Hazen

Updating the Regional Drought Management Plan



Duck River Symposium
December 6, 2023

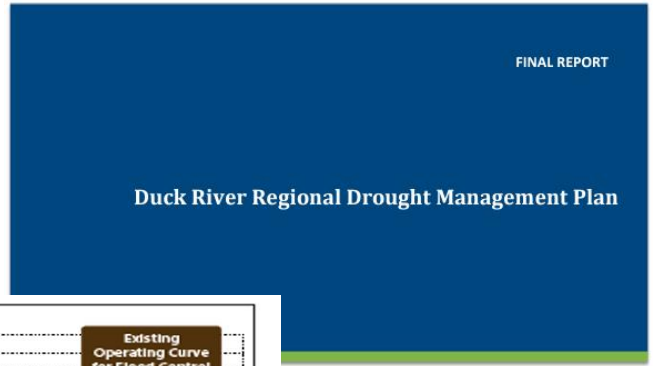
Casey Caldwell
Steve Nebiker

Overview

- DMP history and motivations for update
- Goals for an updated DMP
- Potential updates to DMP
- Case studies

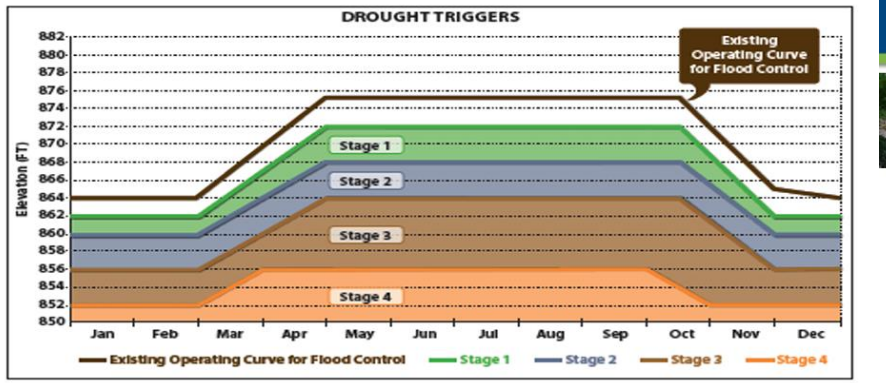
Regional Drought Management Plan (DMP) History

- Development started after the 2007 drought
- Aim to prevent the need for ad-hoc actions during a drought
- Released in 2013
- Triggers based on Normandy Storage
- Reductions in Shelbyville target and basin withdrawals in Stages 3 & 4



Tennessee Duck River Development Agency

April 20, 2013



DROUGHT TRIGGERS

STAGE 1	STAGE 2	STAGE 3	STAGE 4
Drought Monitoring	Drought Alert	Drought Warning	Drought Emergency
- Initiate Drought Monitoring	- Alert Drought Committee - Initiate Public Awareness	- 10 cfs / week reduction of Shelbyville target (down to 120 cfs) - 10% reduction of public water use	- 10 cfs / week reduction of Shelbyville target (down to 80 cfs) - 20% reduction of public water use

- Impose 28 day waiting period between stages
- Move out of stage if above trigger for at least 7 days

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Motivations for updating the DMP

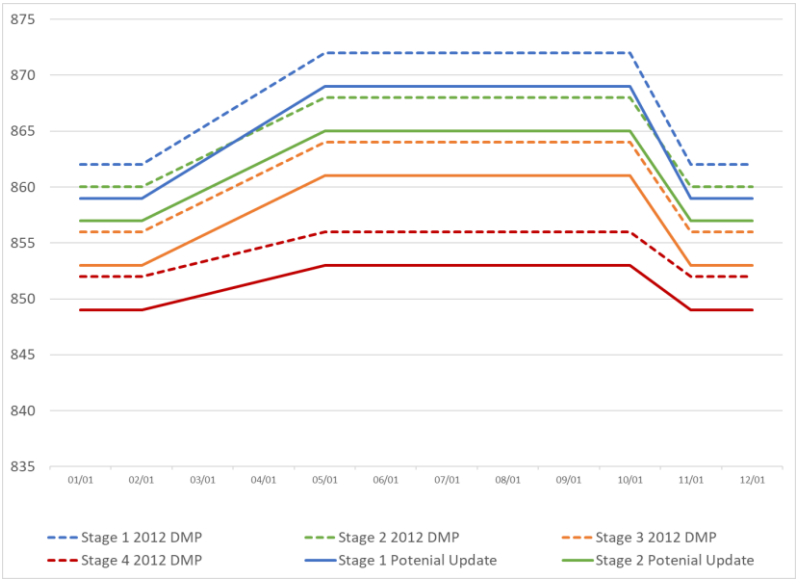
- Population growth in the basin
- New and proposed withdrawal permits in the basin
- Feedback from stakeholders and advisory/regulatory agencies
- New data and tools available
  - **Mussel studies**
  - **USGS ecological flows analyses for fish response**
  - **Updated demand growth projections**
  - **Climate change projections for hydrology**
- Potential to utilize more of Normandy storage during extreme droughts
  - **Improvements to intake and pumps**

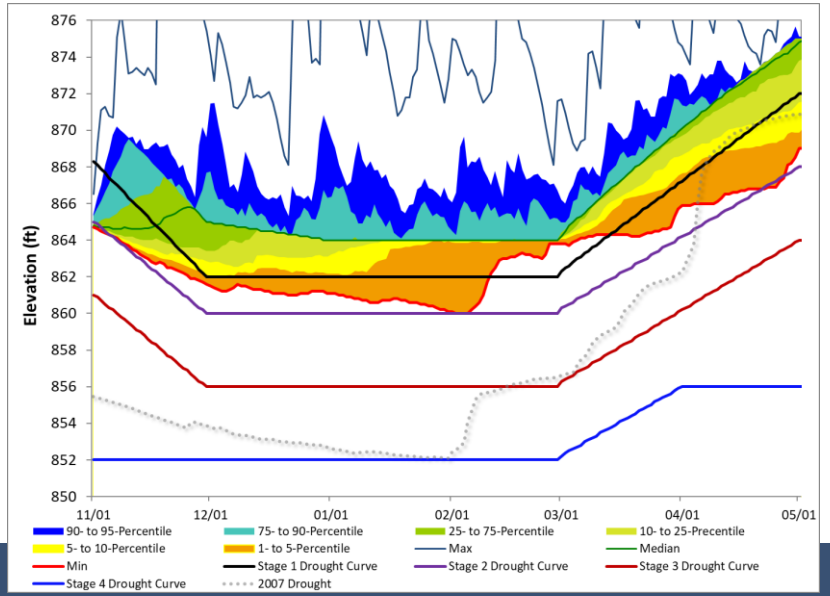
Goals of an updated DMP

- Early stakeholder feedback in development process
- Reduced frequency and magnitude of Shelbyville target cutbacks
- Balancing impacts on Normandy Reservoir, Upper Basin, and Lower Basin

Potential DMP updates

- Keep the rule-curve based drought triggers, but adjust levels (i.e., lower)
- Switch to forecast-based triggers
  - **Use ensemble streamflow forecasts to compute the probability of Normandy hitting specified levels**

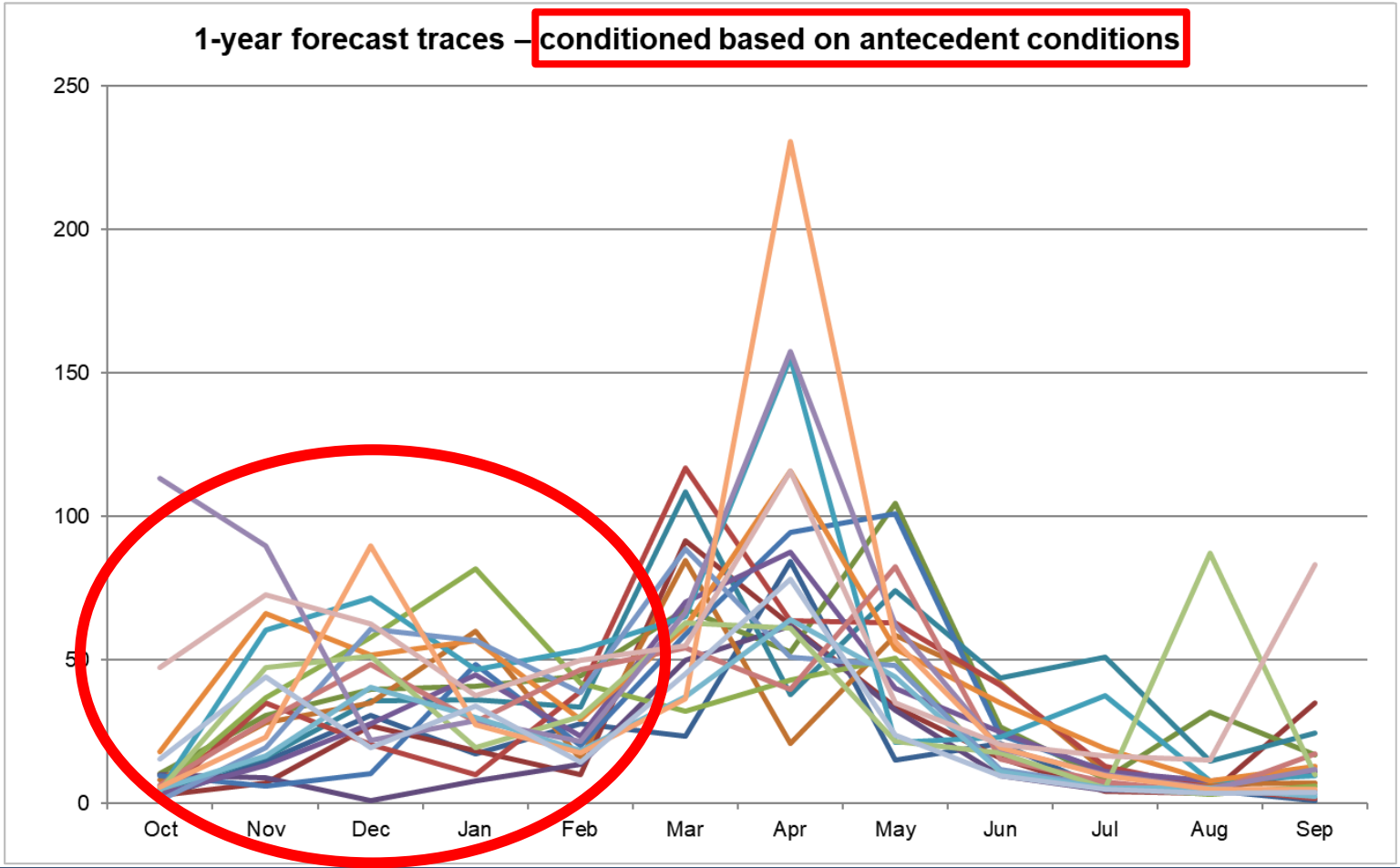




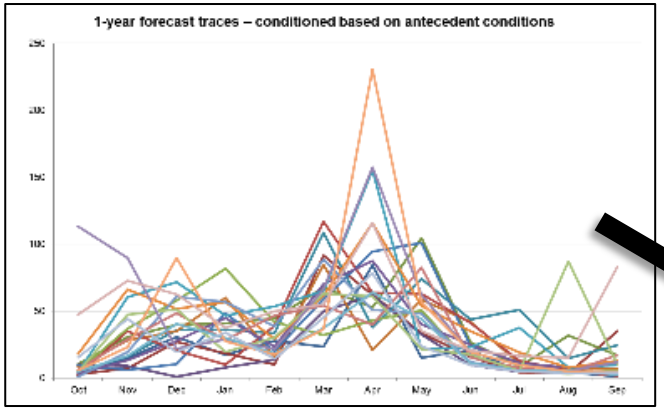
Trigger type pros/cons

Rule-curve based		Forecast / Probability based	
Pros	**Cons**	**Pros**	**Cons**
Ease of Communication	Does not respond to changing hydrology	Adjusts to how wet or dry the basin is that year	Communication of triggers / drought status
Simple to quantify performance	“False alerts” for years that do not end up severe	Potential to avoid “false alerts”	Requires running a model (already do under the current DMP)
	Could act too late during severe droughts	Potential to act more aggressively during a severe drought	

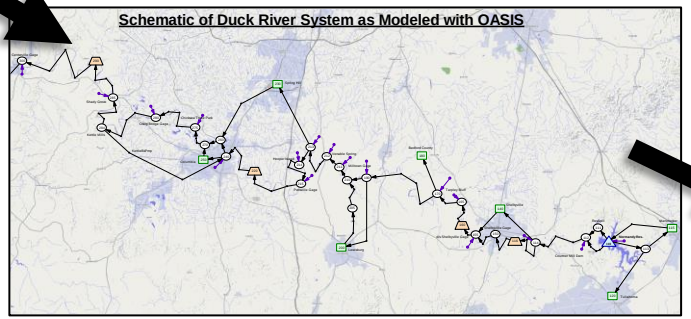
Forecast Informed Operations using Ensemble Inflow Forecasts



Ensemble Inflow Forecasts are used to Forecast Projected Storages/Flows

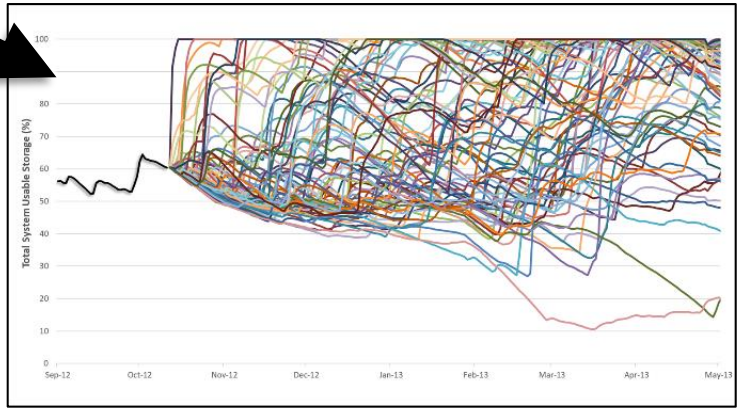


Ensemble of inflow traces for given forecast date

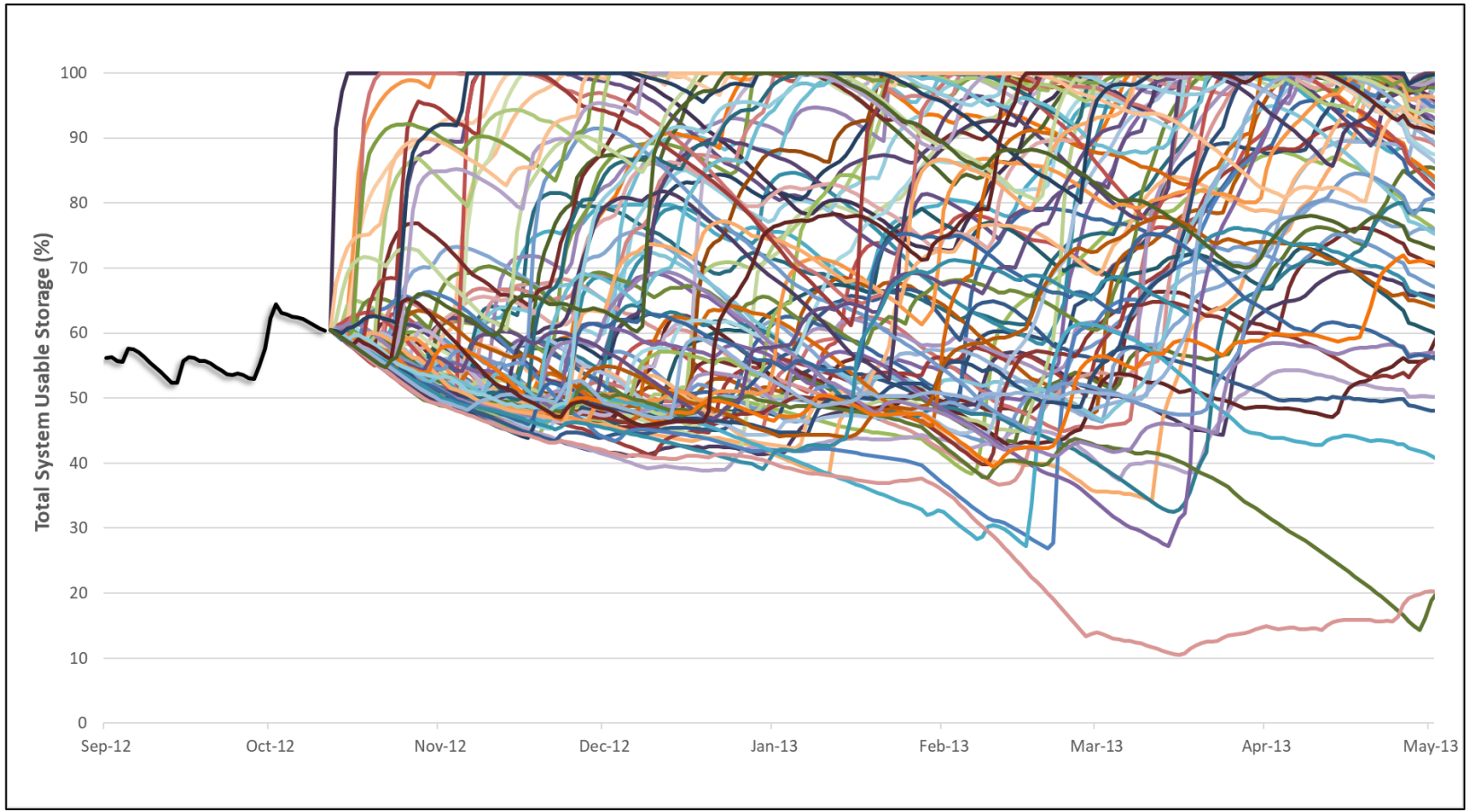


Run inflow traces through model starting on forecast date with actual reservoir levels

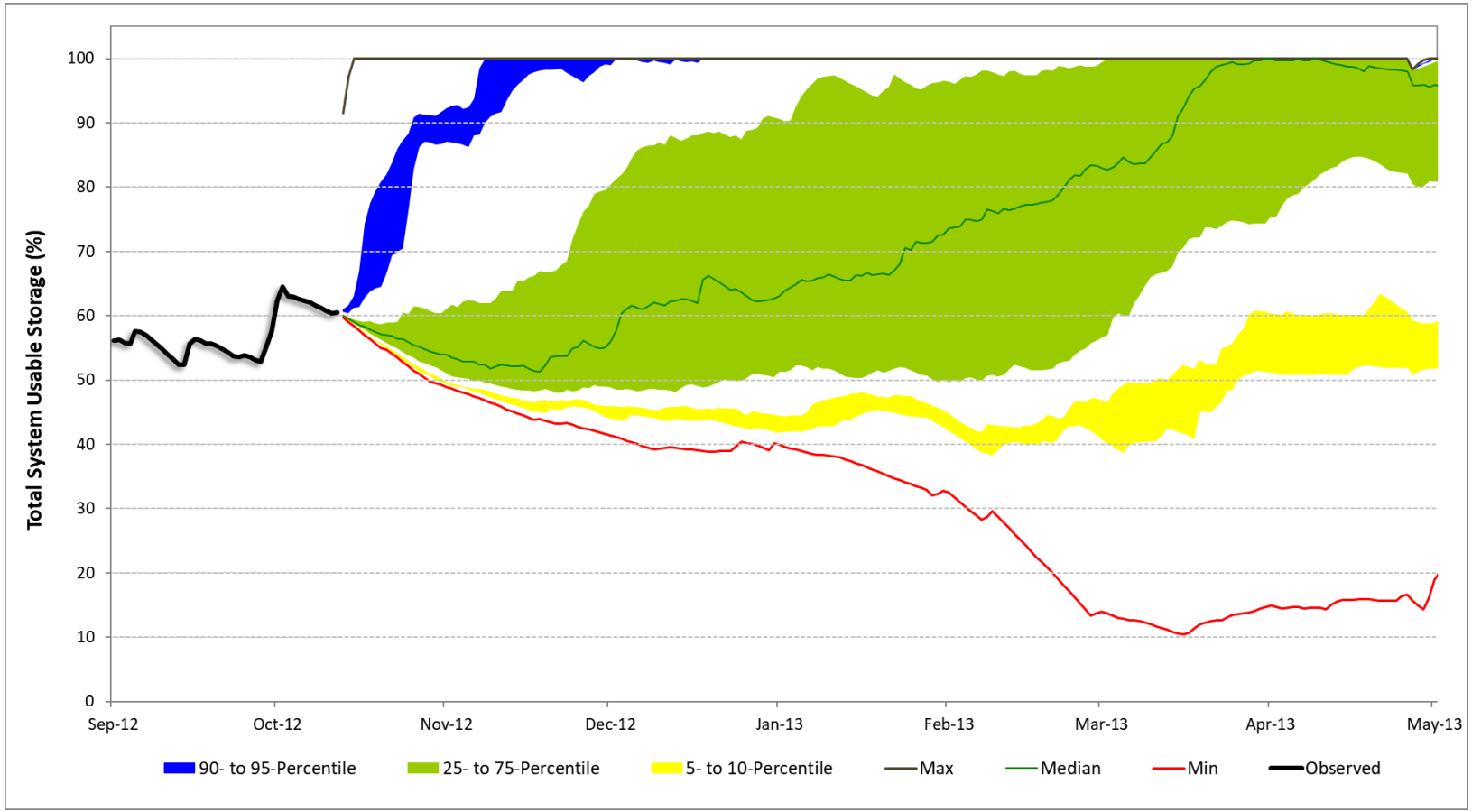
Model produces ensemble of projected reservoir storage (and other system metrics)



Sample storage forecast

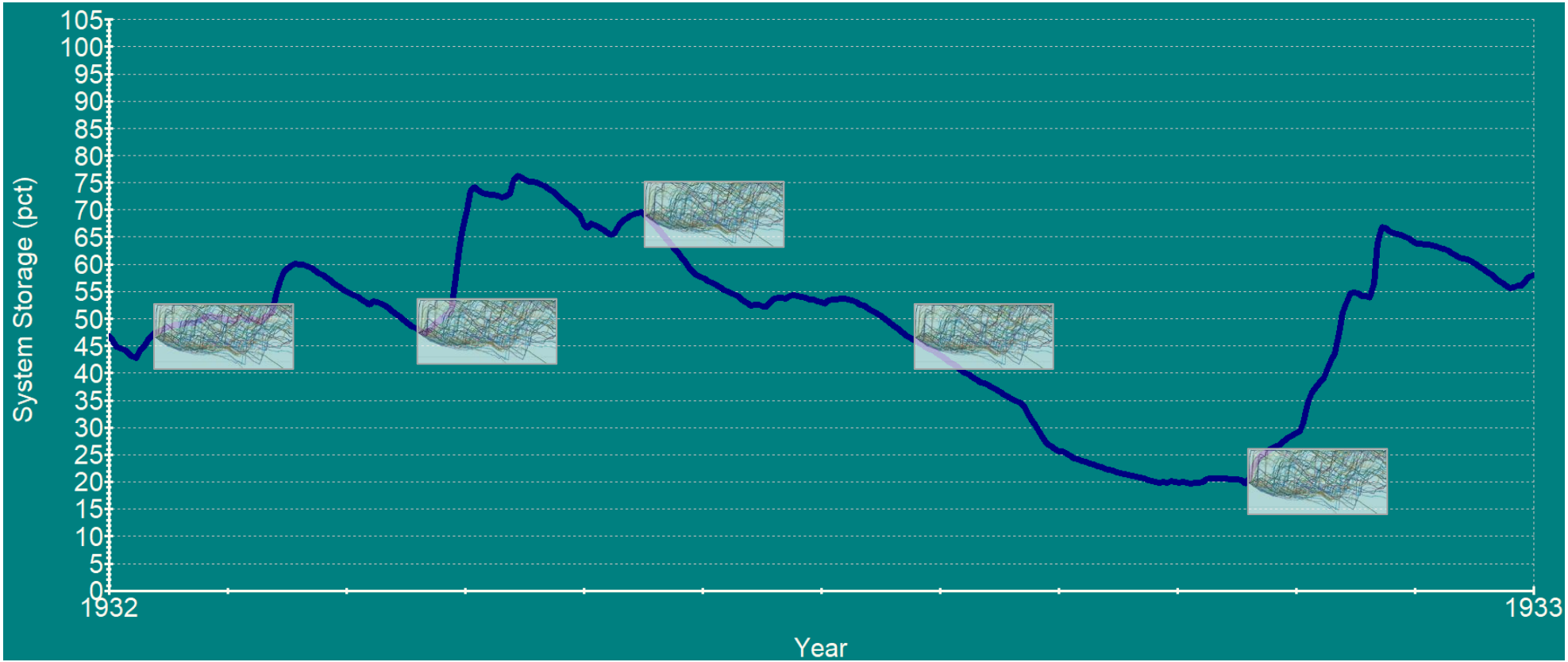


Sample Storage Forecast:
Display ensemble as percentiles for interpretation

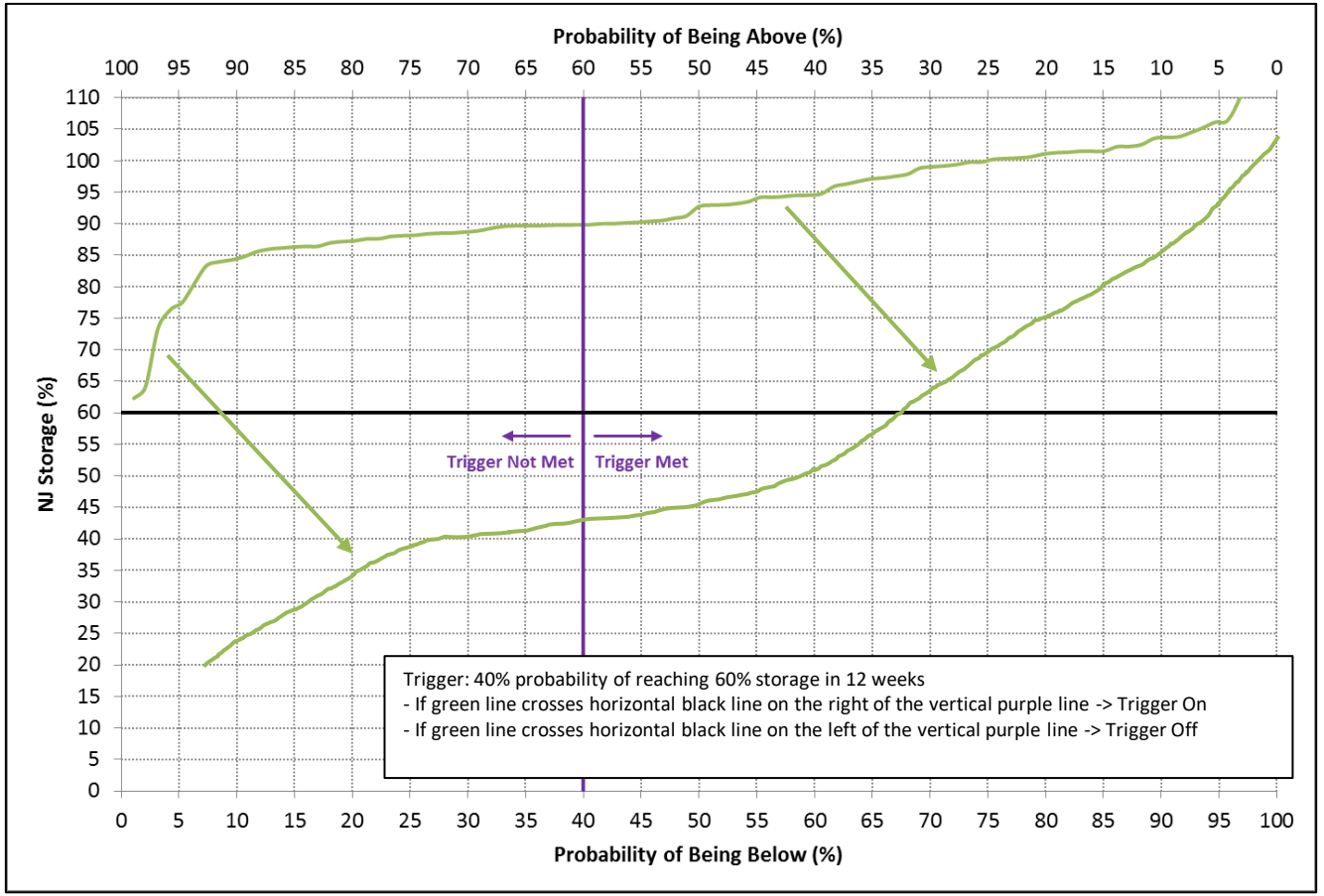


Developing Drought Operating Rules Based on Ensemble Forecasts

- Rule form: take action if there is > *X*% chance dropping below *Y*% storage in *Z* weeks
- Use hindcasts in simulation mode to test rules



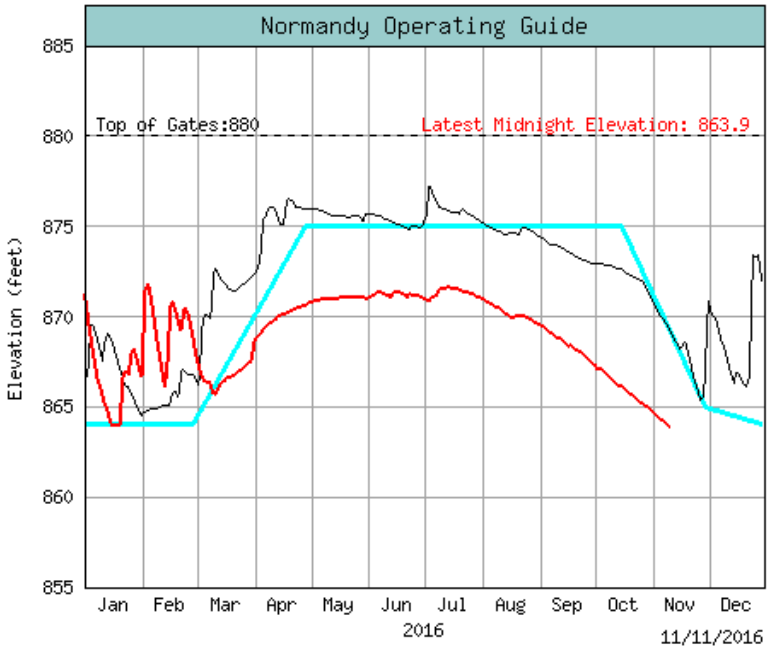
Dynamic Rules Based on the Forecasts

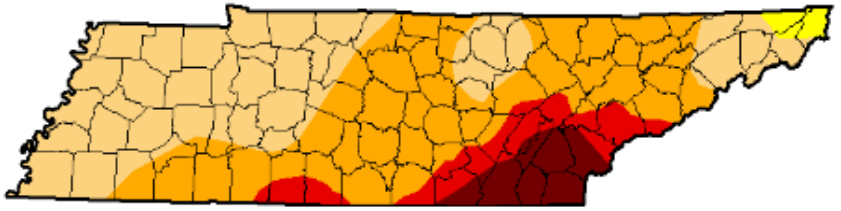


Forecast examples / case studies

- Recap of 2016 Duck forecast
- Asheville, NC
- Smith Mountain (Roanoke River) in Virginia
- Interstate Commission on the Potomac River Basin

2016 Drought

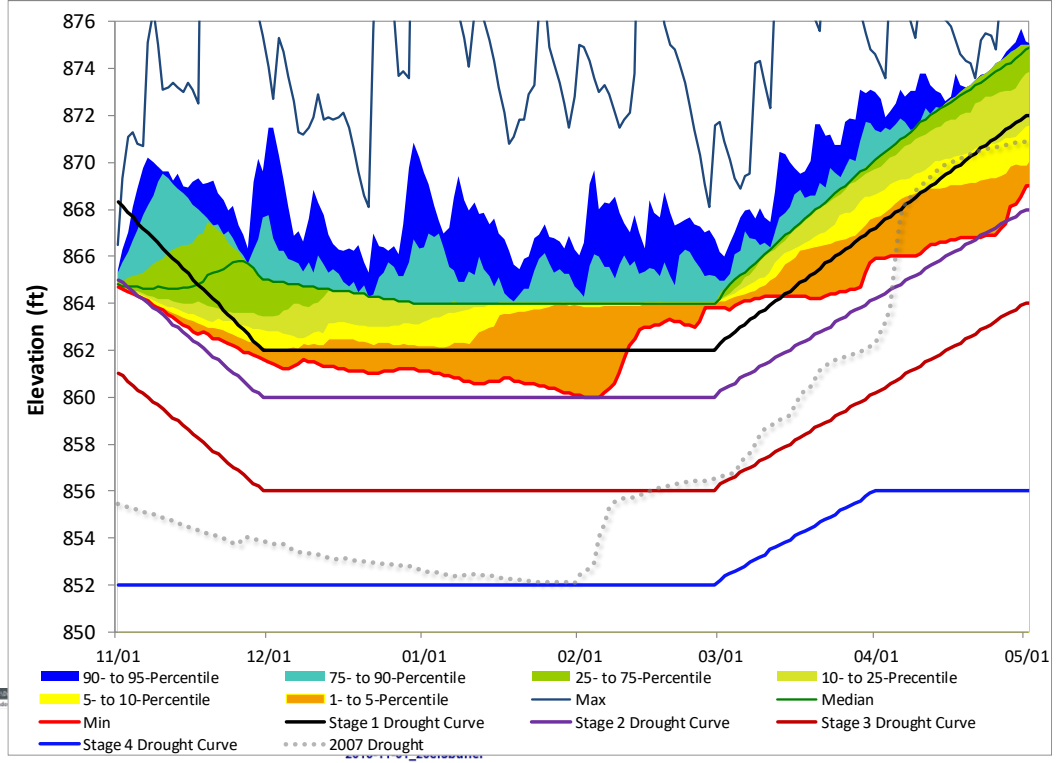


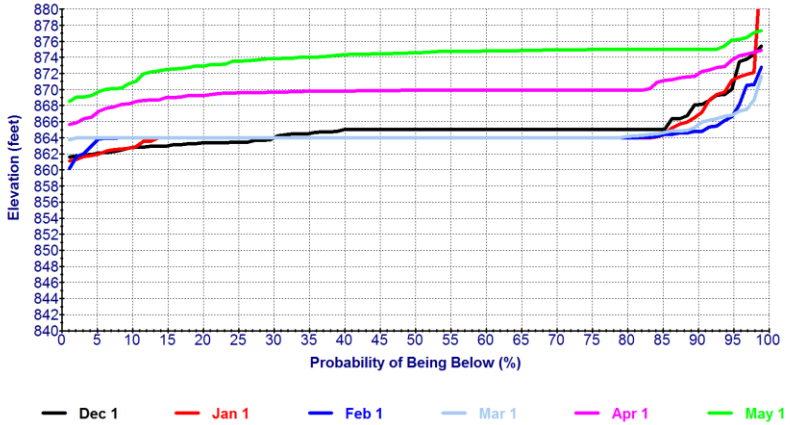


2016 Normandy forecast

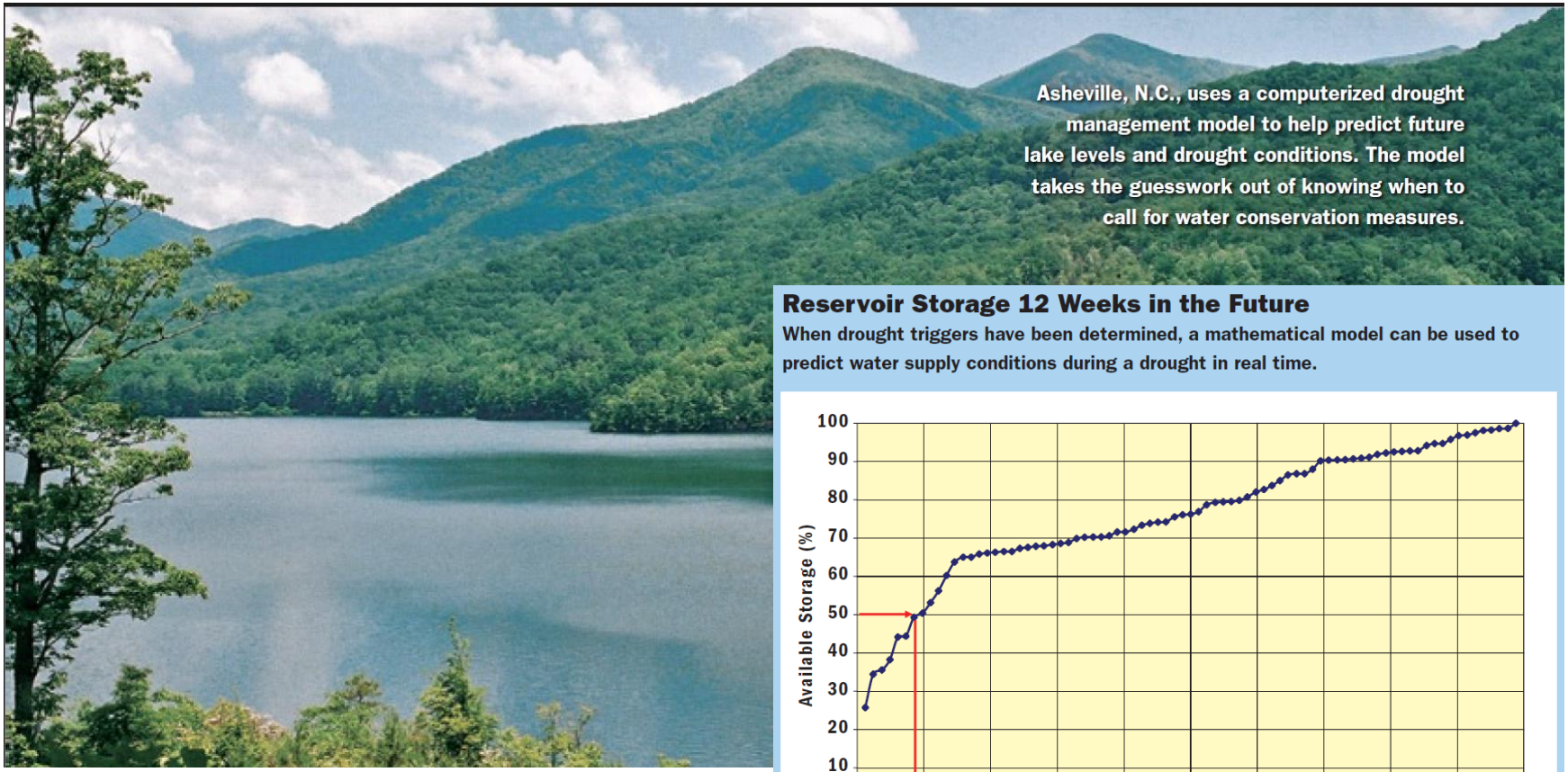
- Forecast indicated that while levels in November were low, there was little chance of hitting a drought trigger or reaching levels experienced in 2007-2008

- Normandy was at or above the winter rule curve by the end of the year





Asheville forecast-based drought plan



Asheville, N.C., uses a computerized drought management model to help predict future lake levels and drought conditions. The model takes the guesswork out of knowing when to call for water conservation measures.

Reservoir Storage 12 Weeks in the Future

When drought triggers have been determined, a mathematical model can be used to predict water supply conditions during a drought in real time.

From AWWA Opflow, June 2010

Roanoke River - Smith Mtn. Relicensing

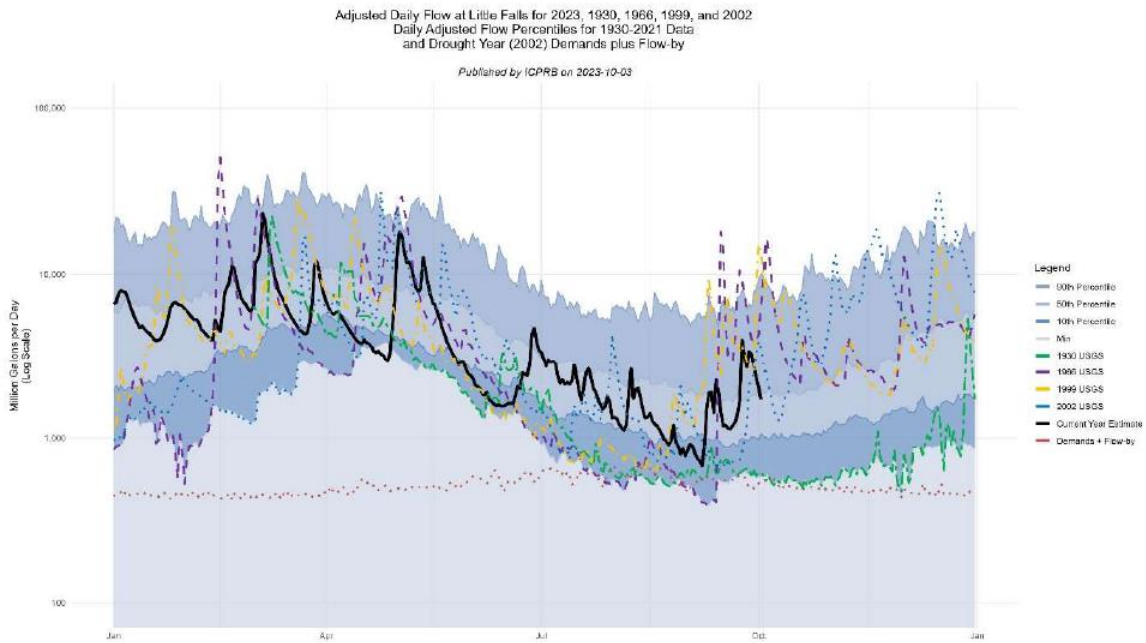
- Competing Objectives
  - **Hydropower generation**
  - **Lake recreation**
  - **Recreational releases downstream**
- As part of FERC license, developed probability-based triggers to preserve reservoir storage during drought
- Each trigger leads to reduction in downstream releases
- Forecasts allow for more proactive drought response during significant droughts
- Forecasts reduce false alerts during non-significant droughts, or times when drought response would have been taken unnecessarily



Interstate Commission on the Potomac River Basin (ICPRB)

- ICPRB is a compact agency of Potomac River Basin states
- Empowered to address water quality and water resources issues
- Uses forecast outlook models to coordinate cooperative water supply operations
  - **Drought protocols for releases from upstream reservoirs**
- Monthly Water Supply Outlook published online and distributed to email list

ICPRB Water Supply Outlook



Adjusted flow represents the natural flow that would occur in the absence of major withdrawals. The USGS publishes adjusted flow data for Little Falls based on actual withdrawals reported by the CO-OP utilities and Loudoun Water. However, the USGS data may not always be available in time for the outlook. In such cases, ICPRB estimates the adjusted flow using a 20-day rolling average of past withdrawal data or observed data collected from the utilities.

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Water Supply Outlook

October 5, 2023
To subscribe please email coop@icprb.org

Interstate Commission on the Potomac River Basin (ICPRB)
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The ICPRB, through its Section for Cooperative Water Supply Operations on the Potomac (CO-OP), coordinates water supply operations during times of drought and recommends releases of stored water. These operations ensure adequate water supplies for Washington metropolitan area water users and for environmental flow levels. The water supply outlooks are published by CO-OP on a monthly basis between April and October. They are meant to provide an update on the possibility of low-flow conditions in the Potomac basin.

Summary/Conclusions

The Washington metropolitan area has an above-normal probability of releases from its backup water supply reservoirs for the fall of 2023. These releases typically occur in response to low flows resulting from insufficient summer precipitation and low groundwater levels. Due to a dry period, CO-OP Drought Operations occurred from August 25th to September 11th. However, the Potomac basin saw some relief after several rainfall events produced 4.3 inches of precipitation for September, exceeding the monthly average by 0.5 inches. Little Falls' adjusted stream flows reached a low of 533 million gallons per day (MGD), peaked above average, and are now within the 10th to 50th percentile flow range. Groundwater levels have been slower to recover, and many wells used in ICPRB's low-flow outlook are now approaching normal levels. This trend is also reflected in the U.S. Drought Monitor, with reduced areas in the basin in the abnormally dry, moderate drought, and severe drought categories. NOAA's U.S. Seasonal Outlook remains optimistic about drought conditions improving. As flows return to median levels, Point of Rocks has reverted to a flow rate of approximately 2,000 cubic feet per second (cfs). This flow rate coincides with the established Daily Monitoring threshold, and on October 4th, the CO-OP Section resumed its daily drought monitoring and reporting. Currently, the Potomac River's flows are adequate to meet the water demands of the Washington metropolitan area without requiring releases from upstream reservoirs. The region has drought-contingency plans to ensure water supply reliability and prevent shortages.

ICPRB's Low-Flow Outlook

There is a 28 to 40 percent conditional probability that natural Potomac flow will drop below 600 to 700 MGD at Little Falls through December 31 of this year; at these flow levels, water supply releases from Jennings Randolph and Little Seneca reservoirs may occur. Releases occur when the predicted flow is less than demand plus a required environmental flow-by. Drinking water demand ranges from 400 to 700 MGD during the summer months, and the minimum flow-by at Little Falls is 100 MGD. Natural flow is defined as observed flow at the Little Falls gage plus total Washington metropolitan Potomac withdrawals, with an adjustment made to remove the effect of North Branch reservoir releases on stream flow.

The conditional probability is estimated by analyzing the historical stream flow records and considering recent minimum stream flow values, precipitation totals for the prior 12 months, current groundwater levels, and the current Palmer Drought Index. Past years in which watershed conditions most closely resemble current conditions are weighted more heavily in determining conditional probability. The historical, or unconditional, probability is based on analyzing the historical record without weighing current conditions. In the table below, the 28 to 40 percent conditional probability of flows below 600 to 700 MGD compares to the 7 to 14 percent historical probability and is considered the more reliable indicator. This month's conditional probability considers the minimum observed Little Falls flow of 533 MGD, which occurred on September 5th before the month's rainfall. Considering just the indicators for groundwater, precipitation, and the Palmer Drought Index, which include the impacts of recent precipitation, the conditional probability of flows below 600 to 700 MGD ranges from 11 to 25 percent.

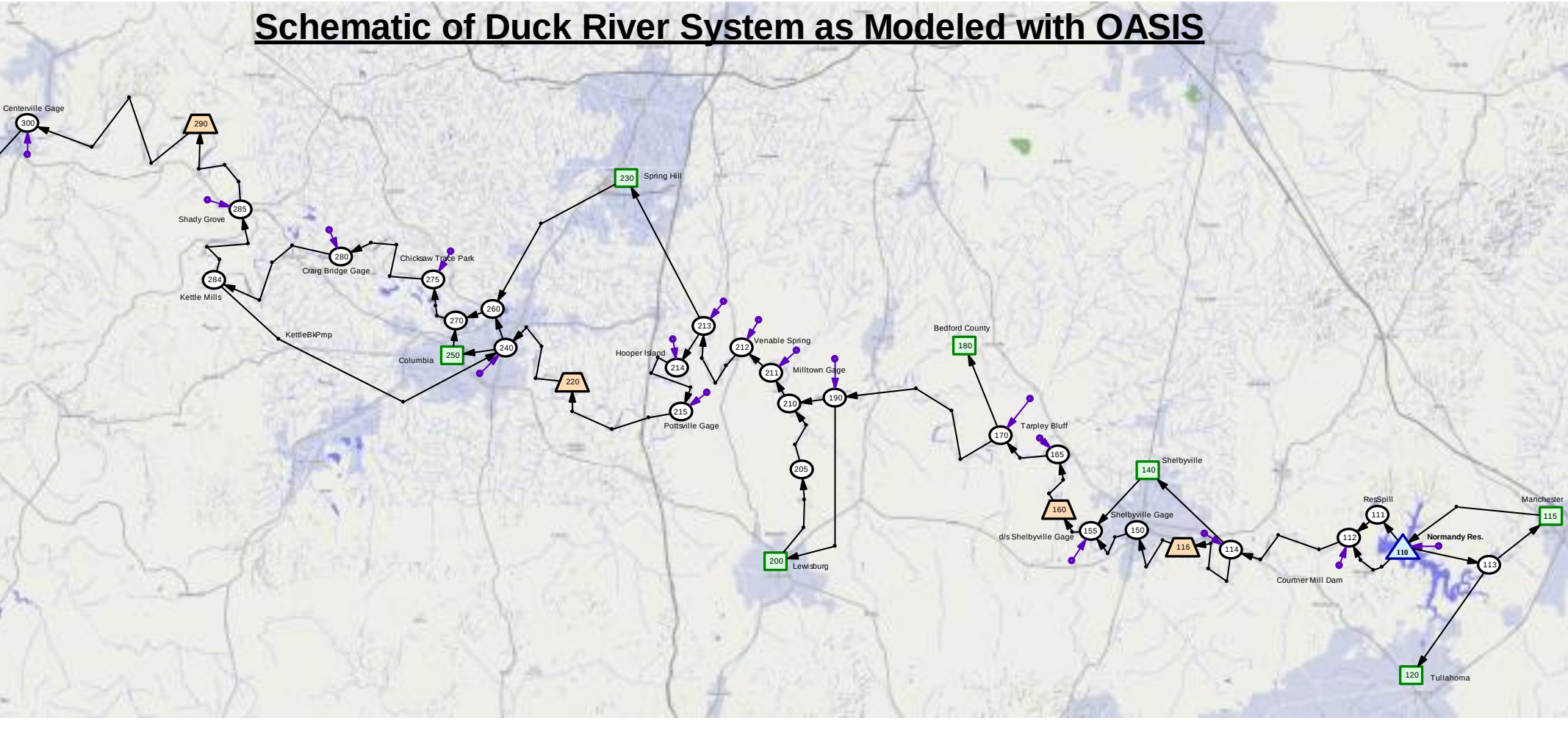
Outlook for natural Potomac River flow at Little Falls – Watershed conditions as of October 3, 2023

Low flow threshold (MGD)	*Low flow threshold (cfs)*	*Historical probability of lower flow September 1 through December 31*	*Conditional probability of lower flow September 1 through December 31*
1200	1858	64%	91%
1000	1548	45%	80%
800	1238	22%	53%
700	1084	14%	40%
600	929	7%	28%

Modeling potential DMP updates

- Using OASIS model, originally developed in early 2000s, refined and updated over the years to better reflect basin conditions and answer new questions
- Models Normandy Dam operations, including minimum release, Shelbyville target, normal operating rule curve, and an approximation of flood operations
- Includes local inflows downstream to Centerville, based on USGS gage flows
  - **Can also use alternative inflow datasets, such as climate-influenced projections or synthetic hydrology**
- Uses annual average withdrawals from latest available TDEC data
  - **Seasonal (monthly) withdrawal patterns based on historical use**
  - **Wastewater discharges based on historical relationship between withdrawals and discharges**
  - **Will be incorporating newly issued or proposed withdrawal permit, as well as updated demand projections**

Schematic of Duck River System as Modeled with OASIS



Potential updated DMP Operations

- Stages 1 & 2
  - **No modeled operations; involves drought monitoring and public outreach**
  - **Public outreach can include voluntary reductions, but no reductions assumed for modeling**

- Stage 3
  - **Mandatory conservation measures, 10% reduction goal**
  - **Shelbyville weekly flow target reductions (5 cfs per week)**
  - **Summer: Dropping from 155 cfs to 145 cfs weekly average with instantaneous remaining 135 cfs**
  - **Winter: Dropping from 120 cfs to 110 cfs weekly average with instantaneous remaining 100 cfs**
- Stage 4
  - **Continue mandatory conservation measures with 20% reduction in demands**
  - **Shelbyville weekly flow target reductions (5 cfs per week)**
  - **Summer: Dropping from 145 cfs to 135 cfs weekly average with instantaneous dropping from 135 to 125 cfs**
  - **Winter: No change from Stage 3**
  - **Emergency actions will be determined by regulatory agencies depending on severity of drought**

Potential Triggers

- Modified rule curves
  - **Initial test of dropping rule curves by 3 ft from 2013 DMP levels**

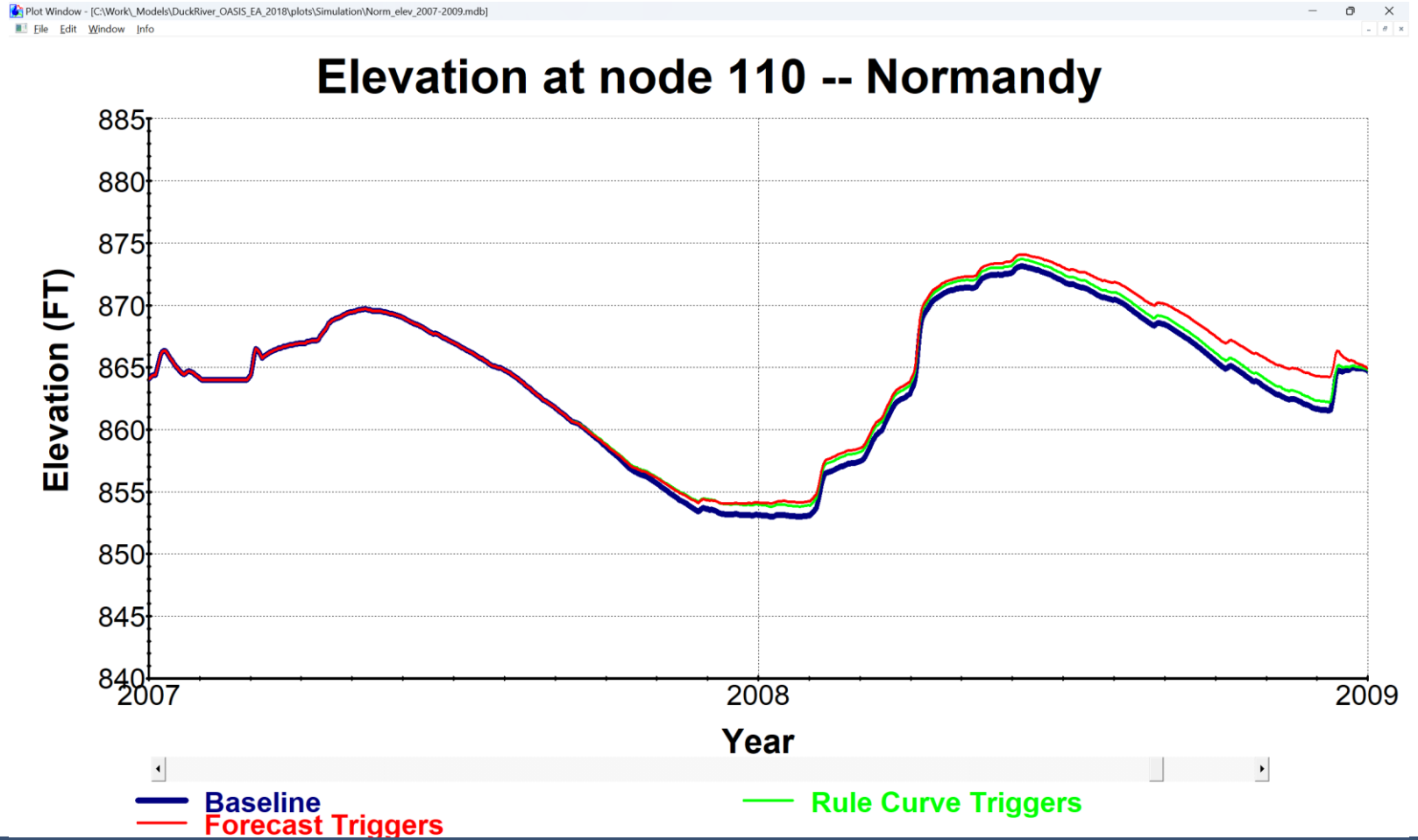
- Forecast-based trigger

  Example rule form:
  - **Stage 1: 40% chance of hitting 862 ft in 12 weeks**
  - **Stage 2: 30% chance of hitting 860 ft in 10 weeks**
  - **Stage 3: 20% chance of hitting 858 in 8 weeks**
  - **Stage 4: 10% chance of hitting 850 ft in 4 weeks**

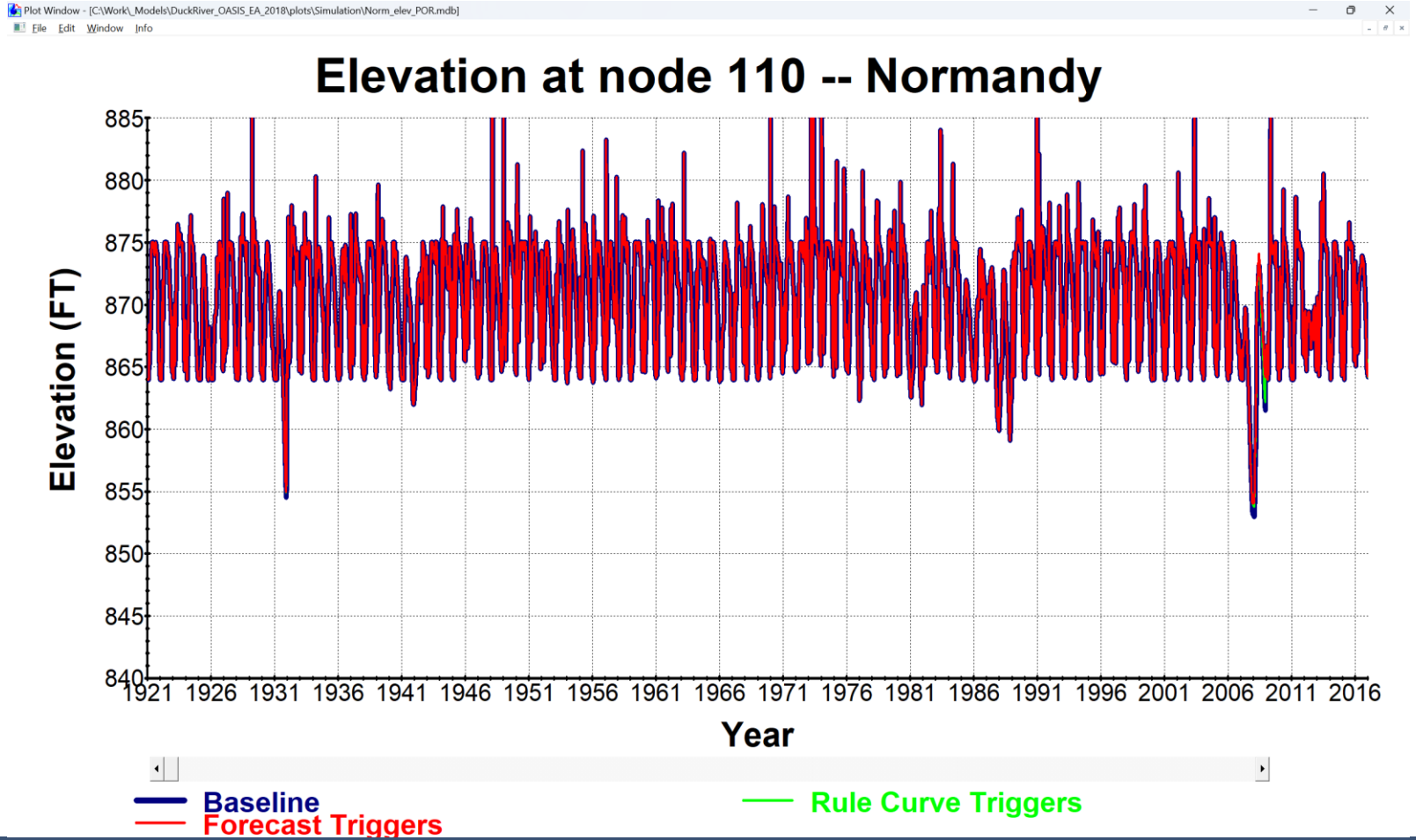
Potential DMP updates – sample model outputs

Preliminary results only from test scenarios

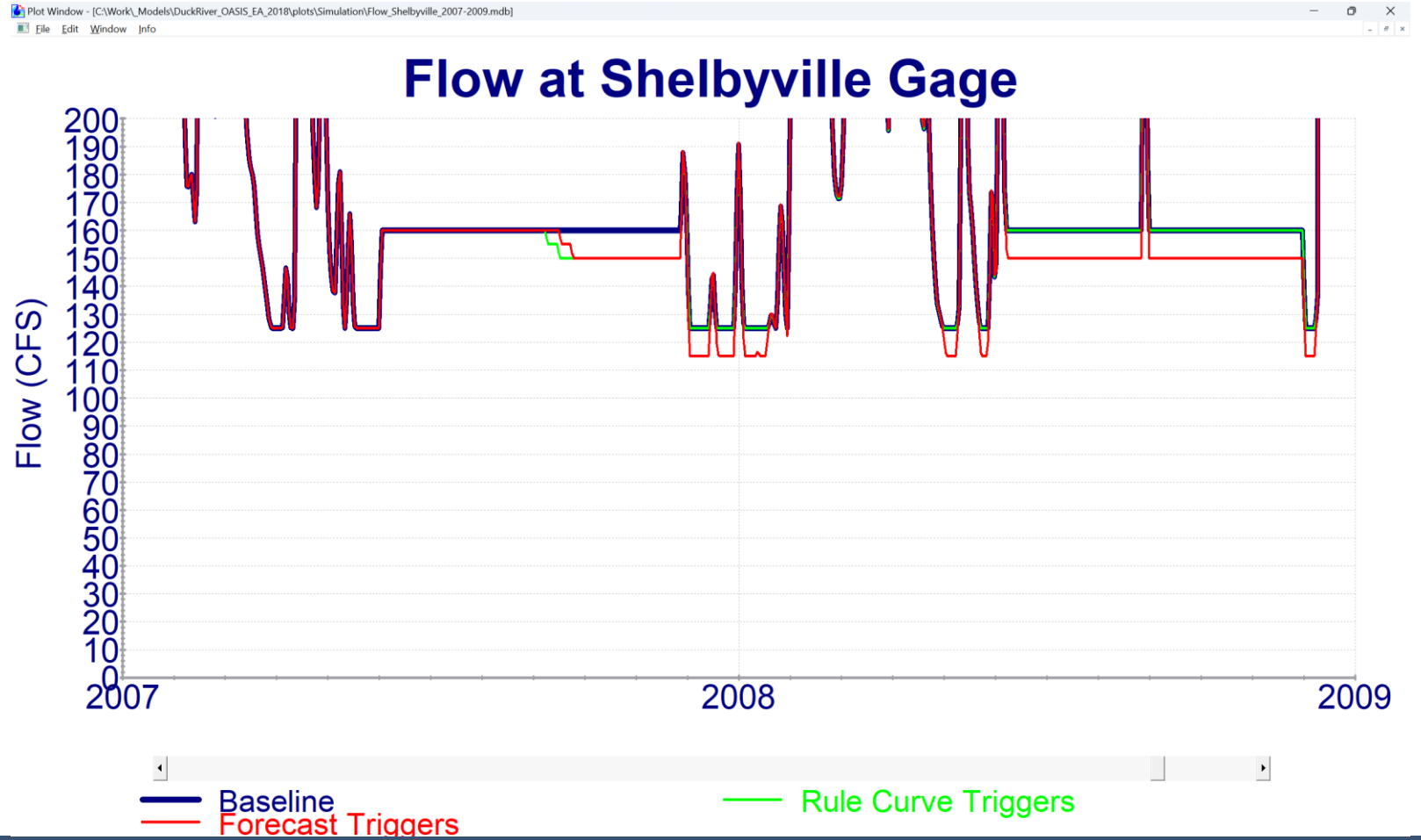
Normandy simulated levels during 2007-2008 drought



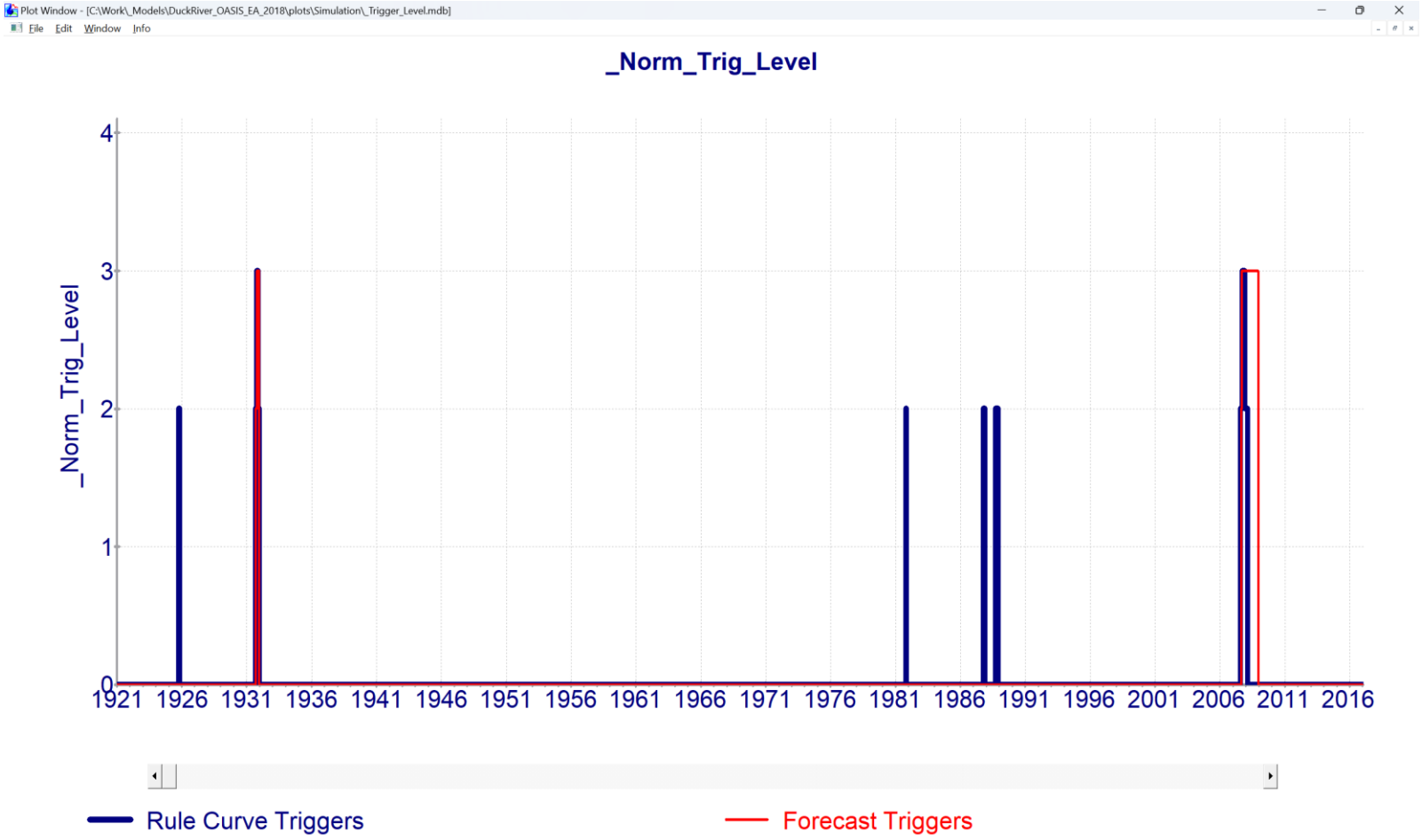
Normandy simulated levels – period of hydrologic record



Shelbyville simulated flows during 2007-2008 drought



Frequency of DMP being activated



Next steps

- Incorporate updated demand projections and withdrawal permits
- Potentially incorporate synthetic hydrology from TVA to look at climate impacts
- Low-flow statistics and coordination with mussel studies and ecological flows research for downstream areas of interest
- Solicit feedback from stakeholders and incorporate into future iterations of modeling