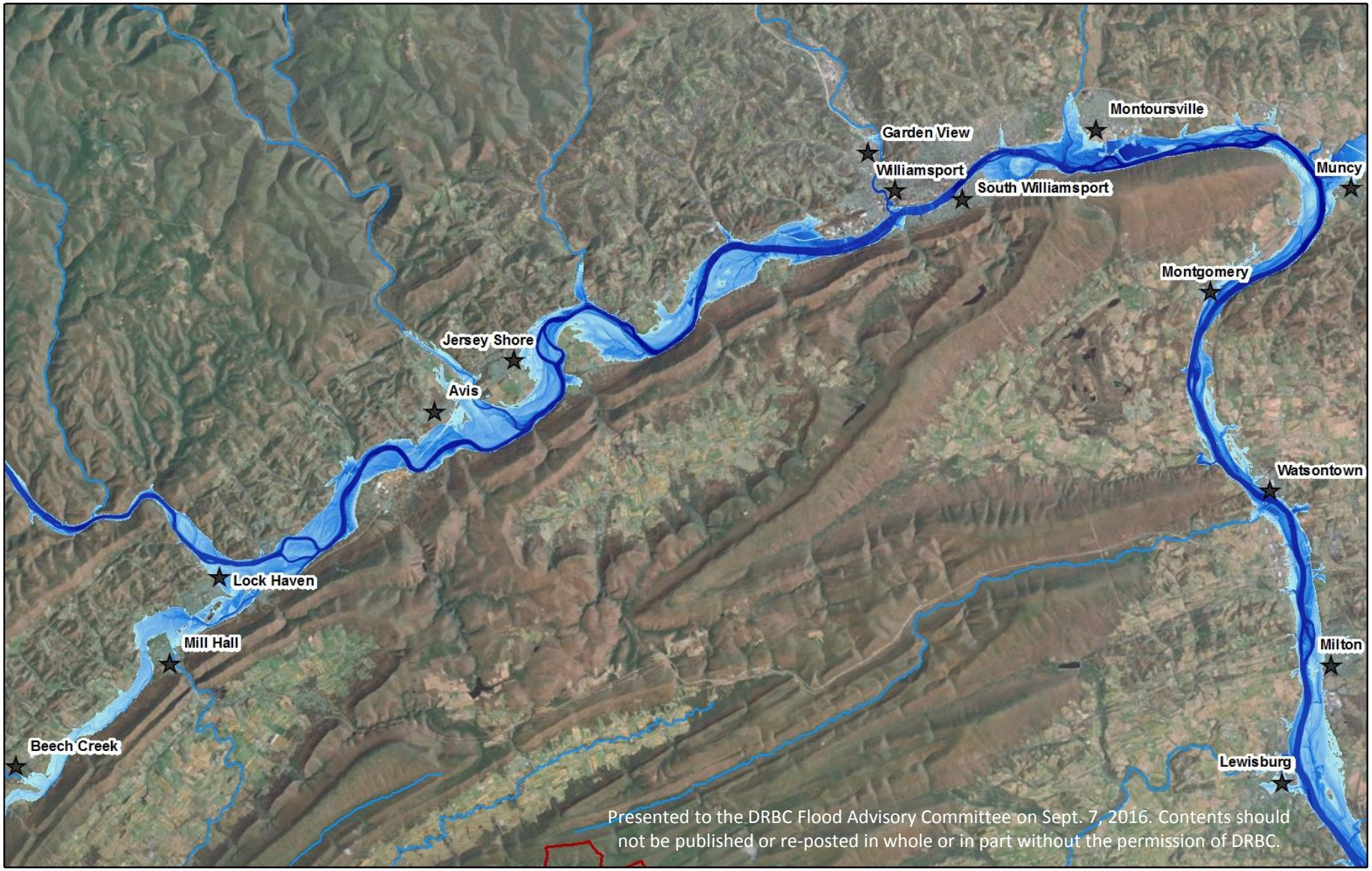
- Simulates operations through user-defined operating rules and scheduled releases
- Uses reservoir inflow and downstream local hydrographs computed by HEC-HMS
- Automatically generates downstream hydrographs for a “no reservoir” condition for project benefit analysis
- Includes 5 USACE dams plus Cannonsville, Pepacton, Neversink, Lake Wallenpaupack, Rio, Toronto, Swinging Bridge, Cliff Lake, Merrill Creek, Nockamixon, Penn Forest, Wild Creek, and Lake Ontelaunee.
- Calibrate/validate to historic events

River Hydraulics (HEC-RAS)





- Analyzes river hydraulics to compute water depth, velocity, & inundation boundaries
- Computes water surface profiles and stage hydrographs from ResSim and/or HMS hydrographs
- Steady-flow or unsteady-flow analysis
- Inundation boundaries and depth grids computed in RAS Mapper / GeoRAS
- Extends from Reedy Point, DE to Pepacton and Cannonsville Dams
- Major tribs include Schuylkill, Lehigh, and Lackawaxen Rivers
- 750 river miles to be modelled
- Calibrate/Validate historic events



West Branch Susquehanna River Watershed

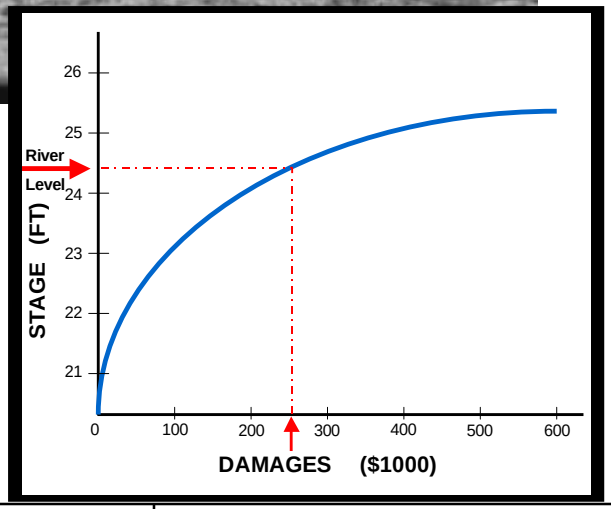
CWMS
CORPS WATER MANAGEMENT SYSTEM

0 2 4
Miles

N
W E
S

Watershed
West Branch Susquehanna River Centerline
Tributary Centerline
Towns

TS Agnes Full Model Depth Value
High : 38.76 ft
Low : 0 ft



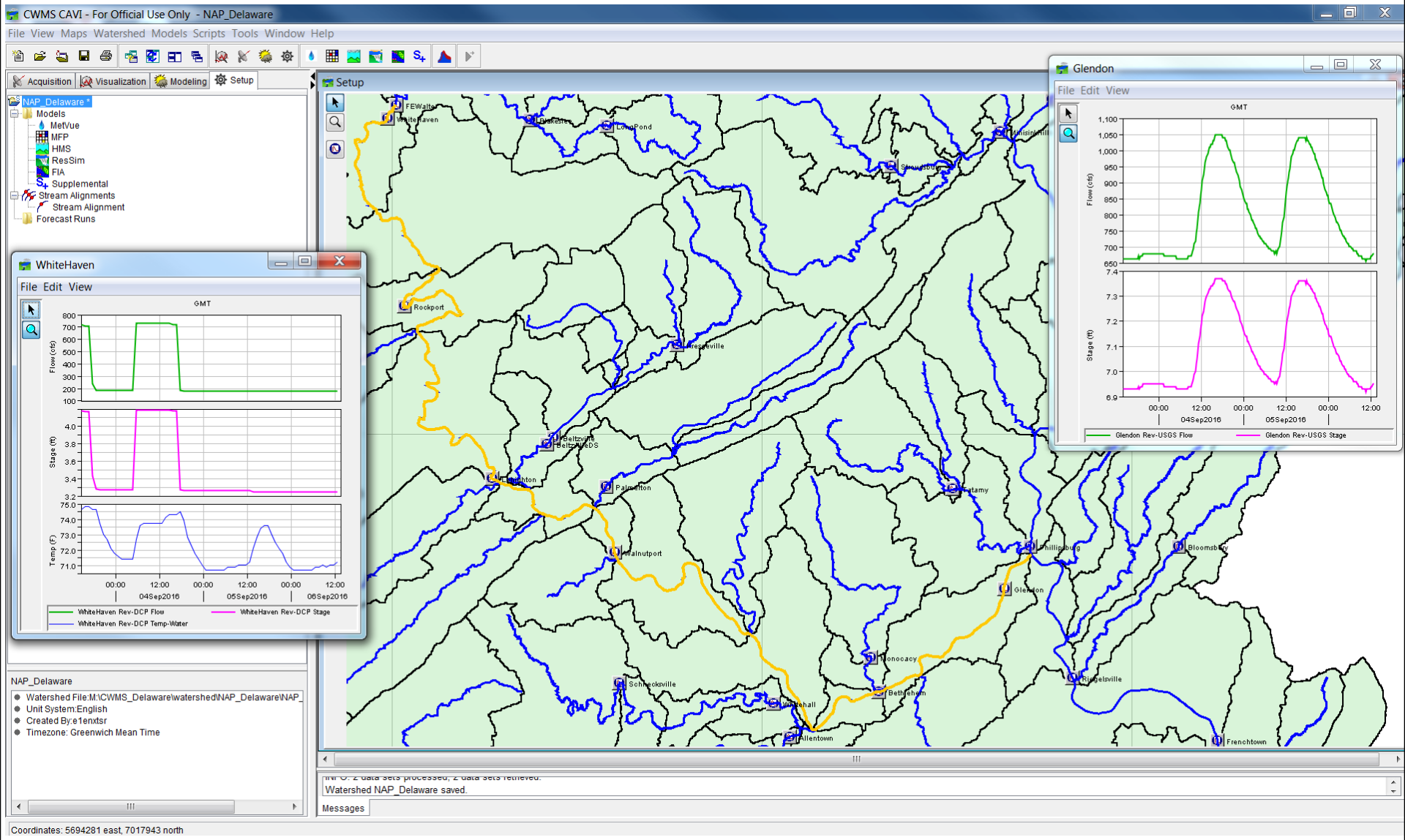
Economic / Impact Analysis (HEC-FIA)

- Computes agricultural and urban damages and project benefits by "impact area"
- Computes damages and benefits between different scenarios, and with and without project conditions
- "Action tables" provide a list and time of actions to take during an event, based on forecasted stages
- Updates to stage damage relations for Delaware River Basin damage centers

Impact Action Table

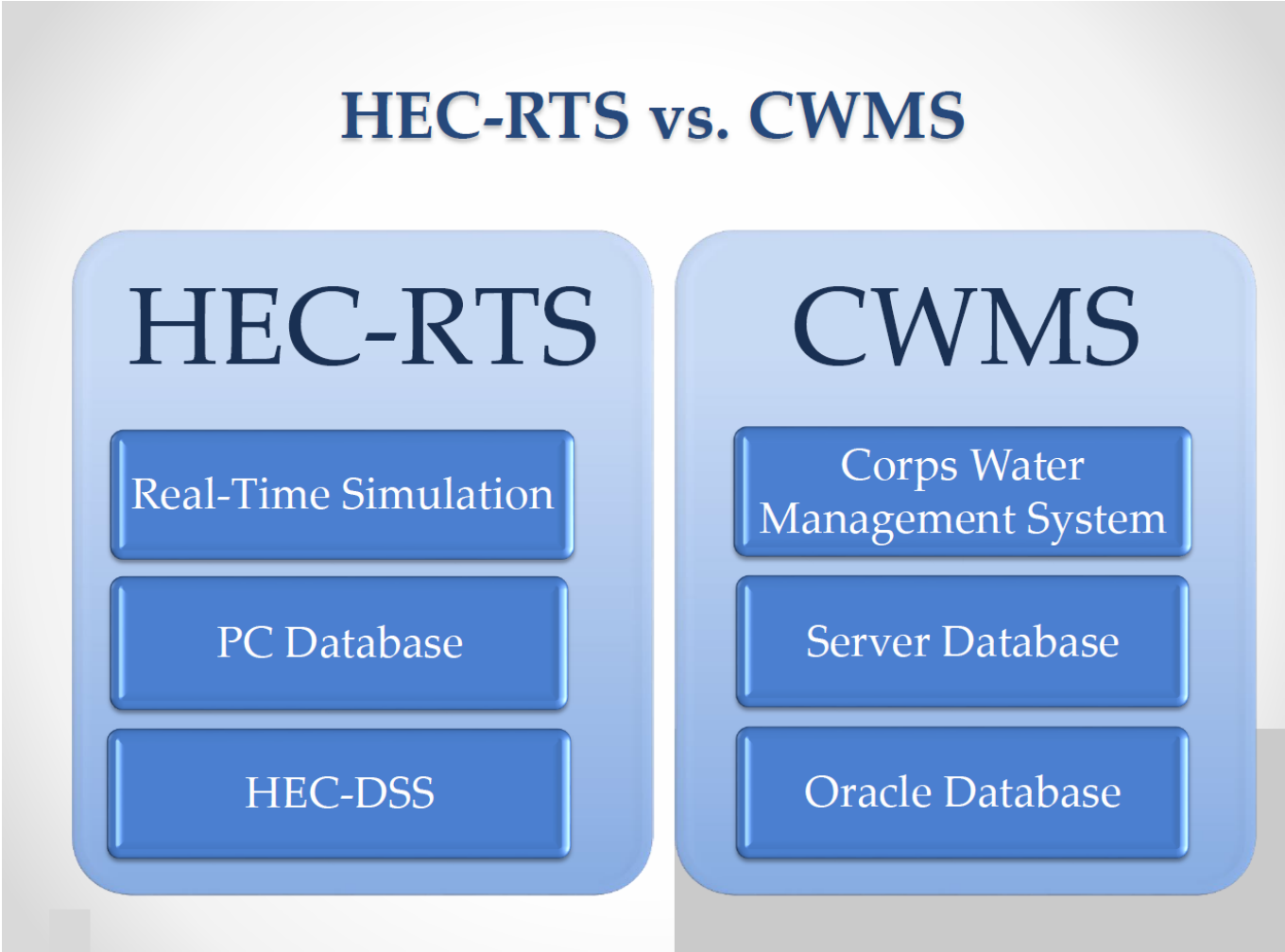
Impact Area	Stage (ft)	Impact	Action	Time	
				Initial Forecast	Modified Releases
Cottage Area	556.0	Flood Warning Stage	Initiate reconnaissance and alert appropriate p	22Mar2002 0600	22Mar2002 0600
	558.0	Flood Stage	Full alert, warn of potential evacuation.	22Mar2002 0700	22Mar2002 0700
	560.0	Damage to infrastructure, landscape, etc.	Close life lines & roads to everyone but local tr	22Mar2002 0900	22Mar2002 0900
	561.0	Egress begins to be a problem.	Evacuate residences & perform surveillance.	22Mar2002 1000	22Mar2002 1000
				Max Flood Stage - 25Mar2002, 07:00 562.63 ft	Max Flood Stage - 25Mar2002, 07:00 562.63 ft
Lock Haven	535.2	Zero stage reading		19Mar2002 1000	19Mar2002 1300
	540.1	Flap gates of interior drains under water	Check drains to ensure operation	21Mar2002 2300	21Mar2002 2300
	543.2	Elevation of Grant Street Dam		22Mar2002 0100	22Mar2002 0100
	545.0	Handrails at Summer Beach nearing inun	Remove handrails & close Grant Street Dam p	22Mar2002 0200	22Mar2002 0200
	549.0	Grant Street Dam platform elevation		22Mar2002 0400	22Mar2002 0400
	553.0	Flood Warning Stage	Begin levee patrol	22Mar2002 0600	22Mar2002 0500
	556.2	Flood Stage	River overtops bank	22Mar2002 0900	22Mar2002 0700
	556.3	Bath house floor elevation	Close bath house	22Mar2002 0900	22Mar2002 0700
	557.2		Prepare to close Closure Structure No. 3	22Mar2002 1000	22Mar2002 0700
	559.1		Close Closure Structure No. 3	22Mar2002 0800	22Mar2002 0800
	559.2		Prepare to close Closure Structure No. 2, notif	22Mar2002 0800	22Mar2002 0800
	561.0		Close Closure Structure No. 2	22Mar2002 1000	22Mar2002 1000
				Max Flood Stage - 25Mar2002, 07:00 562.07 ft	Max Flood Stage - 25Mar2002, 07:00 562.07 ft
Sayers Lake Area	586.0	Streambed	None	19Mar2002 1300	19Mar2002 1300
	590.0	Gate Sill	None	19Mar2002 1300	19Mar2002 1300
	610.0	Late Winter Conservation Pool	None	19Mar2002 1300	19Mar2002 1300
	625.0	Mid winter Conservation Pool	None	22Mar2002 1000	22Mar2002 1000
	630.0	Summer Recreation Pool	None	22Mar2002 1600	22Mar2002 1600
	631.0	Marina and Launch Ramps	Lift gangplanks connecting marina and launch	22Mar2002 1800	22Mar2002 1800
	633.0	Marina and Launch Ramps	None	22Mar2002 2200	22Mar2002 2200
	634.5	Entrance to Parking @ Winter Lot	Close road to winter parking lot	23Mar2002 0200	23Mar2002 0300
	635.0	Invert, Howard flap gates for interior drain	Begin monitoring Howard interior drainage area	23Mar2002 0400	23Mar2002 0500
	636.0	Top Well # 3 Pump Station at Green Brid	Close road to pump station at Green Bridge	23Mar2002 0900	23Mar2002 1400
	636.1	Low Pt. Sycamore Loop Road	Close Sycamore Loop Road	23Mar2002 1000	23Mar2002 1500
	636.6	Low Pt. Winter Boat Storage Area	Move boats from winter storage area	23Mar2002 1400	
	637	Floor of Restroom-W Hunter Run Launch	Close restroom at Hunter Run	23Mar2002 1700	
	637.4	Low Pt. Road at Hunter Run Launch	Close road below Hunter Run parking lot	23Mar2002 2200	
	637.5	Parking Lot Entrance @ Bald Eagle Laun	Close road to Bald Eagle launch area	24Mar2002 0000	
	637.7	Entrance to Main Marina	Close main marina	24Mar2002 0300	
				Max Flood Stage - 25Mar2002, 07:00 647.86 ft	Max Flood Stage - 25Mar2002, 07:00 636.41 ft

CAVI – Control and Visualization Interface



RTS – Real Time Simulation

Publicly Available



Path Forward

- Currently at the 25% milestone for the CWMS implementation for the Delaware River Basin
- CWMS scheduled to be complete by Summer 2017
- The RTS version of CWMS would follow