An Evaluation of Water Quality Modeling Used to Inform Operational Decisions for the NYC Water Supply

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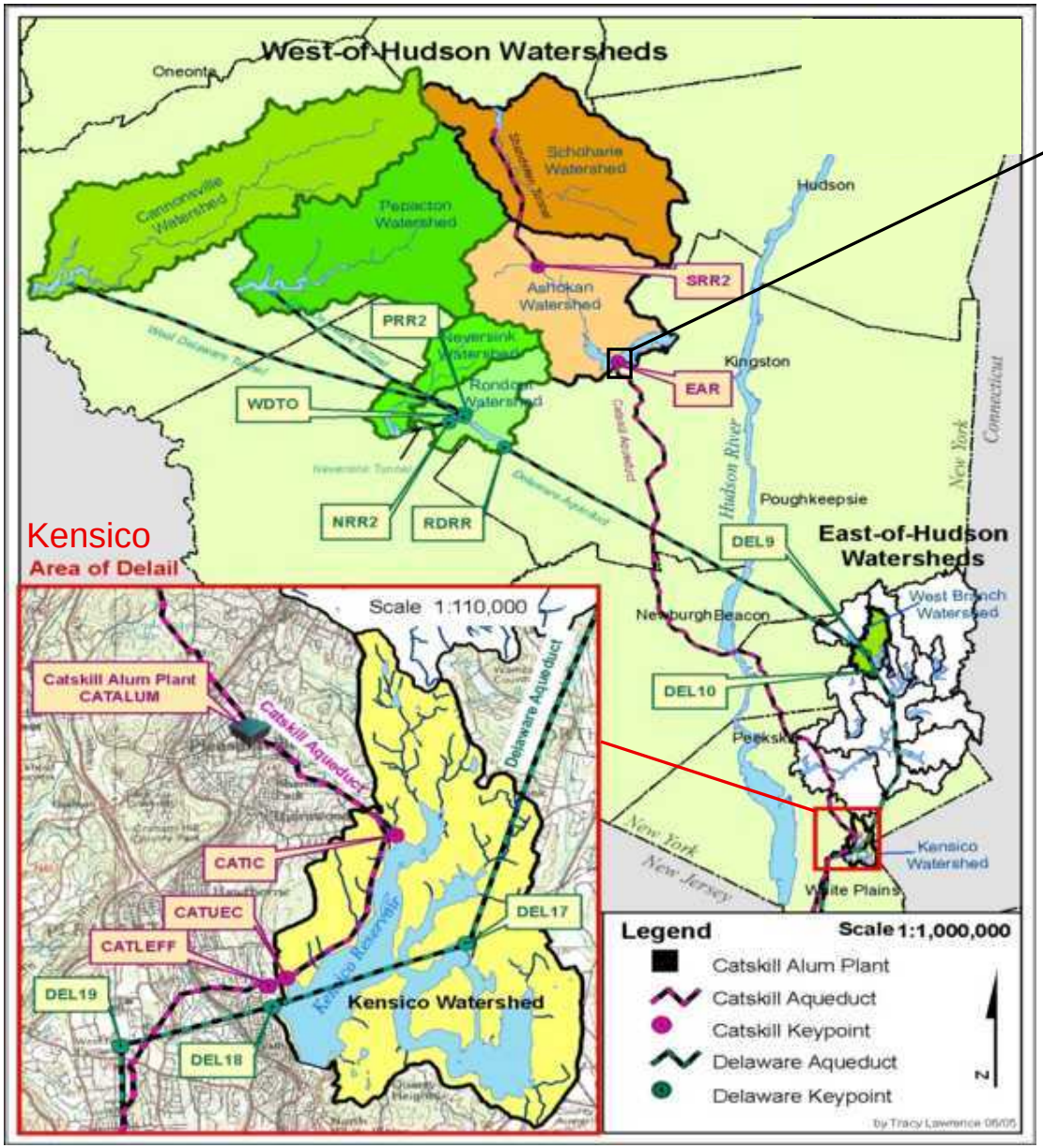
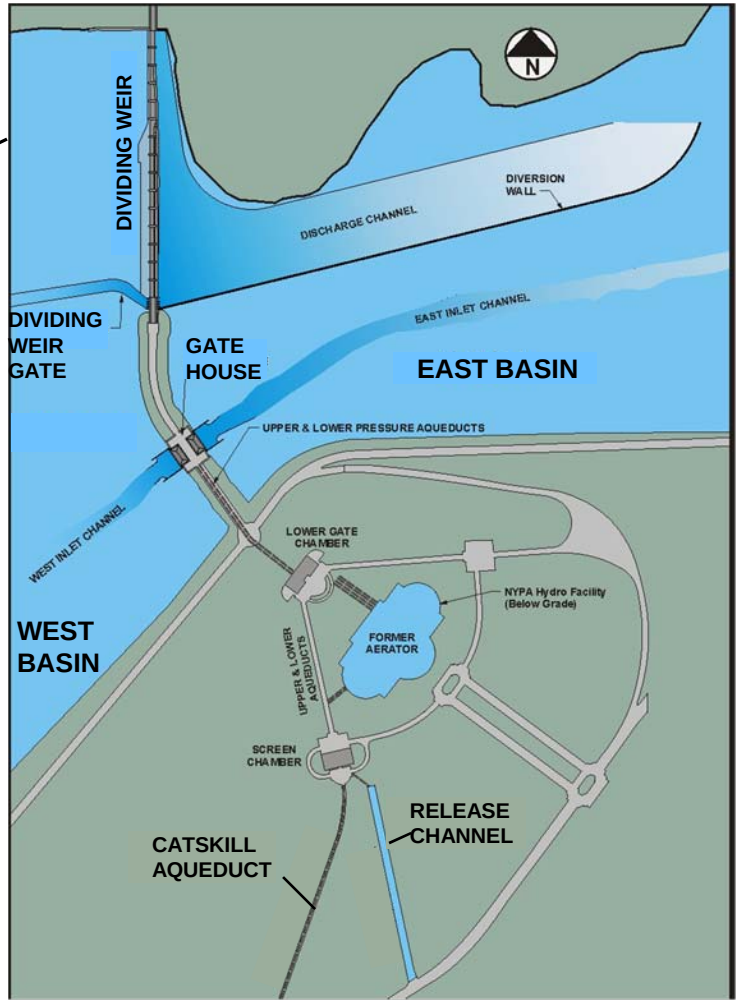
Introduction

- Elevated turbidity can be an issue for the Catskill System of the NYC water supply during and after periods of high streamflow.
- Informed use of operations during event periods can help to mitigate the impacts of turbidity on the water supply
- DEP has developed an extensive suite of water quality and water system models which are used to analyze turbidity transport in the Catskill System.
- During recent storm events, DEP's water quality and water system models were used to help inform operational decisions and reduce turbidity entering the water distribution system.
- How well does the modeling system work in predicting the range in future turbidity which is subsequently used to inform operations?

System Description



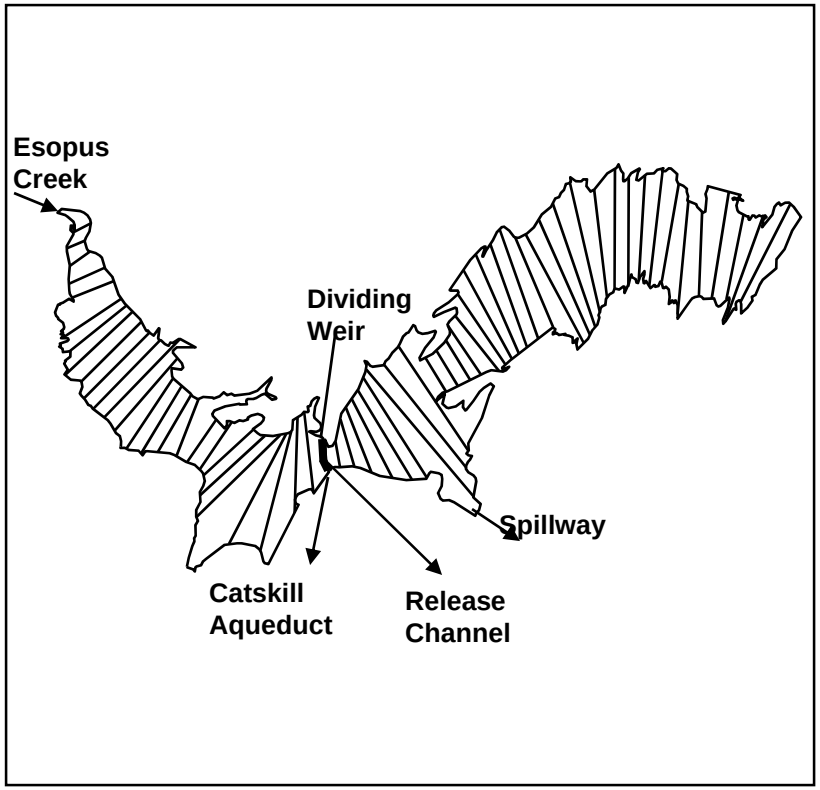


Ashokan Reservoir Options

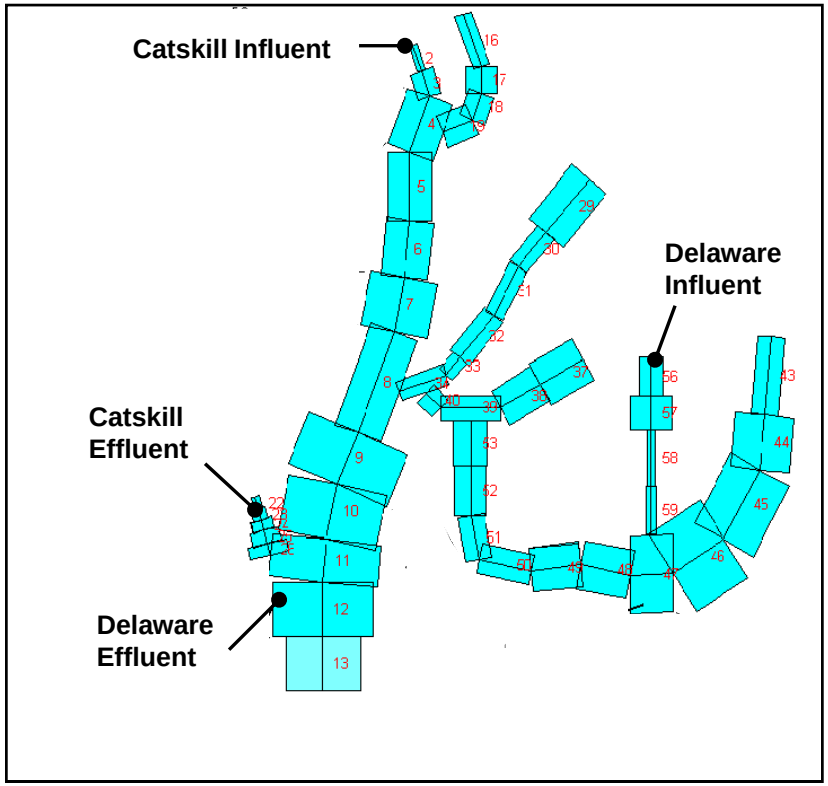
Model Description

CEQUAL-W2 Two Dimensional Reservoir Models

Ashokan



Kensico



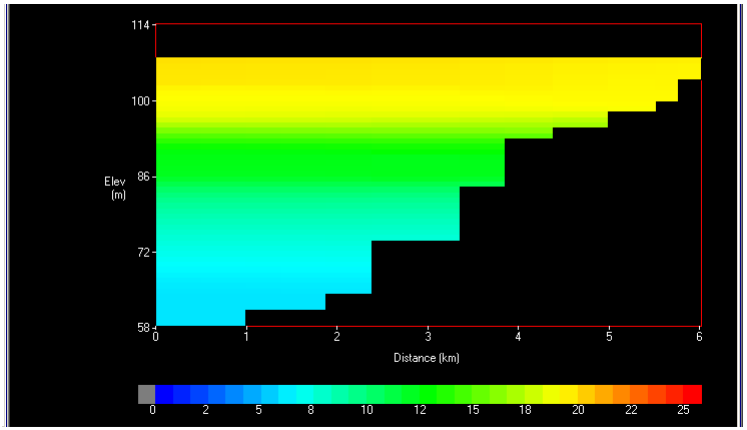
- CEQUAL-W2 Models adapted to simulate turbidity transport by Upstate Freshwater Institute (UFI).
- Models are connected using OASIS-W2 combined modeling software and applied in a positional analysis mode.
- Linked models can also be run using LinkRes software developed by UFI and adapted for positional analysis by DEP.

Model Description

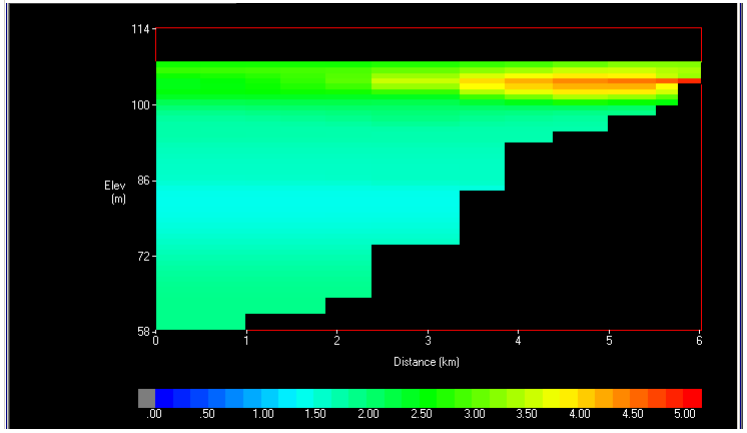
CEQUAL-W2 Two Dimensional Reservoir Models

Example Longitudinal Profiles

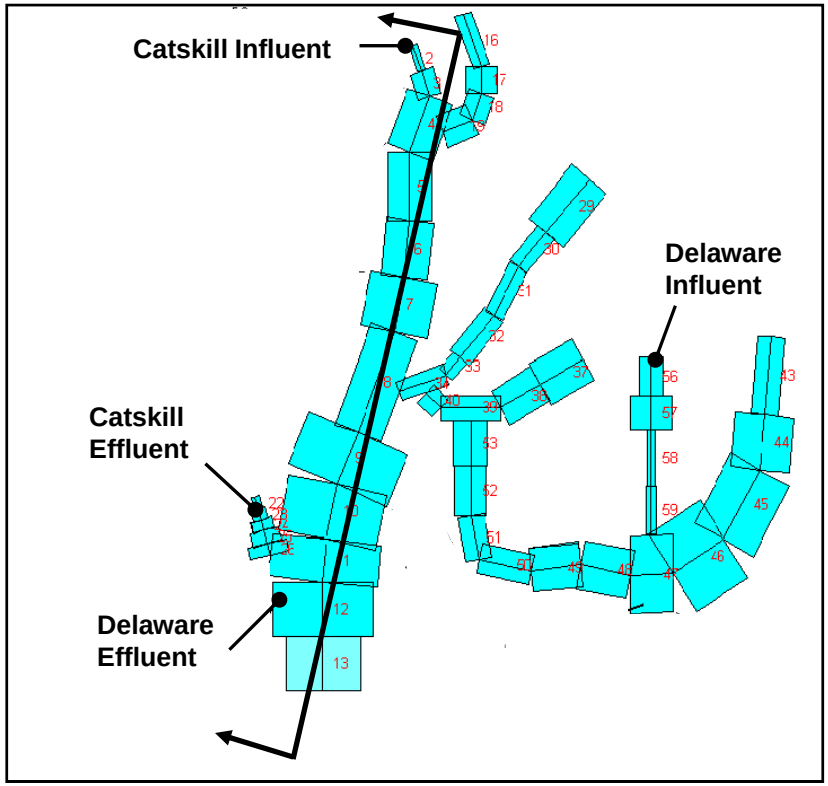
Temperature



Turbidity Profile

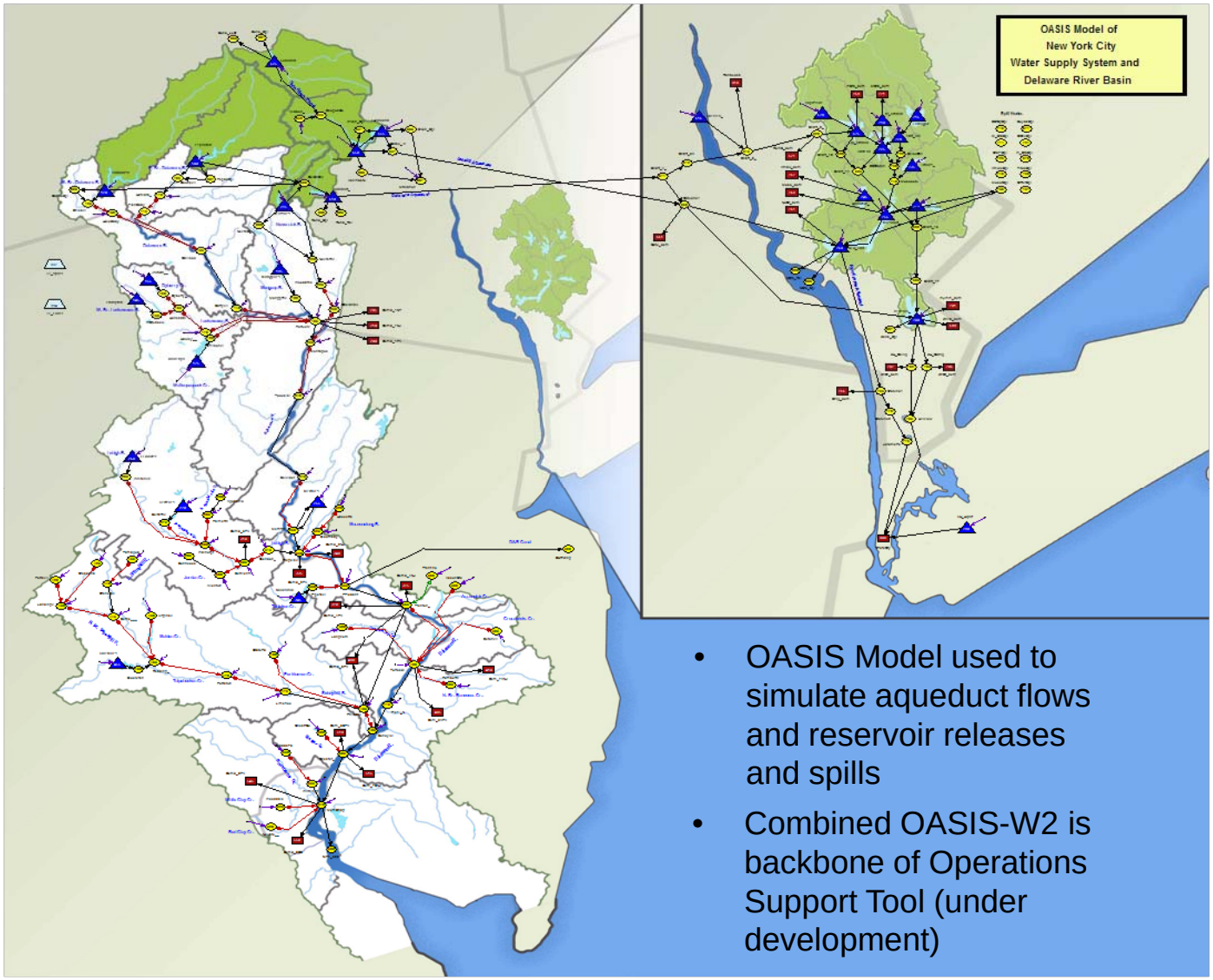


Kensico



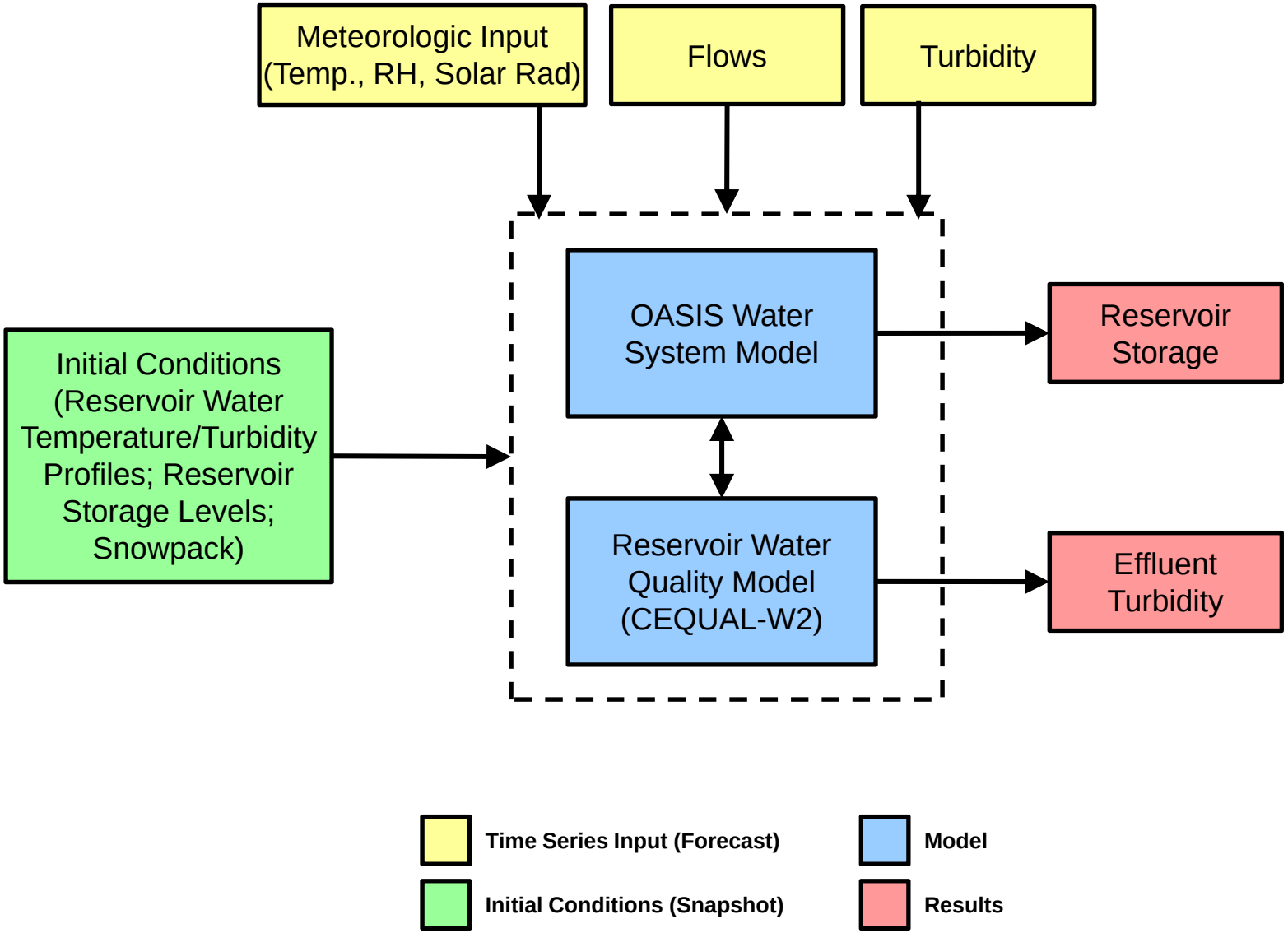
Model Description

OASIS system model combined with CEQUAL-W2 Reservoir Models



- OASIS Model used to simulate aqueduct flows and reservoir releases and spills
- Combined OASIS-W2 is backbone of Operations Support Tool (under development)

Model Description – Application Method



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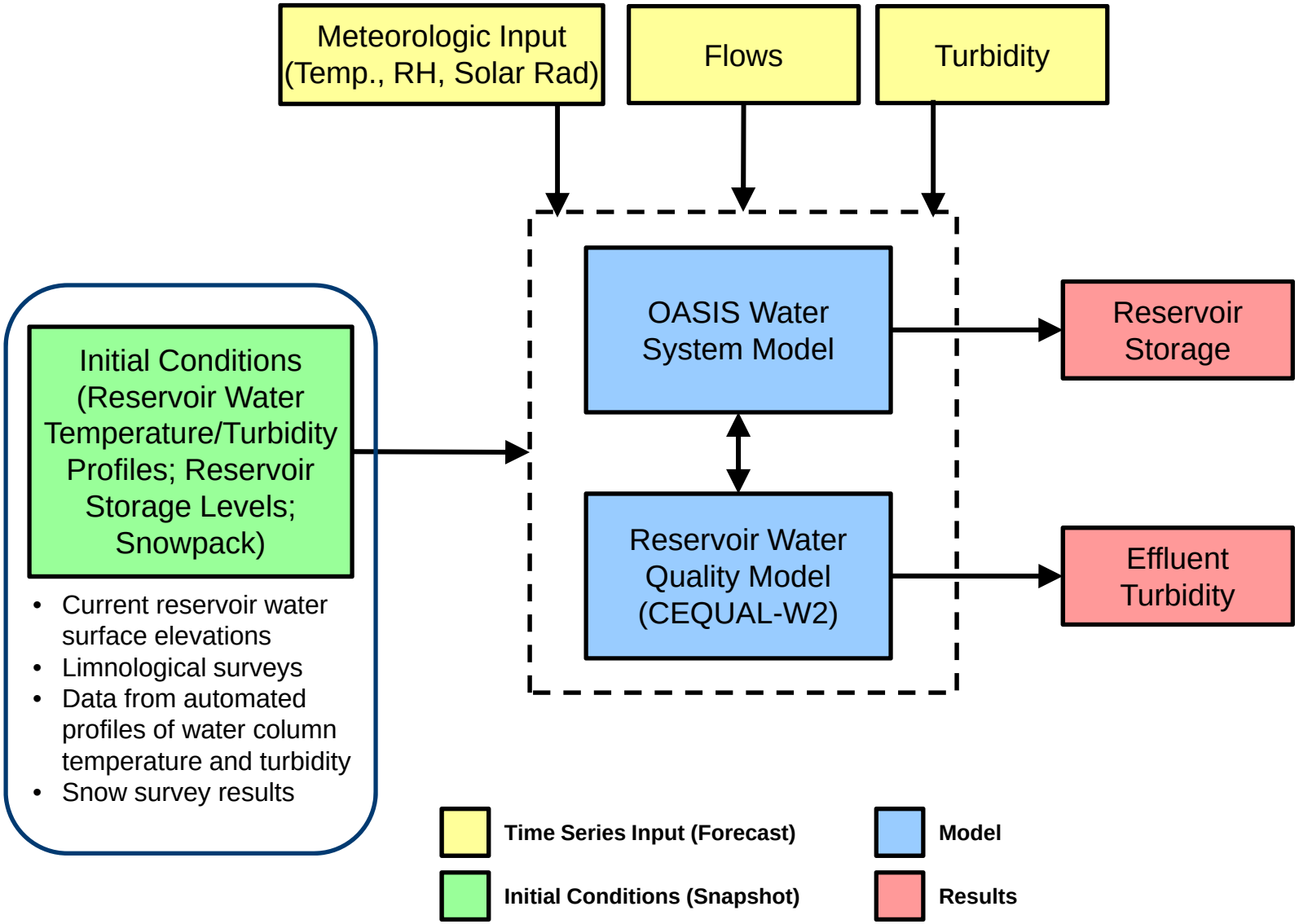

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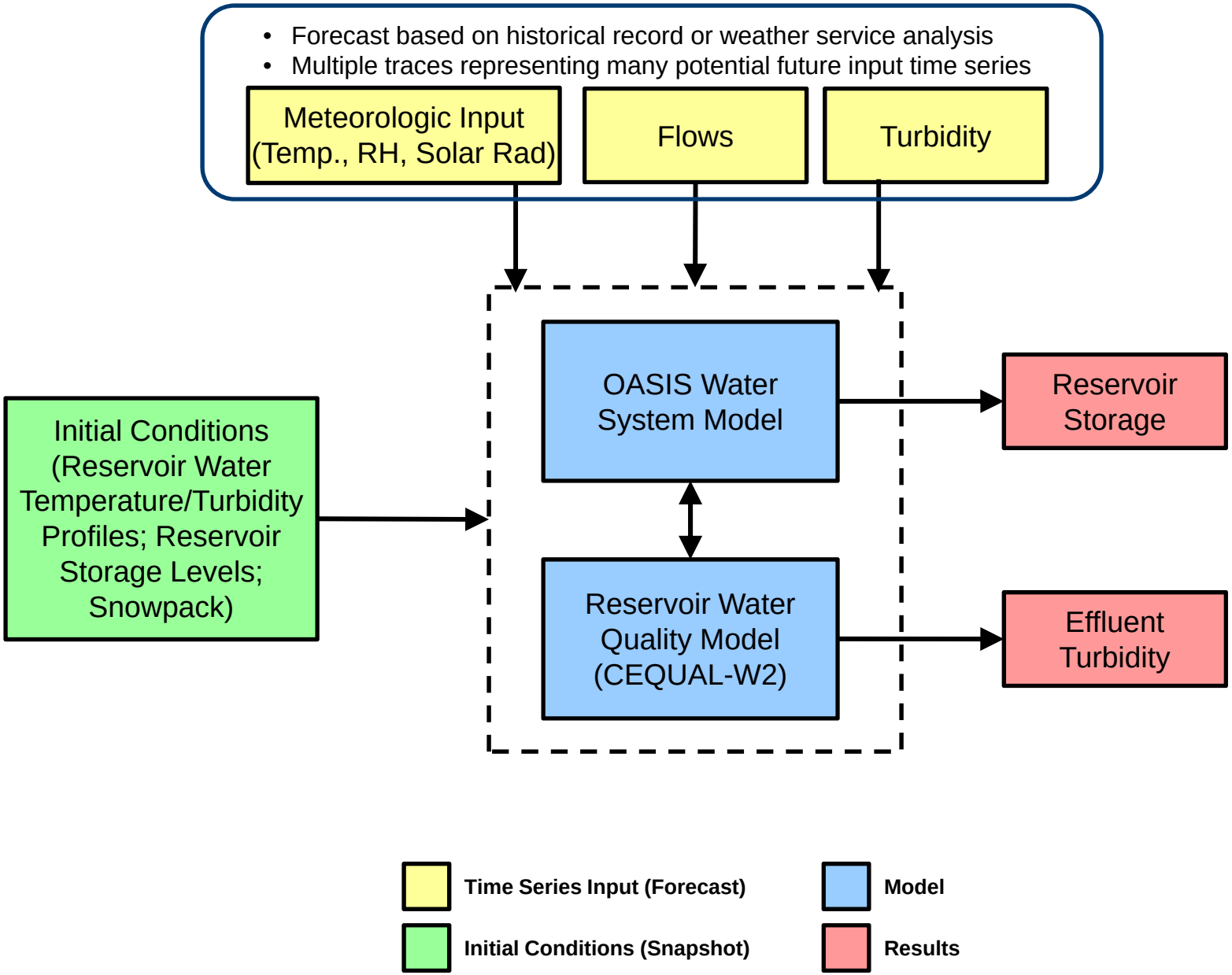

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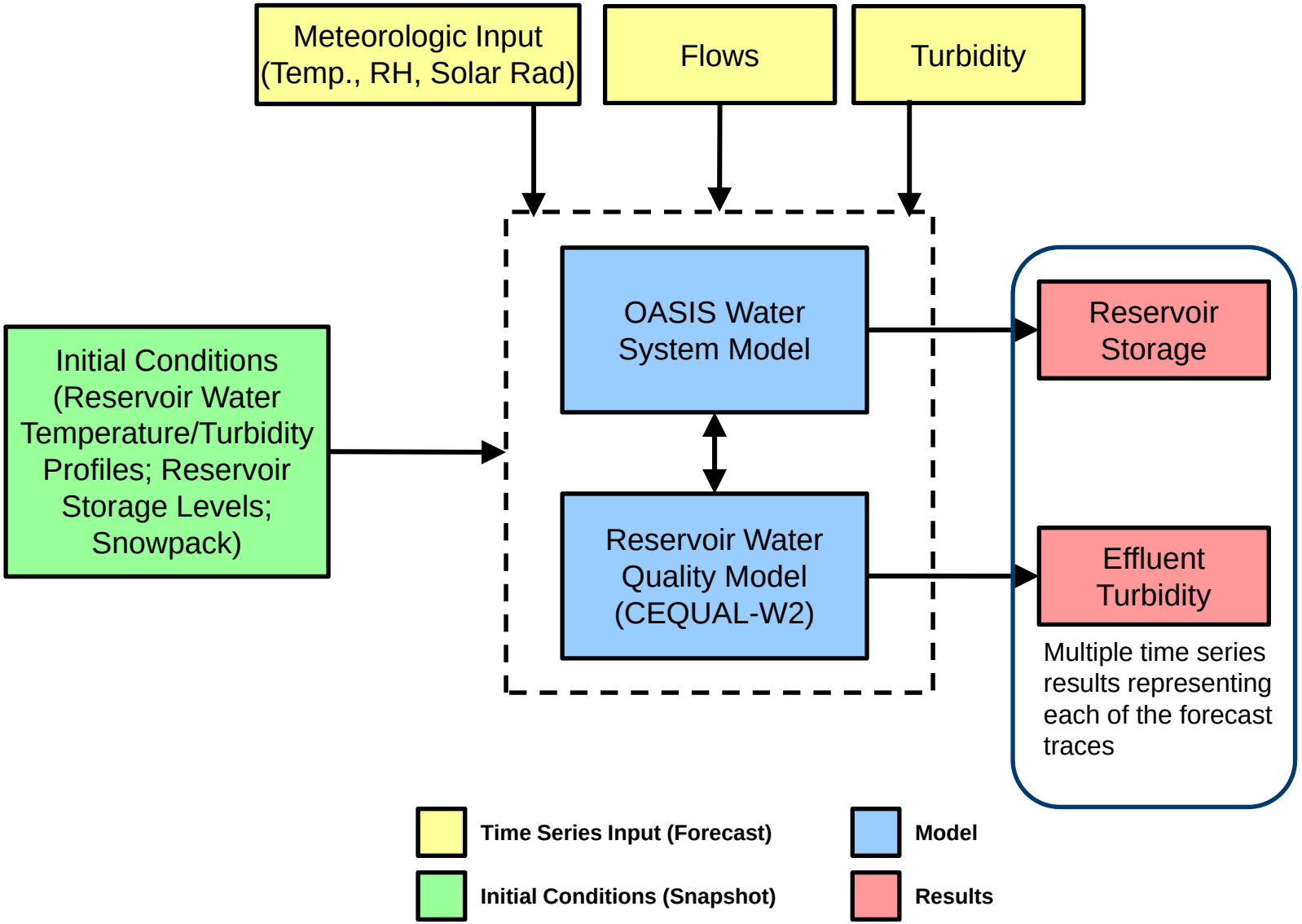
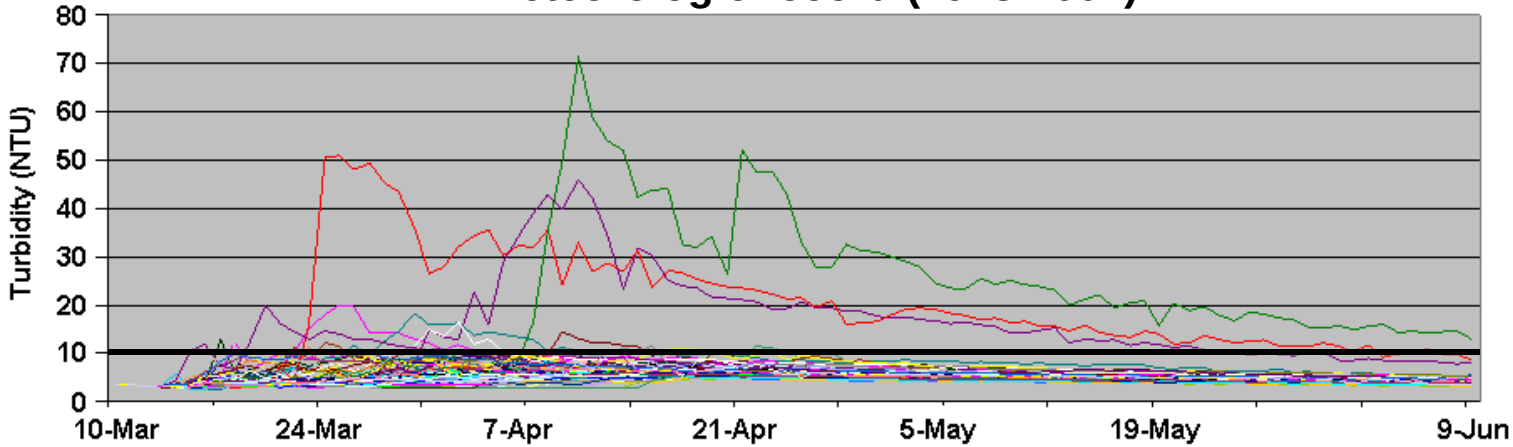


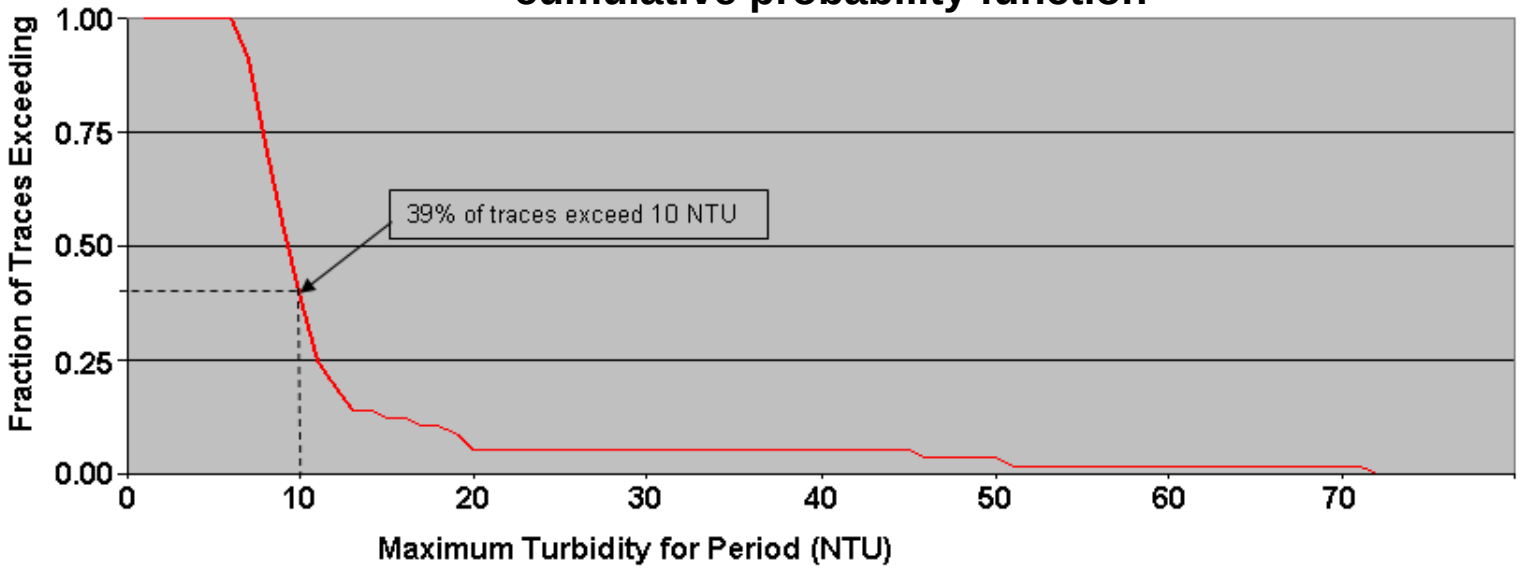
Model Description – Application Method

Example of Positional Analysis

Model run for 57 inflow traces based on historical flow and meteorologic record (1948-2004)



Statistics of traces can be translated to cumulative probability function



Case Study – Late December 2011

- In late August and early September, Tropical Storms Irene and Lee greatly impacted turbidity in the Ashokan and Schoharie Reservoirs and alum use was initiated on Catskill inflow to Kensico Reservoir.
- At the time of these model runs in late December 2011, the impact on the Catskill system was still significant.
- On December 20 Ashokan turbidity ranged from 22-170 NTU. Schoharie turbidity on December 14 ranged from 45-60 NTU.
- Alum continued to be used to reduce impact of turbidity entering Kensico Reservoir. In addition, the Catskill Aqueduct flow was reduced through the use of stop shutters.

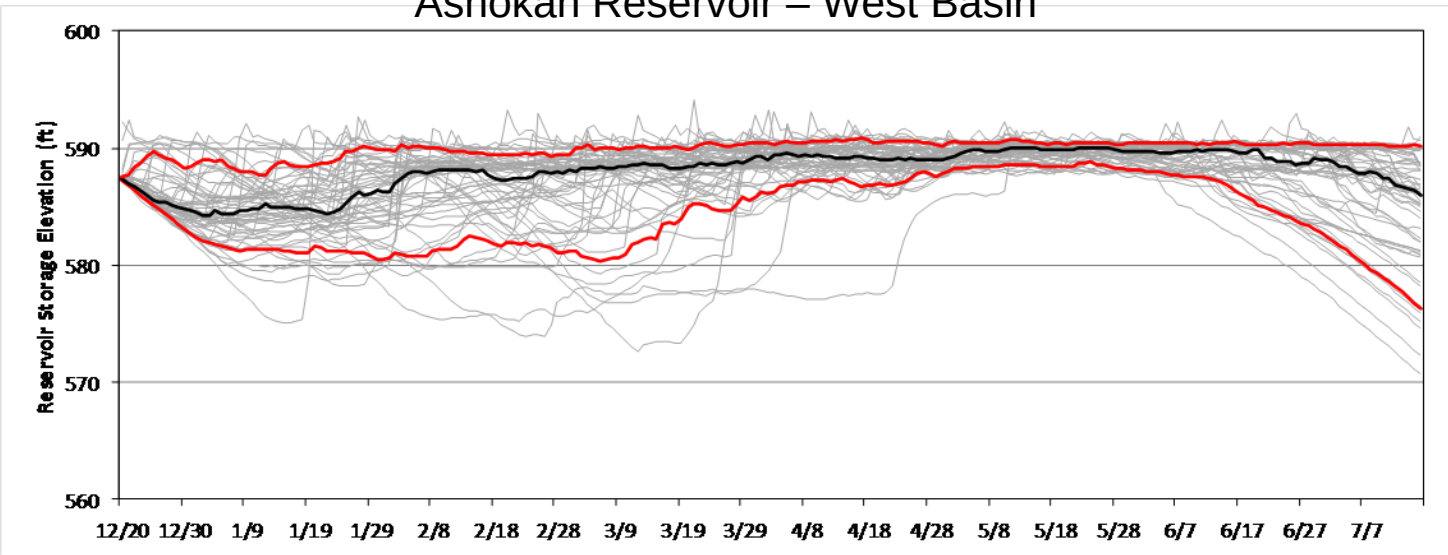
Schoharie Reservoir, Jan 5, 2012

- These simulations are run to provide an estimate of the time that it might take for Ashokan Reservoir turbidity to reduce to a level at which alum use would no longer be necessary.
- Simulations consisted of integrated OASIS/W2 model run.

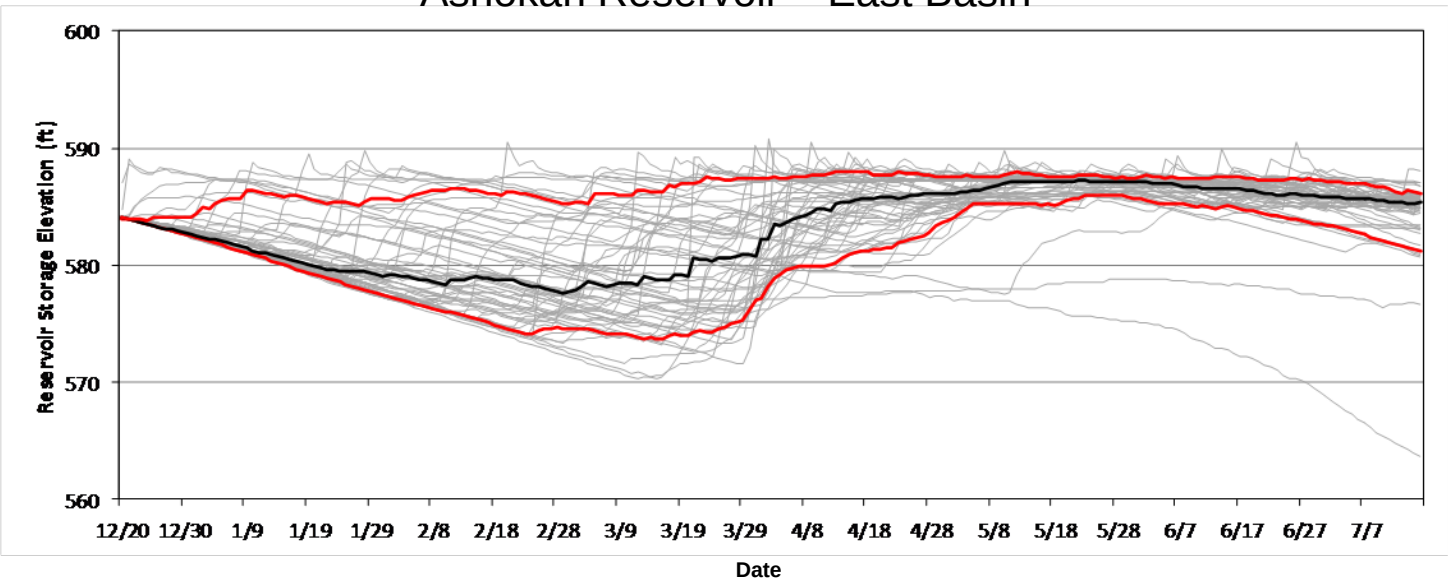
Ashokan Reservoir – Water Surface Elev

OST Simulations of Dec. 20, 2011

Ashokan Reservoir – West Basin



Ashokan Reservoir – East Basin



Individual Traces

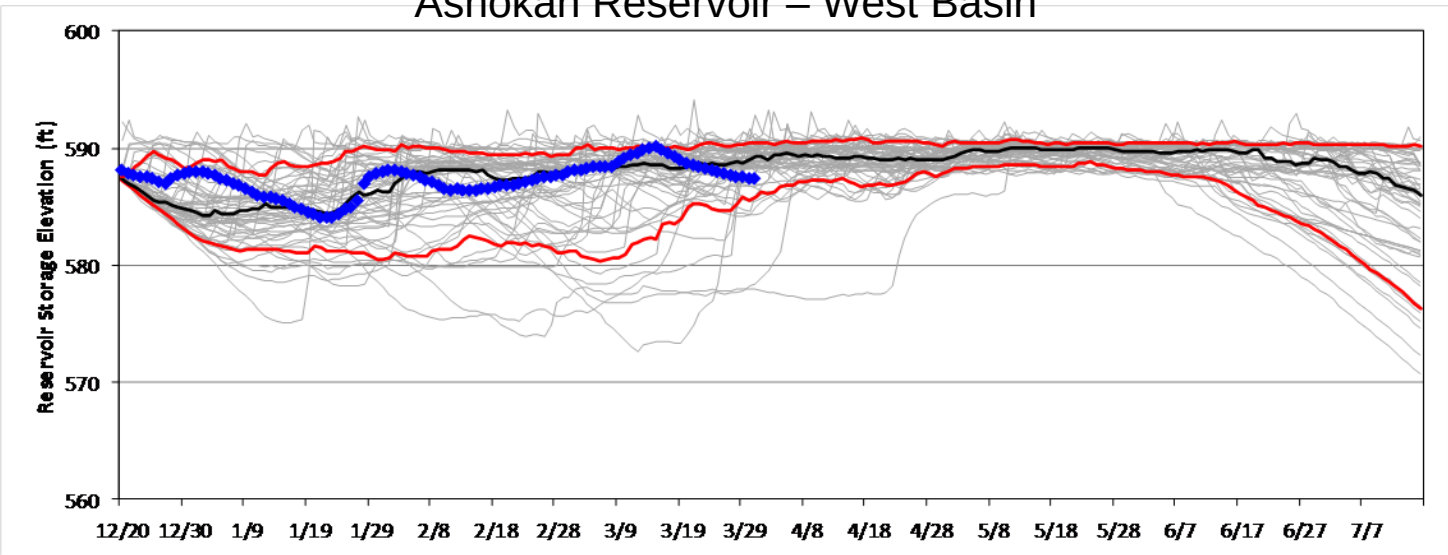
Median

10th and 90th Percentiles

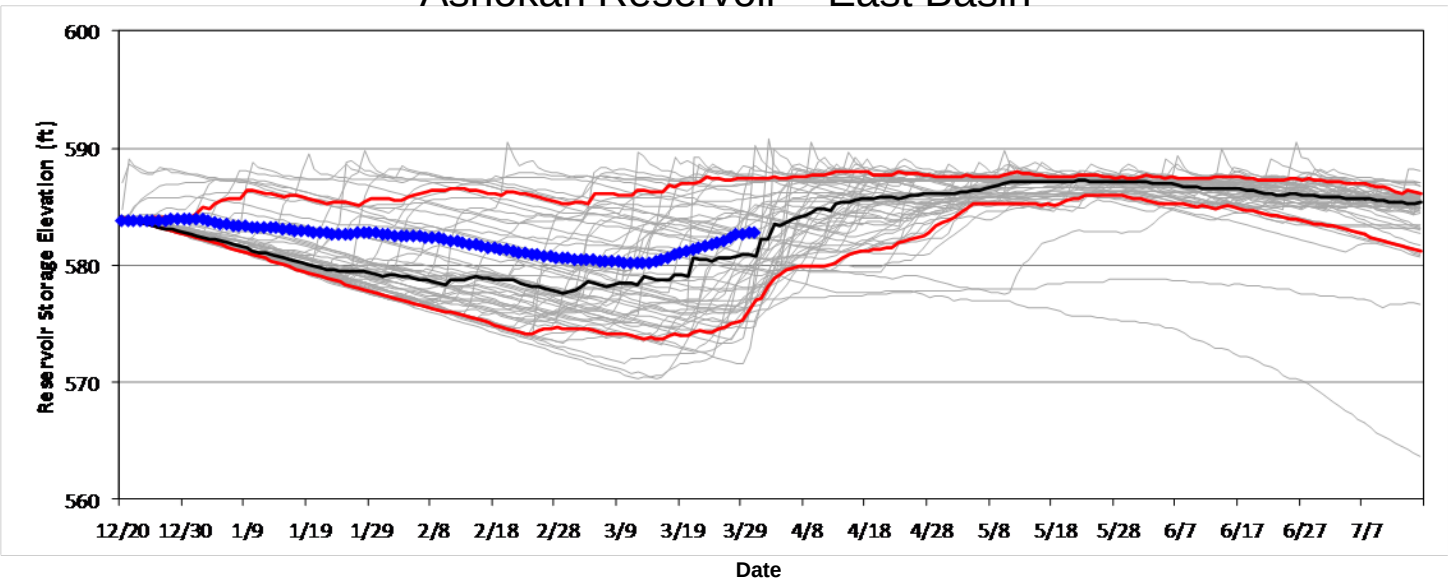
Ashokan Reservoir – Water Surface Elev

OST Simulations of Dec. 20, 2011 vs. Actual Elevation

Ashokan Reservoir – West Basin



Ashokan Reservoir – East Basin



Individual Traces

Median

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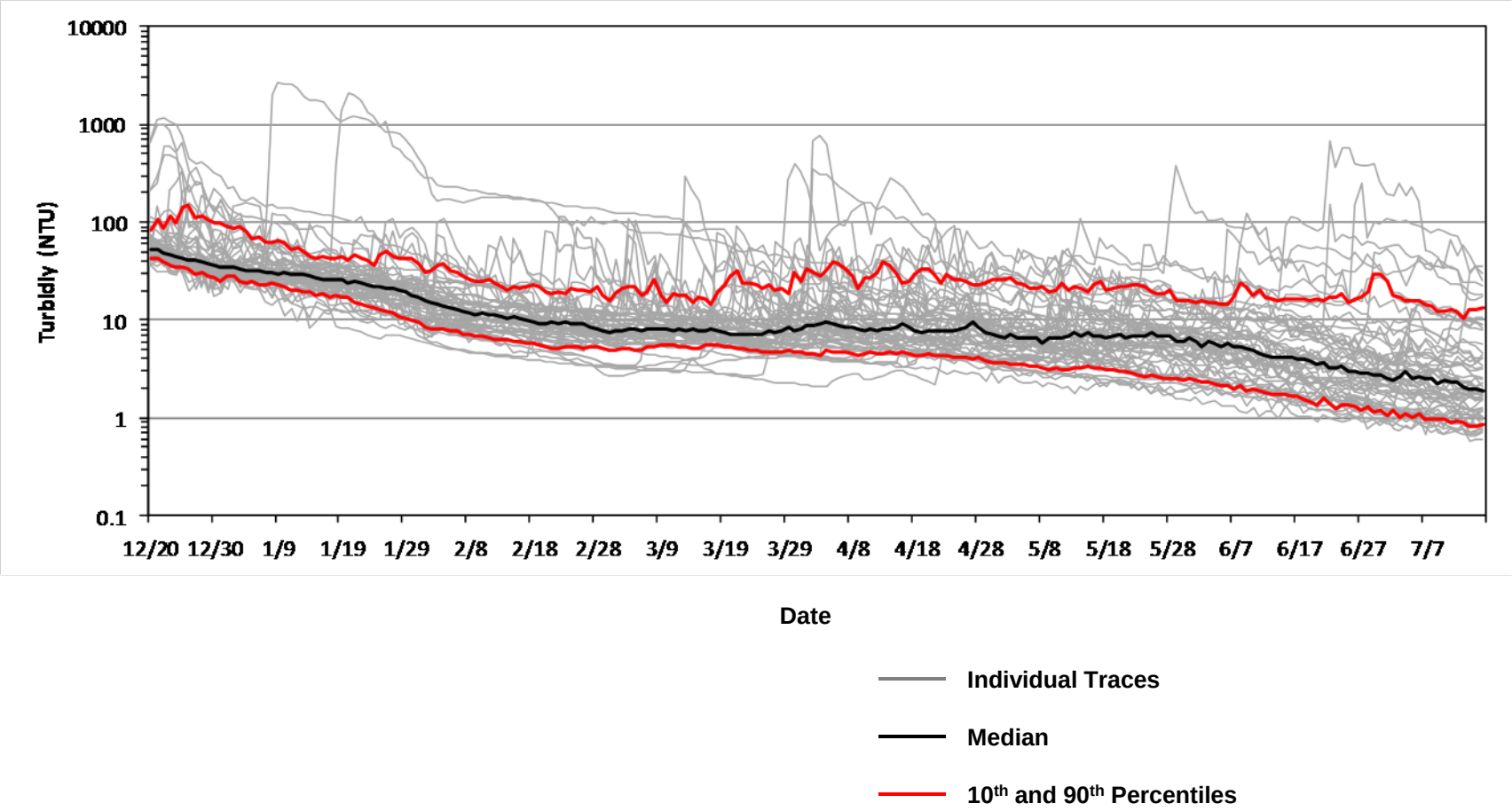
Recorded Elevation 2012

Schoharie Reservoir Results

OST Simulations of Dec. 20, 2011 vs. Keypoint Data
Shandaken Tunnel



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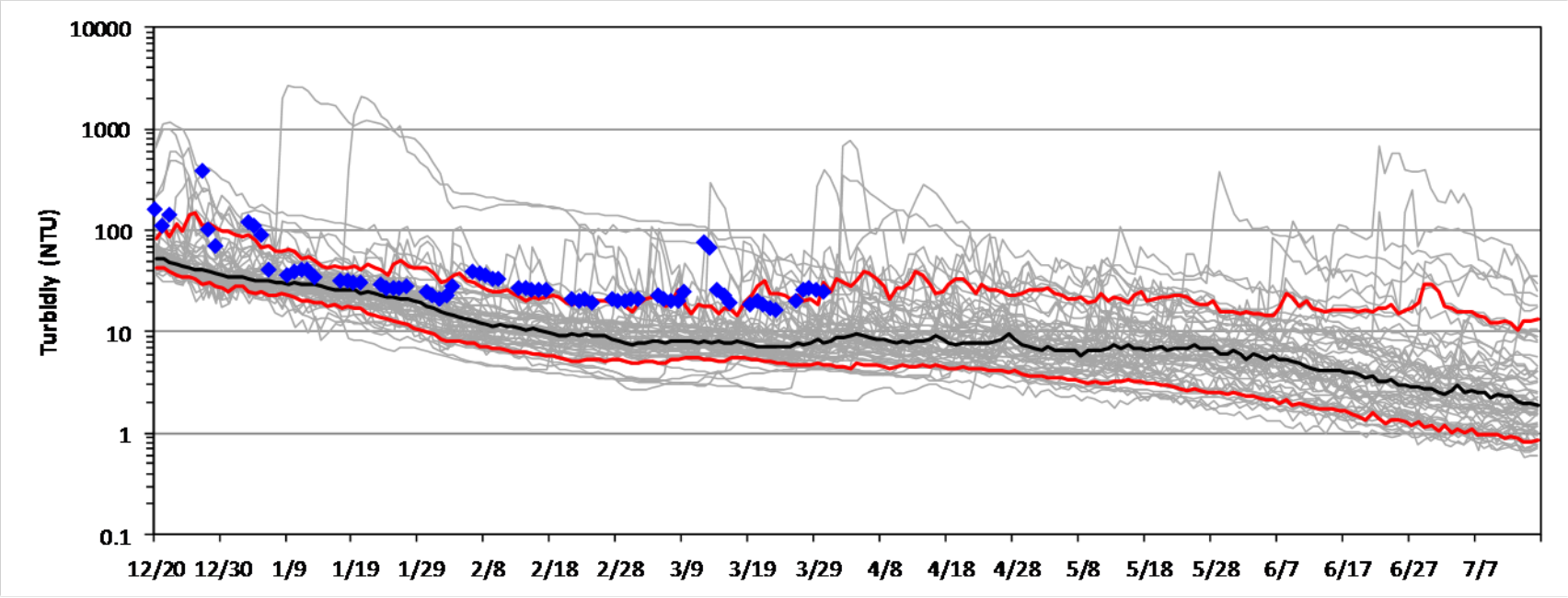

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Keypoint Data - Shadaken Tunnel Portal

Ashokan Reservoir – West Basin Results

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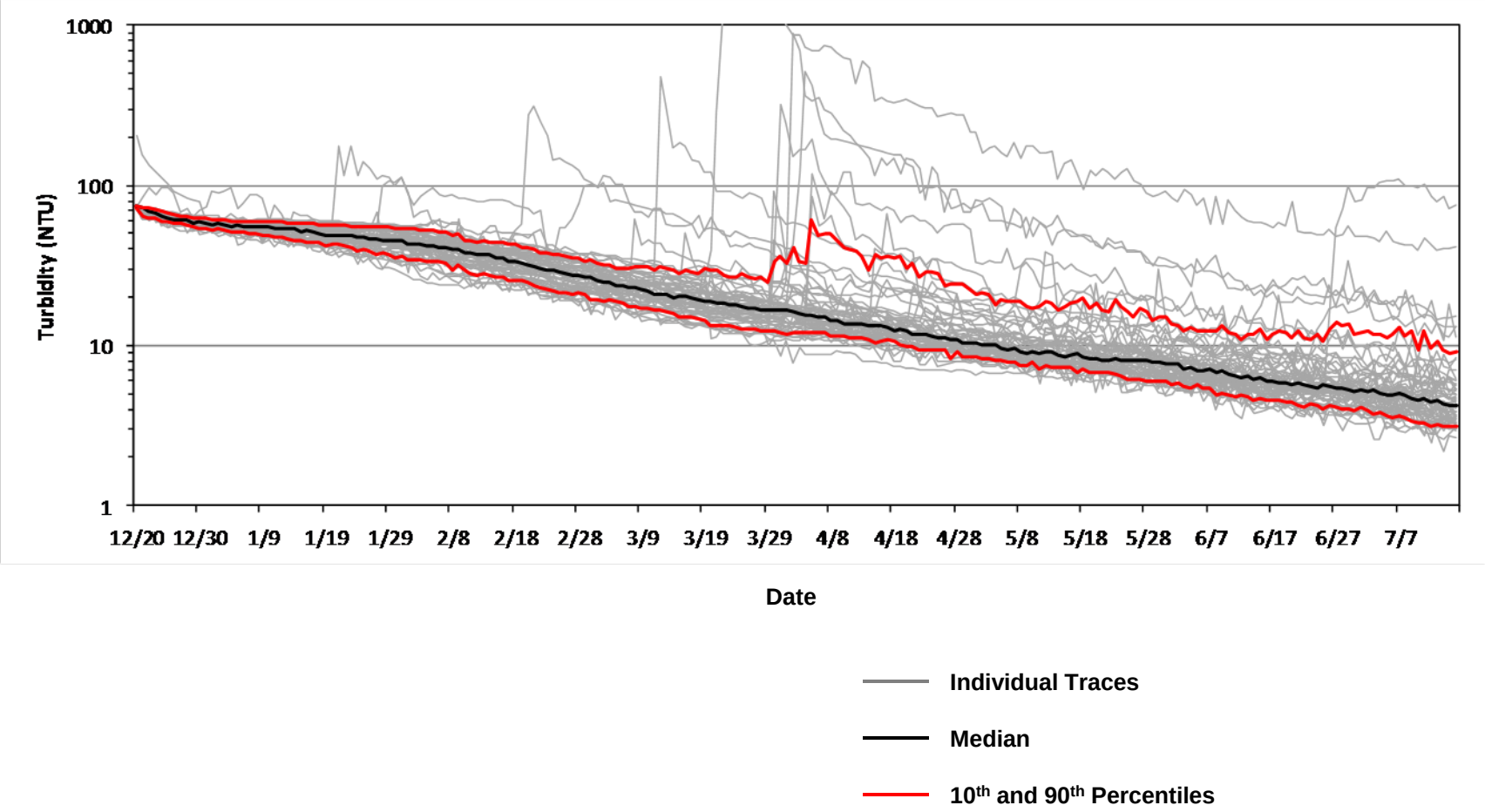
Ashokan West Basin Entering Dividing Weir Gate



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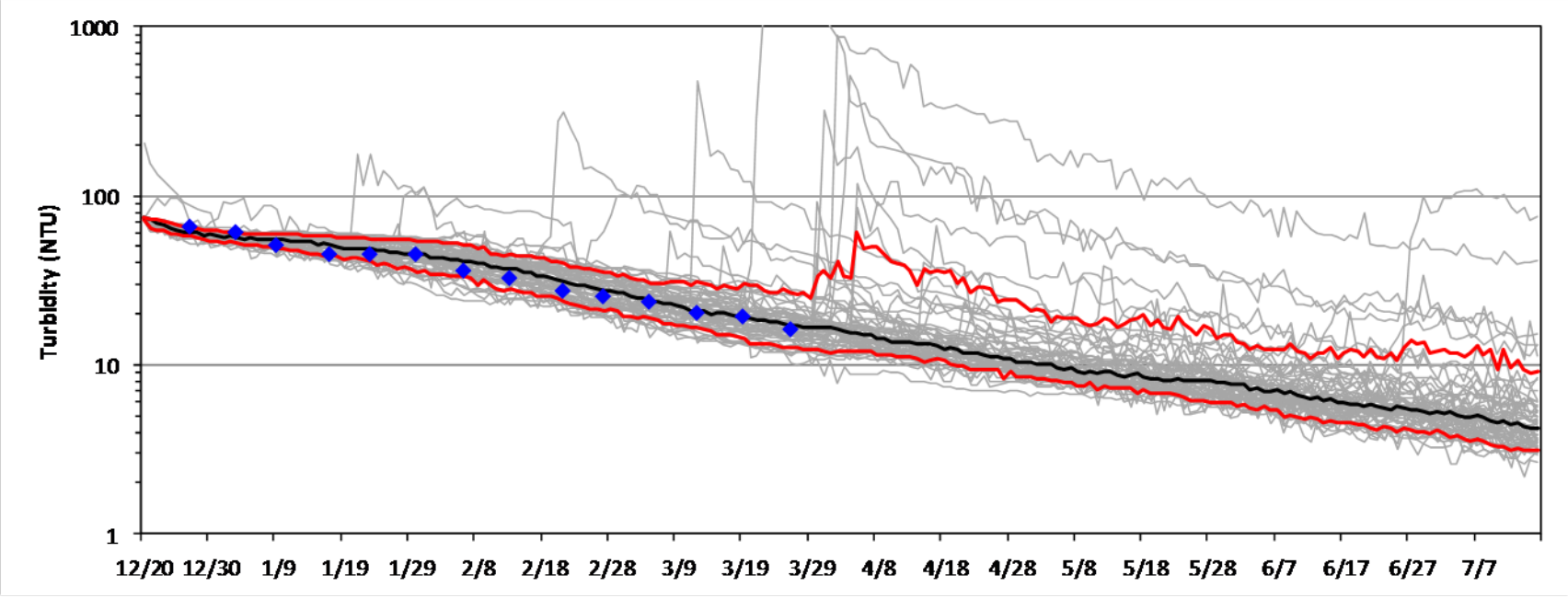

Date

Individual Traces

Median

10th and 90th Percentiles

Keypoint Data - West Basin Gate House (middle level)

Ashokan Reservoir – East Basin Results

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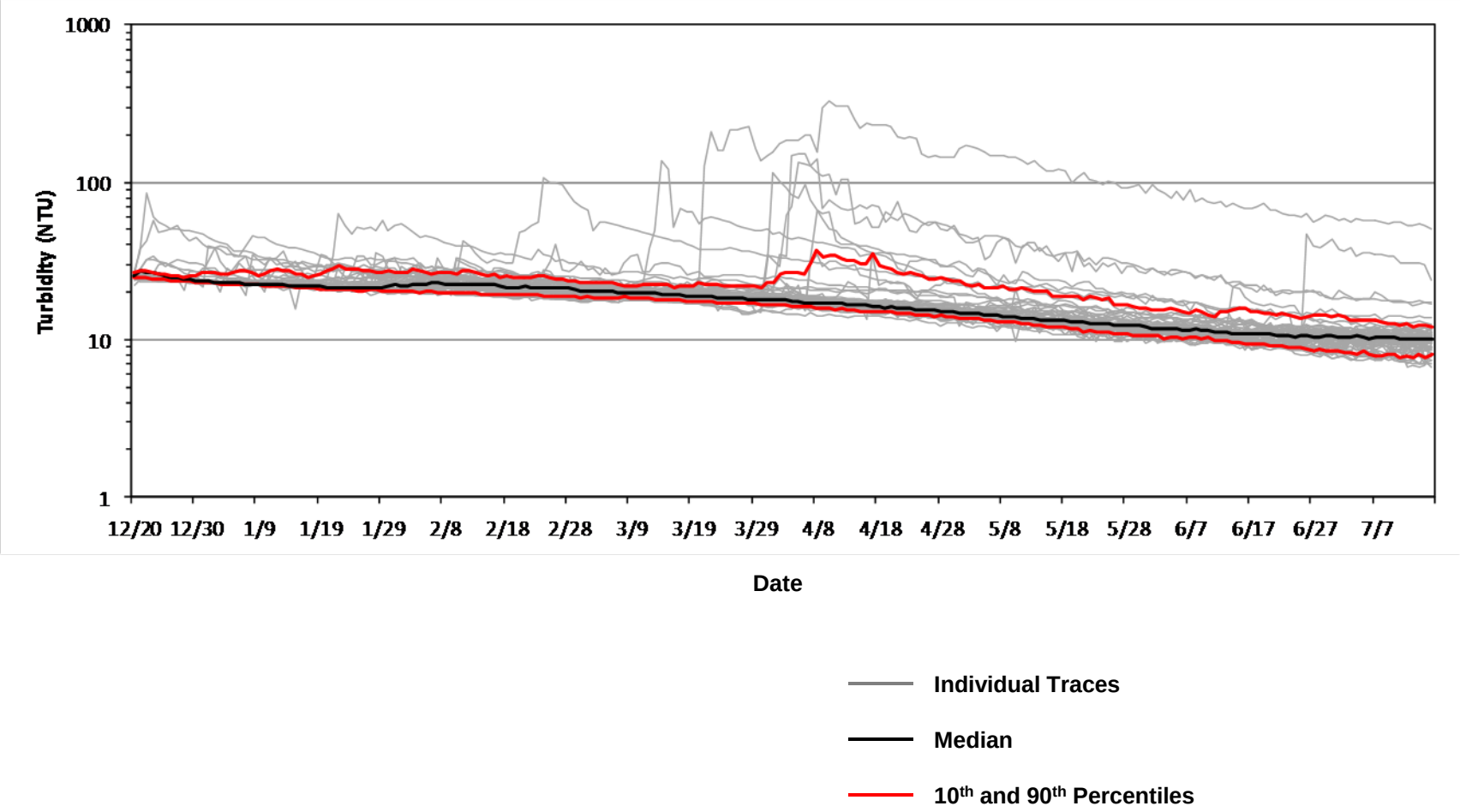
Turbidity Ashokan East Basin near Gate House



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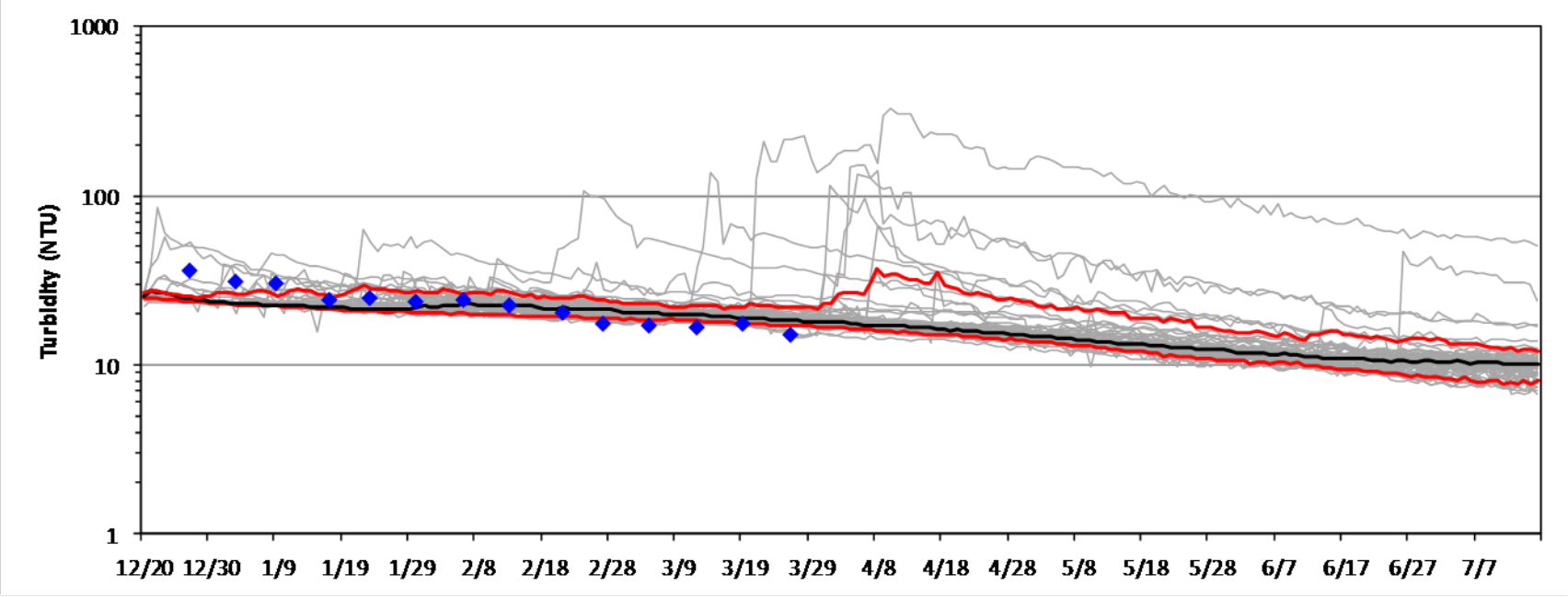

Individual Traces

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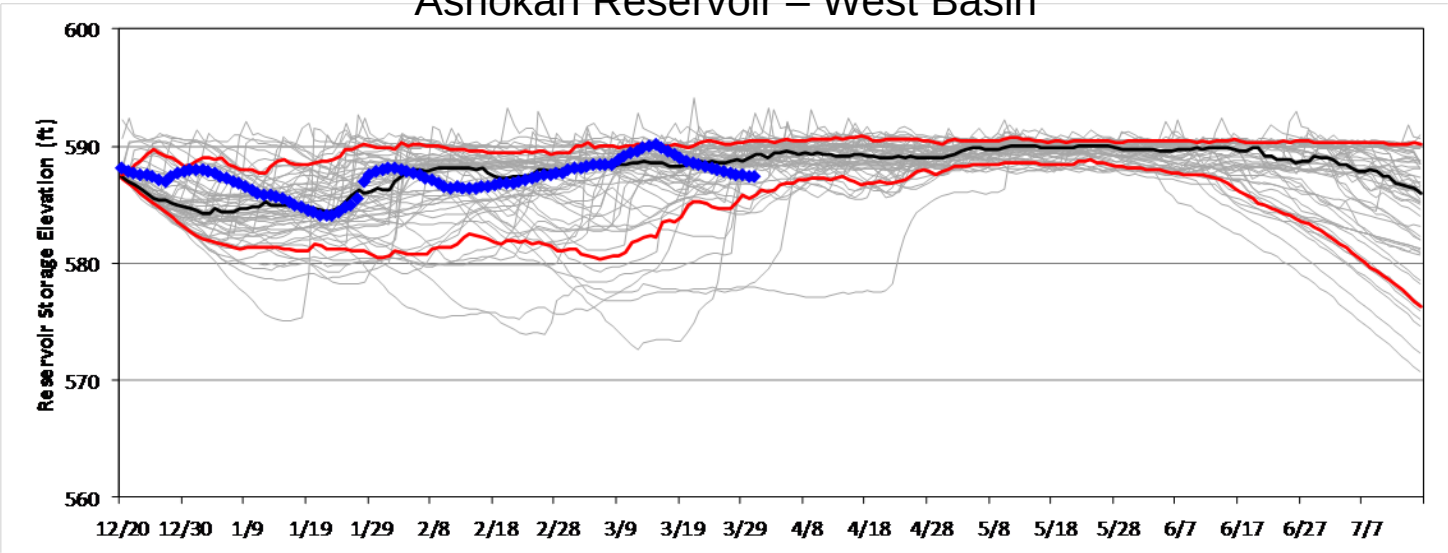

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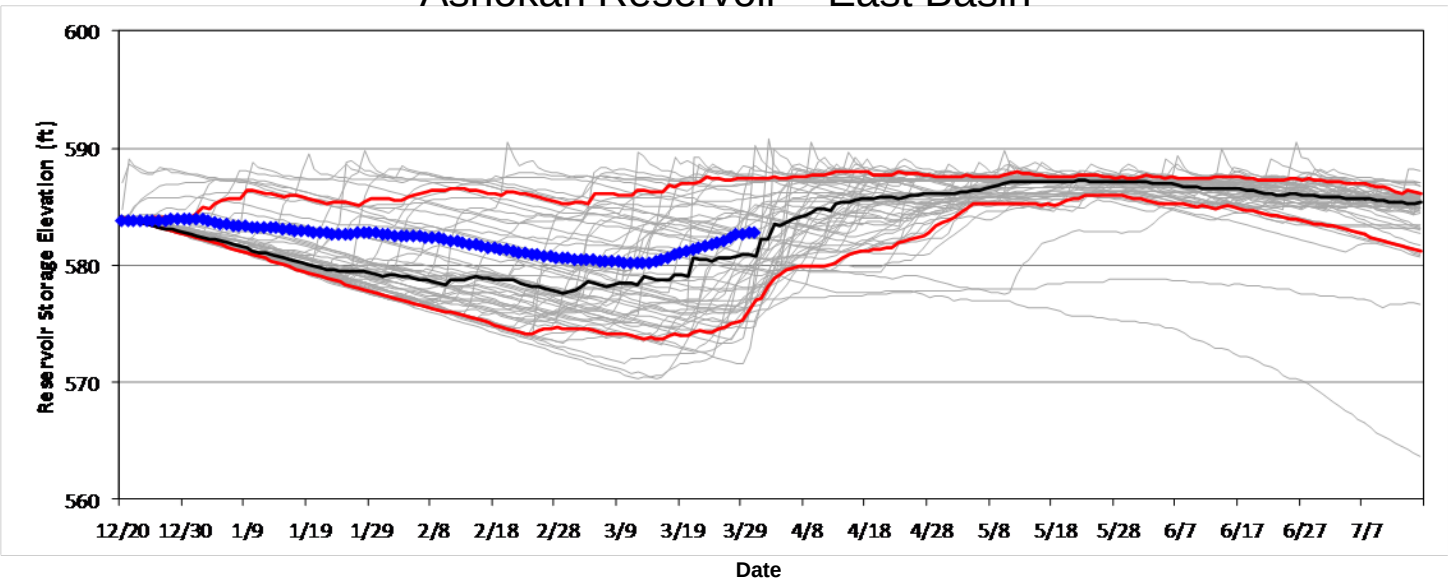

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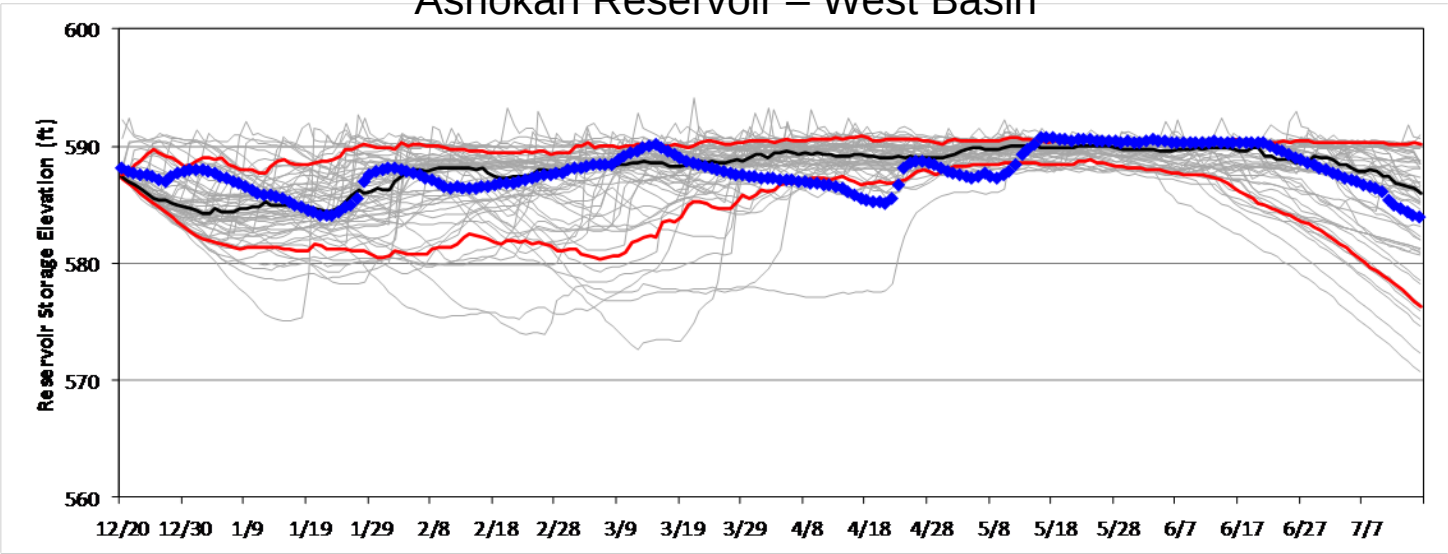

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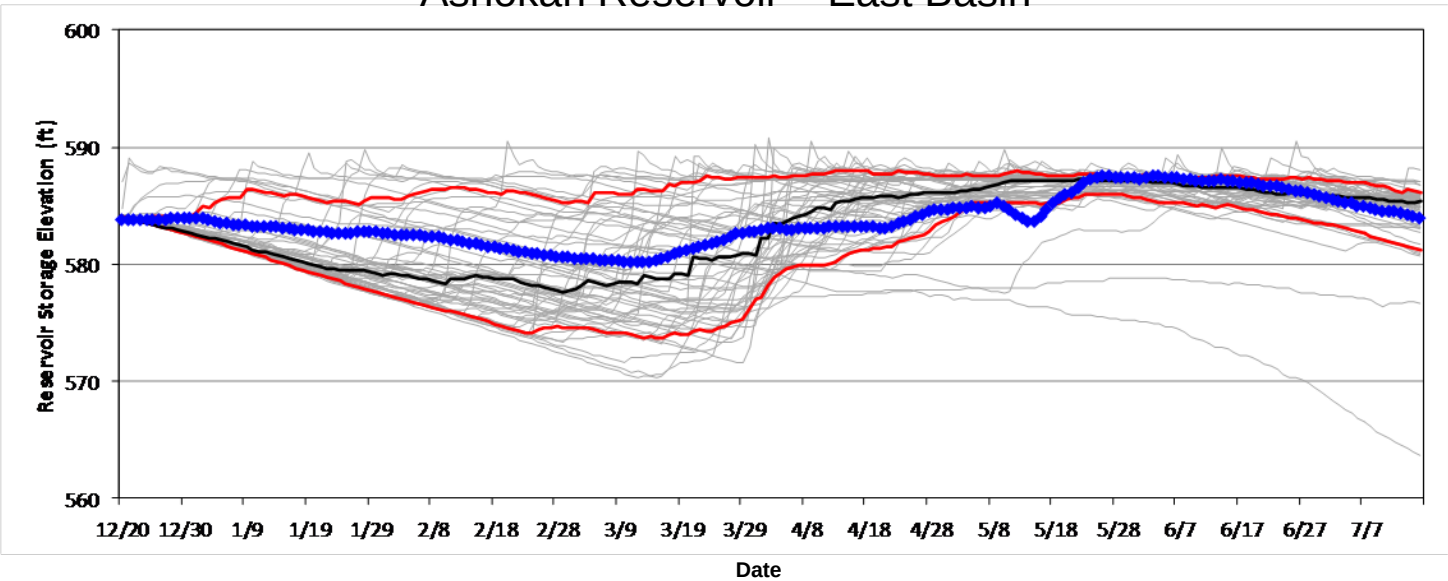

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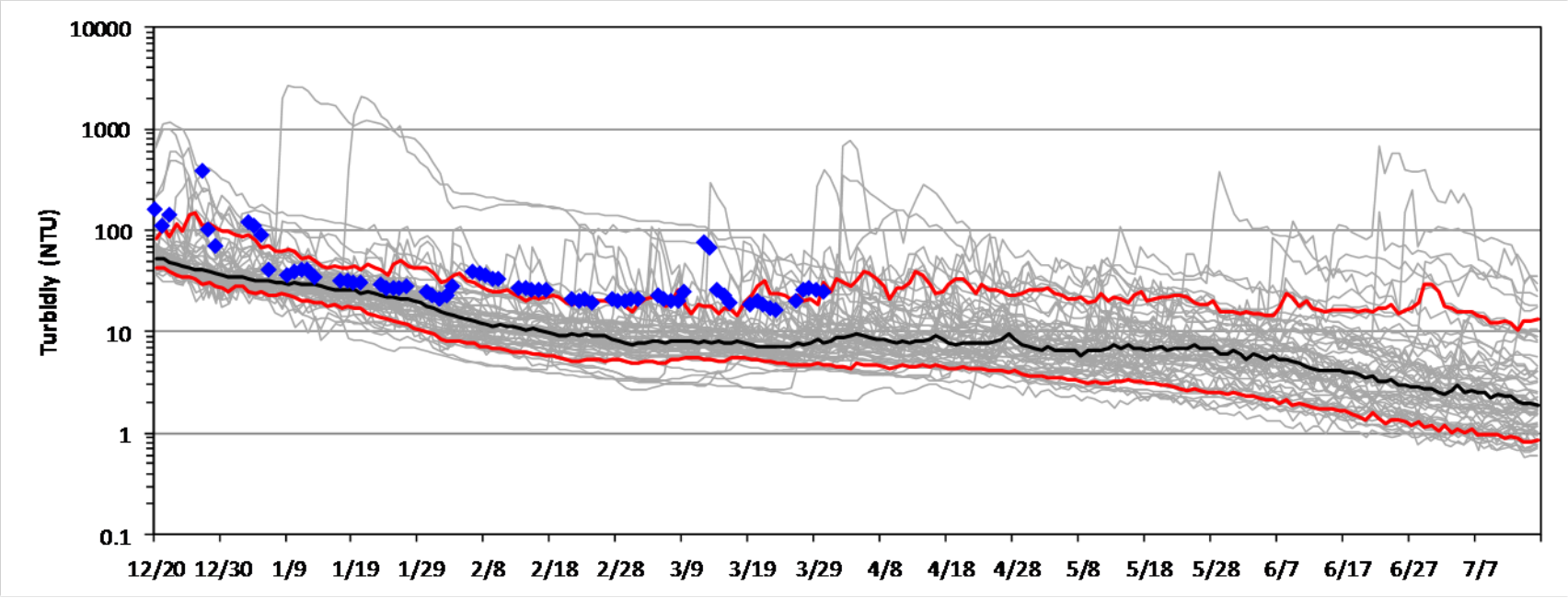

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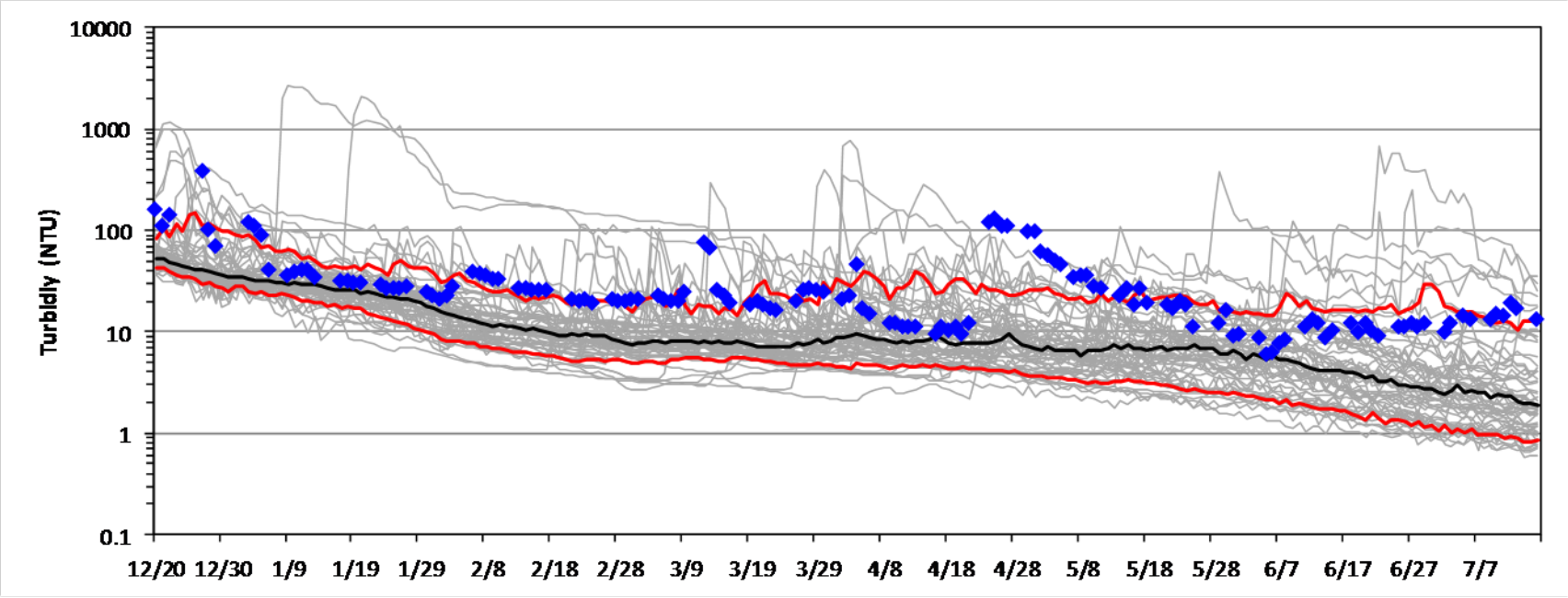

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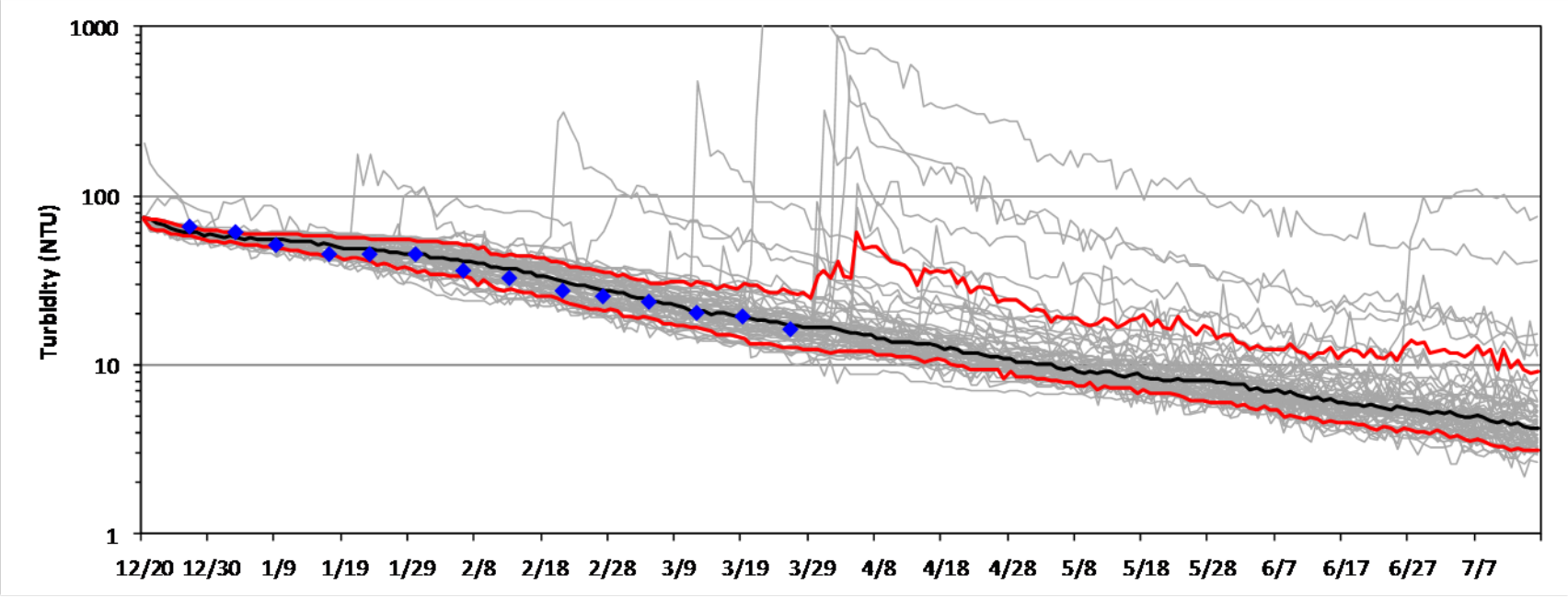

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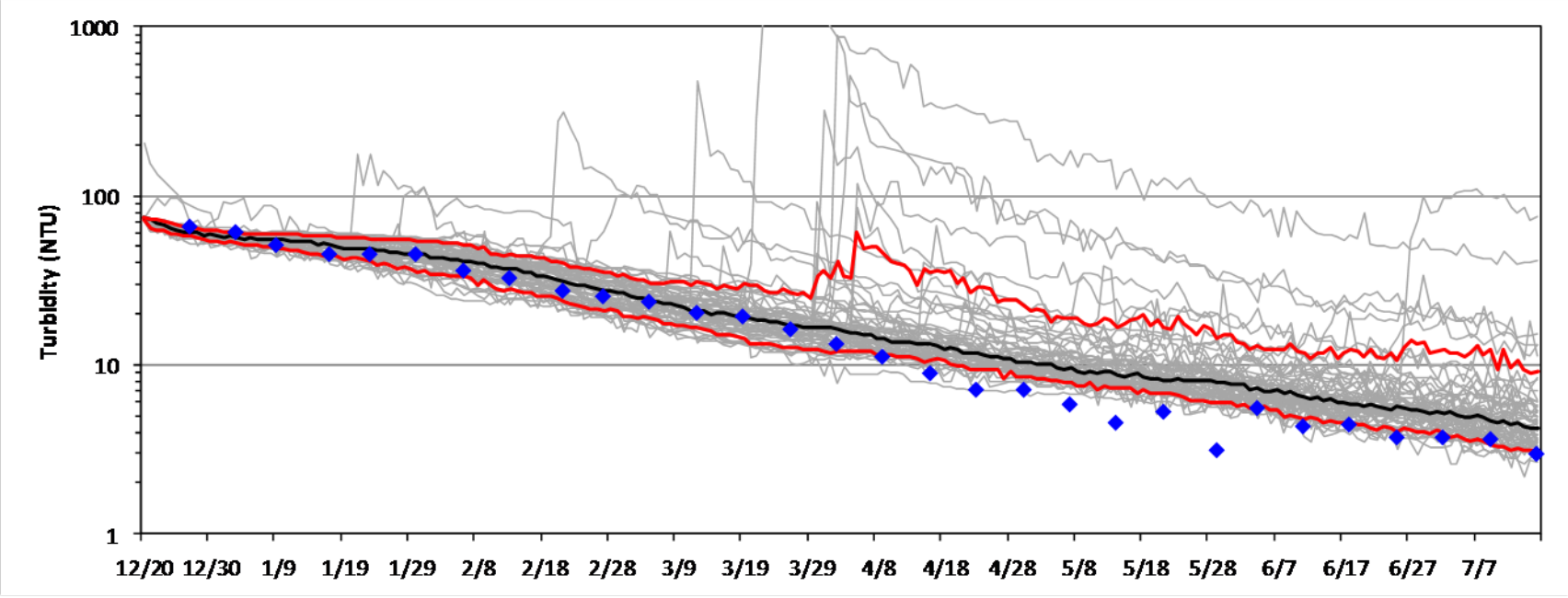

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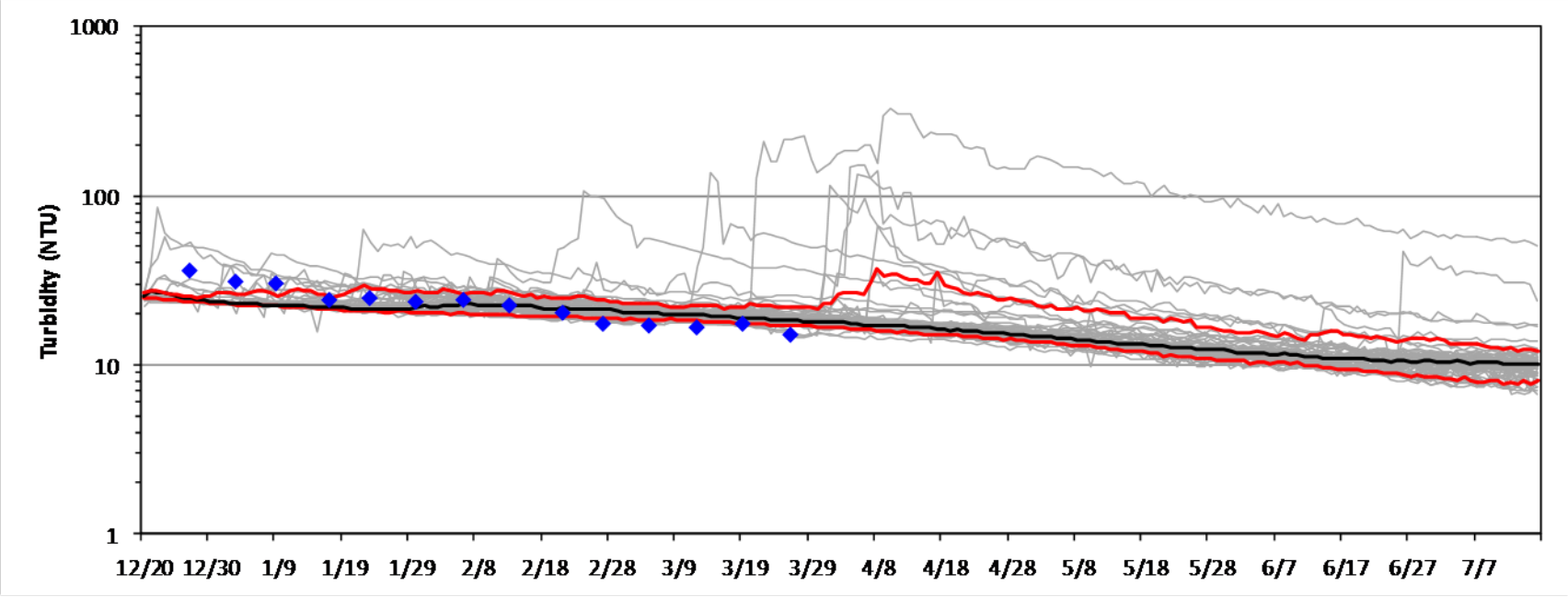

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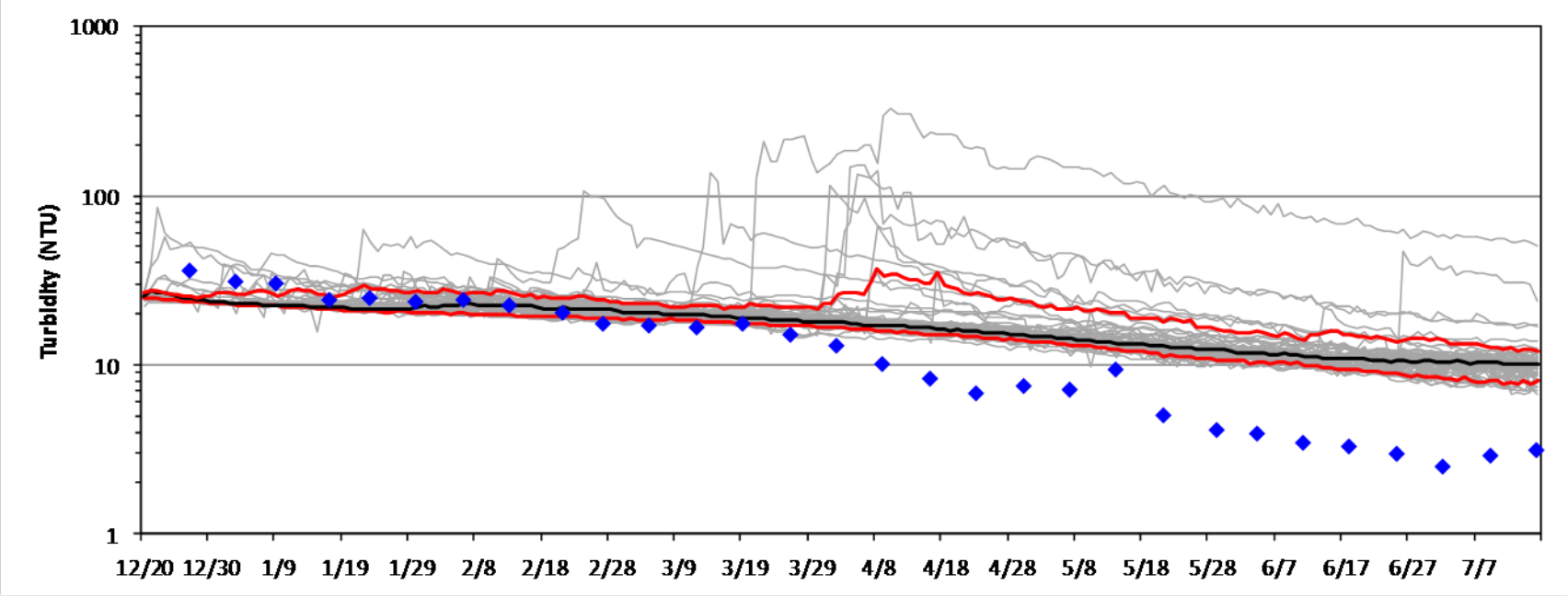

Individual Traces

Median

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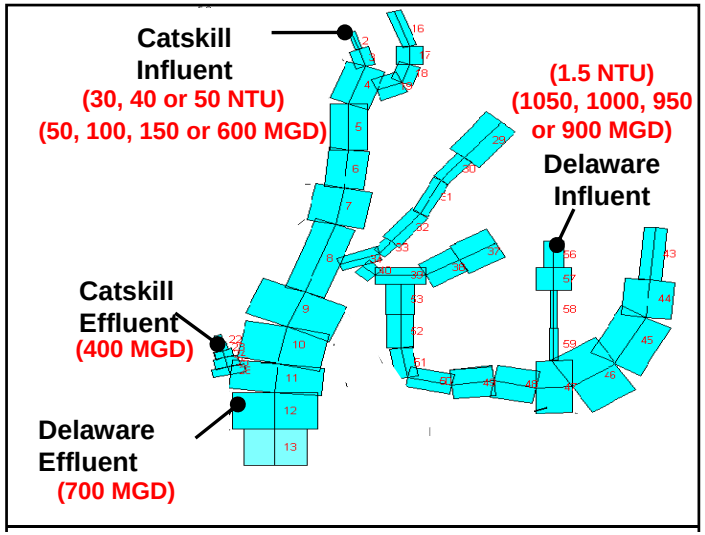
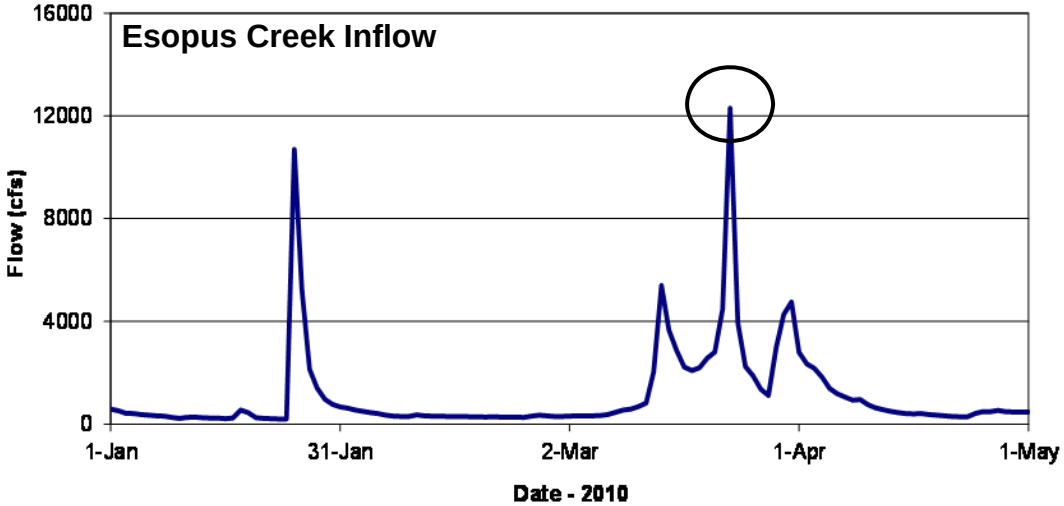
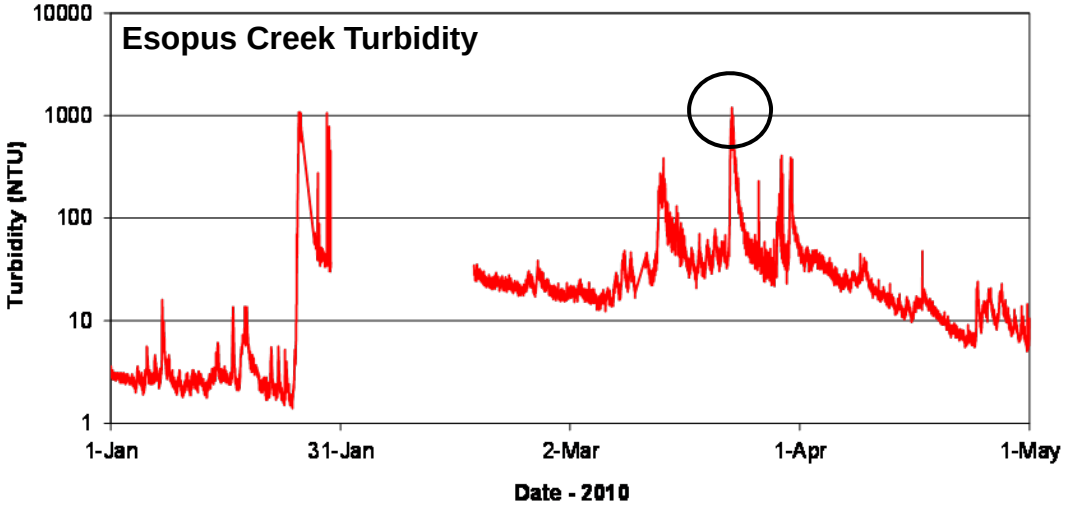
Keypoint Data - East Basin Gate House

Case Study – Late March 2010

- A large rain and snowmelt event occurred on March 22, leading to elevated turbidity in Ashokan Reservoir.
- Stop shutters were installed in the Catskill Aqueduct to permit reduced flows from Catskill into Kensico Reservoir.
- What aqueduct flow rates should be used based on potential turbidity inputs from the Ashokan diversion?
- Kensico CEQUAL-W2 reservoir model is used to determine effects of elevated turbidity at various Catskill Aqueduct flow rates on Kensico Reservoir effluent.

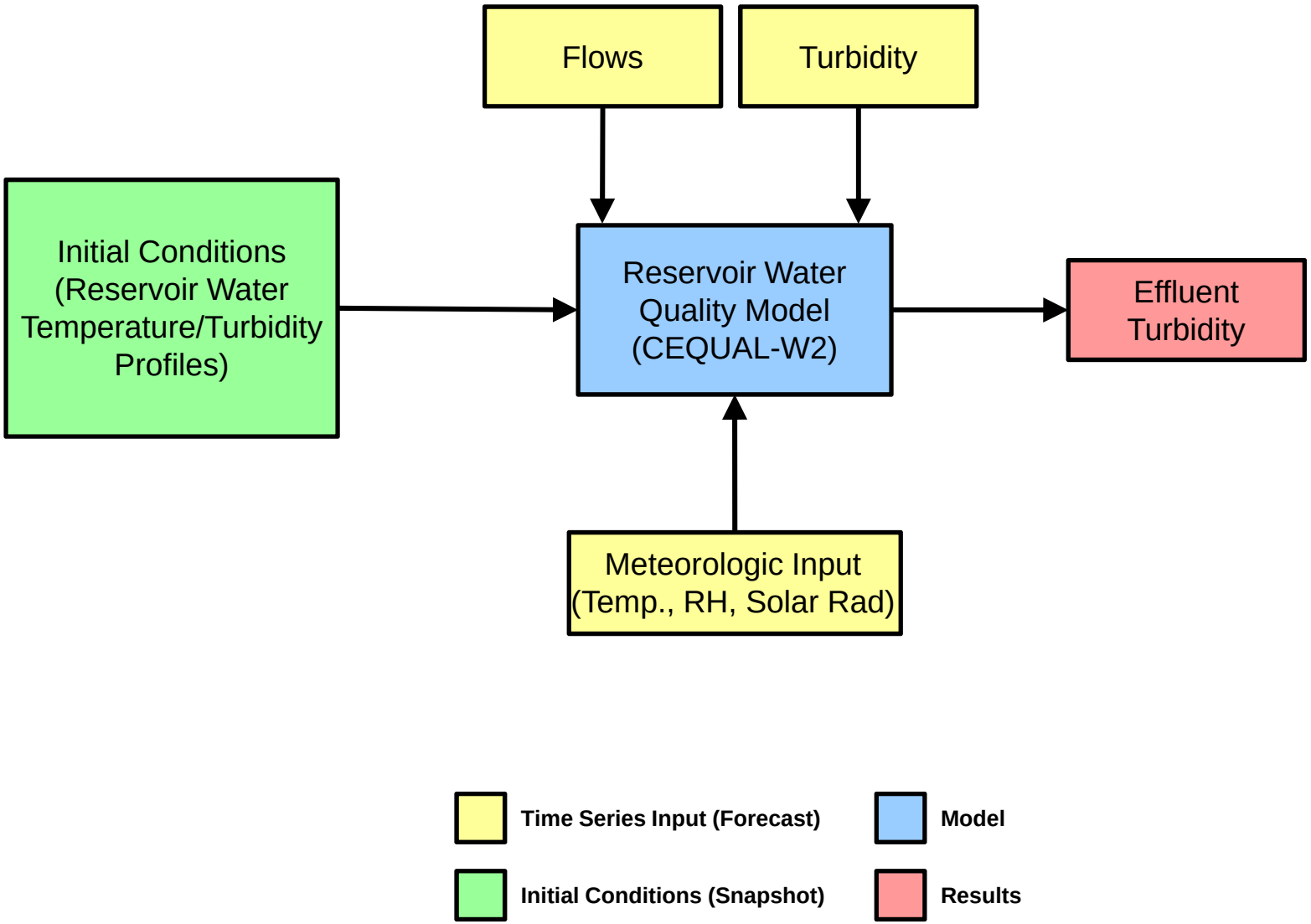






Model Description – Application Method

Kensico Sensitivity Model Application



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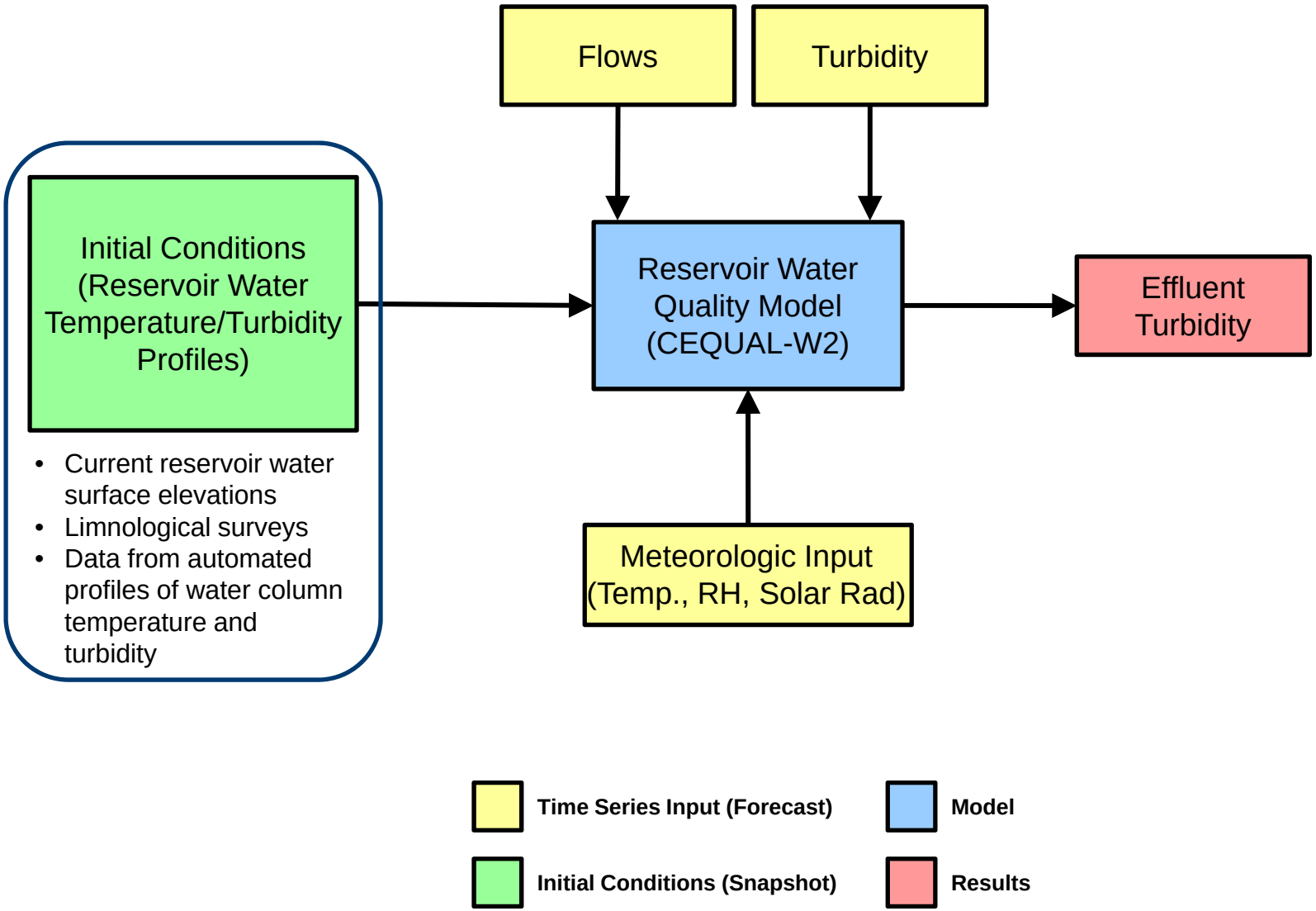

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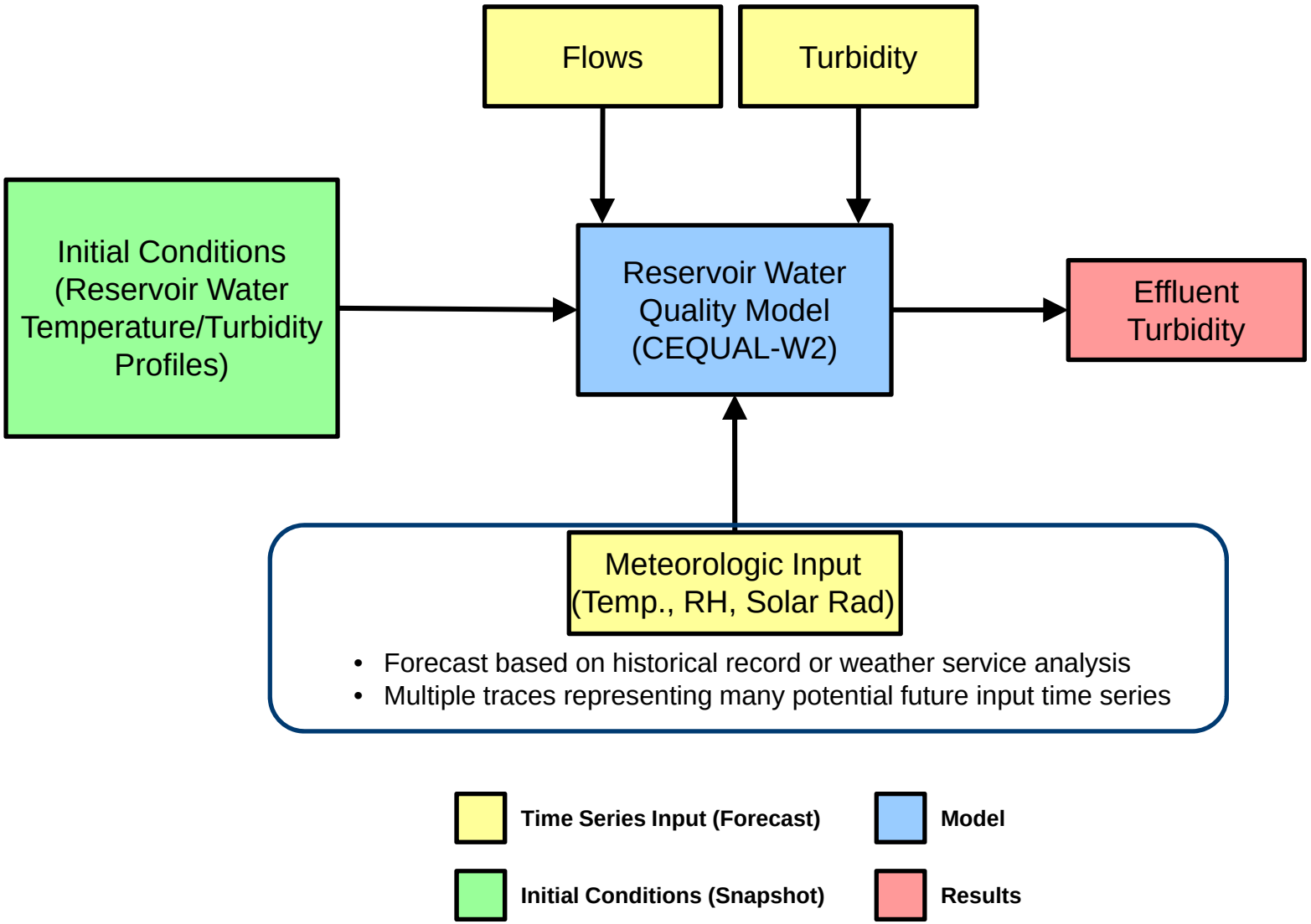

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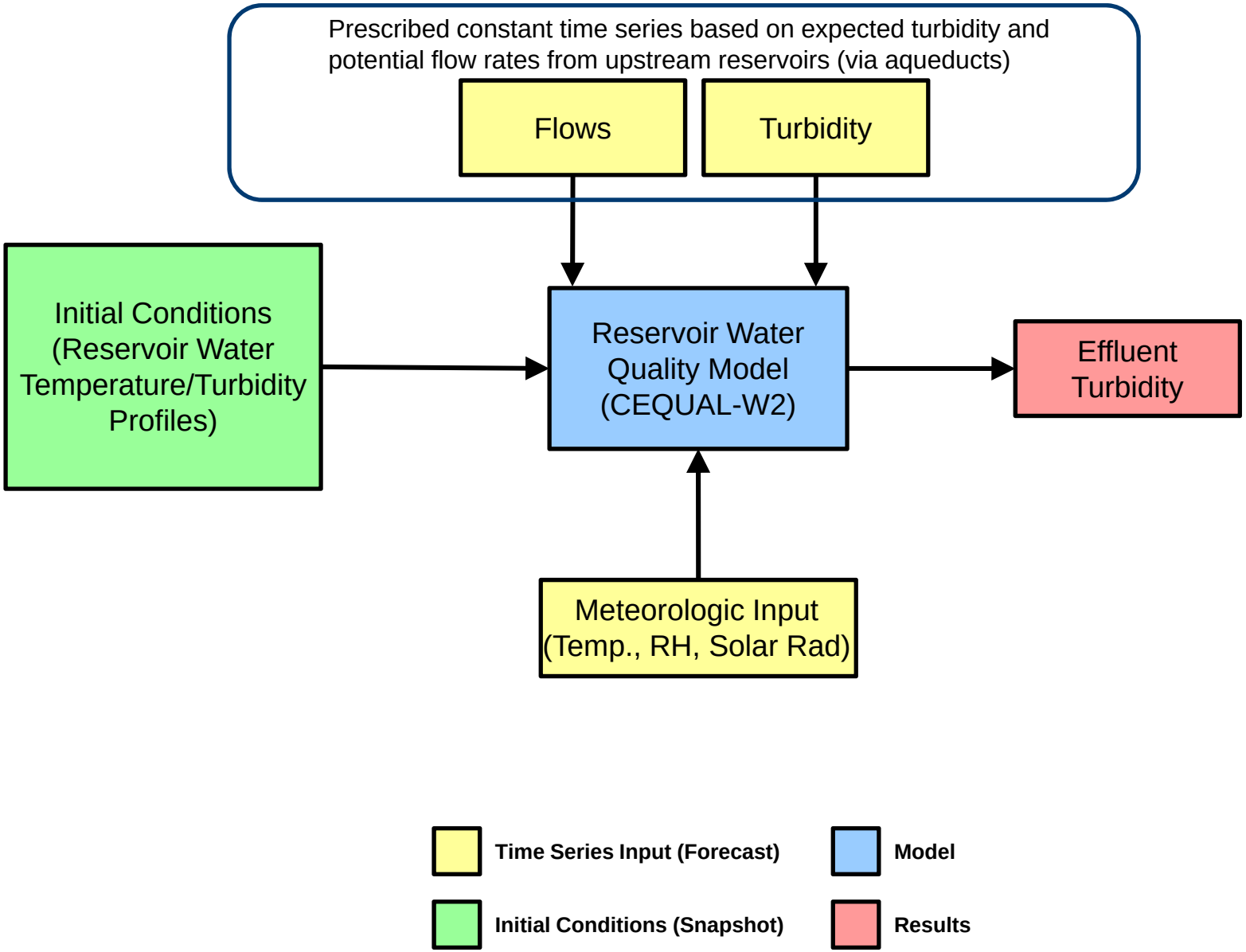

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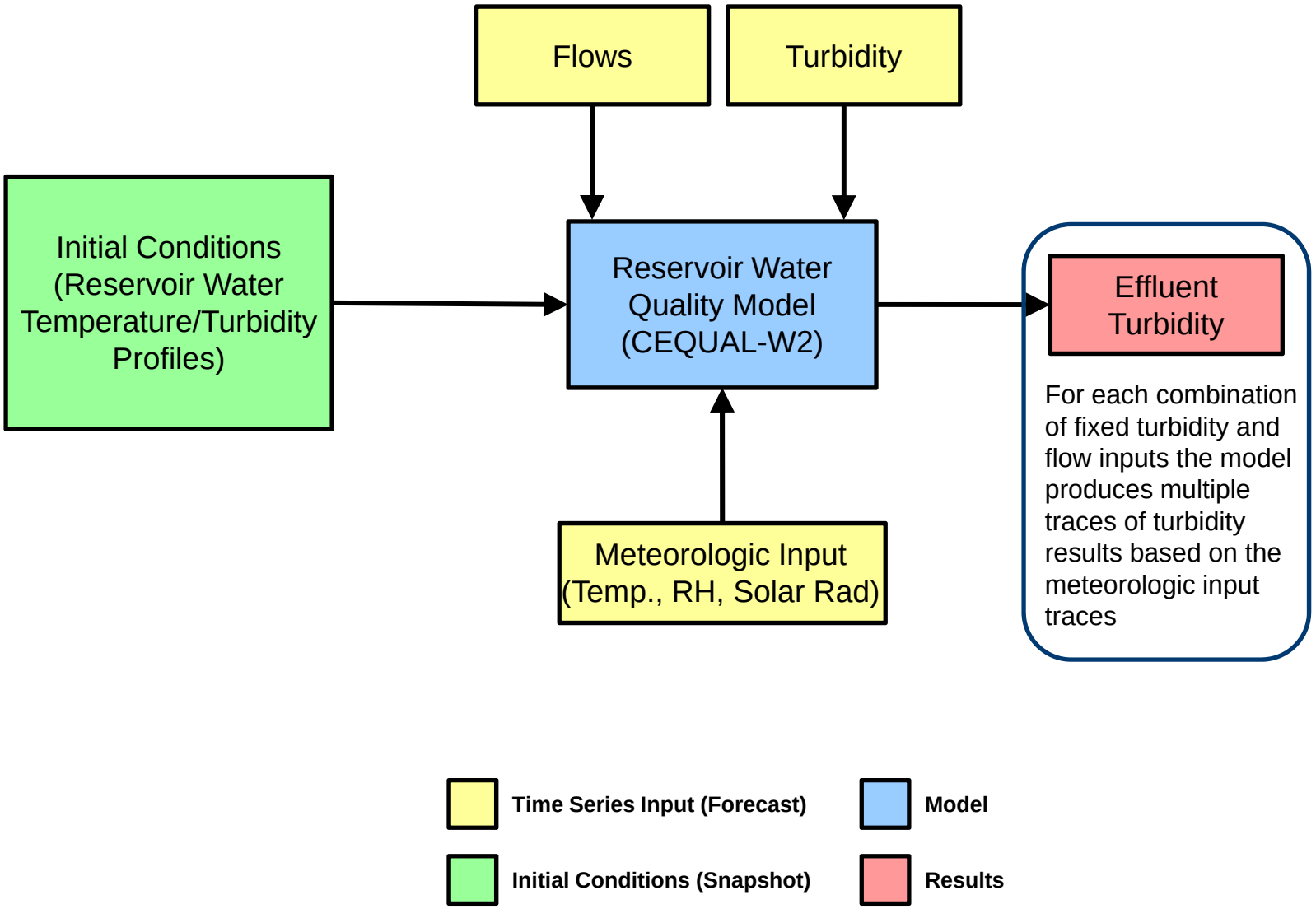


Kensico Analysis Results – March 25, 2010

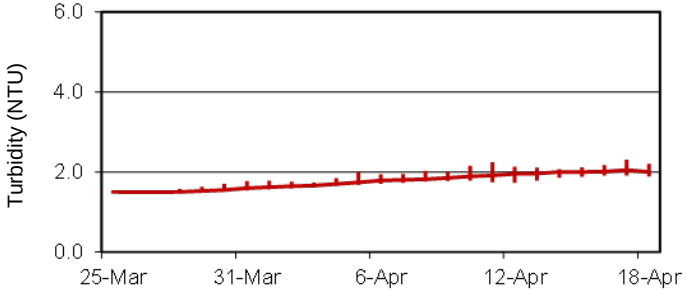
Simulated Delaware Effluent Turbidity

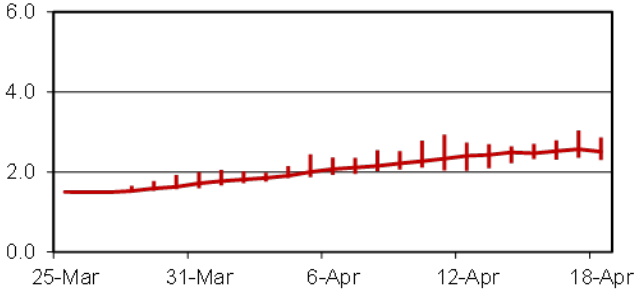
Catskill Aqueduct Inflow

Catskill Aqueduct Influent Turbidity

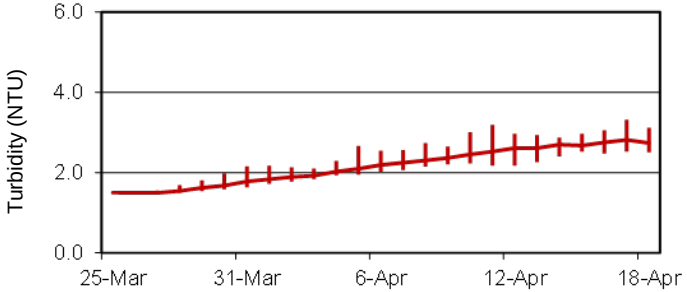
30 NTU | **50 NTU**

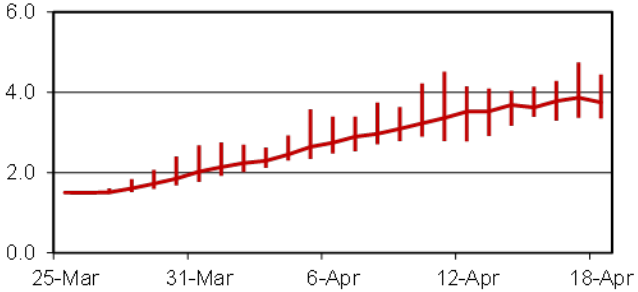
50 MGD



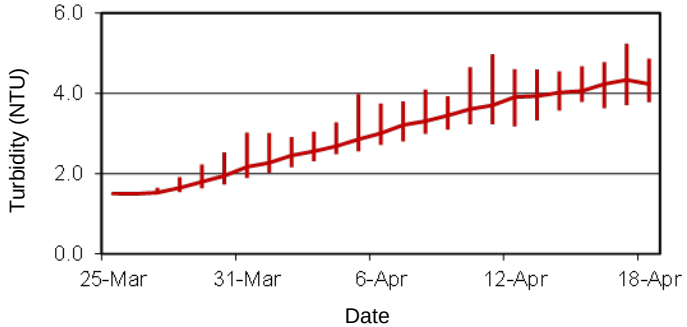


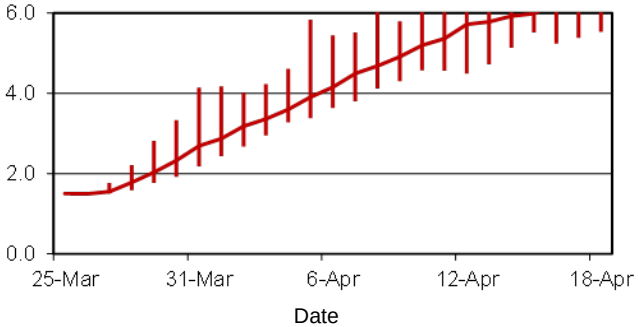
100 MGD





200 MGD



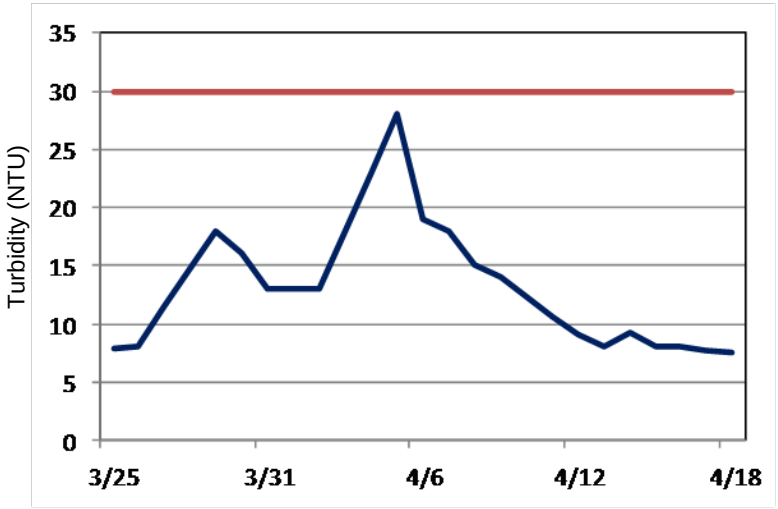


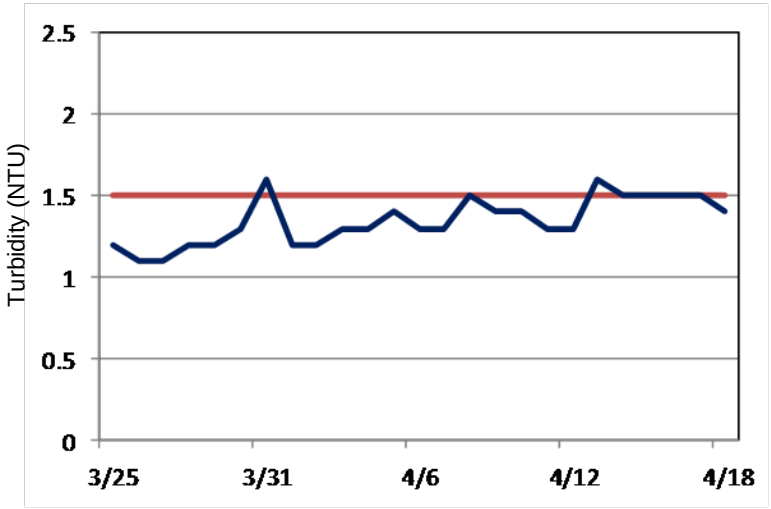
Kensico Results - Comparison

Catskill Aqueduct Input Chosen for Comparison: 30 NTU @ 50 MGD

Catskill Aqueduct | Delaware Aqueduct

Influent Turbidity

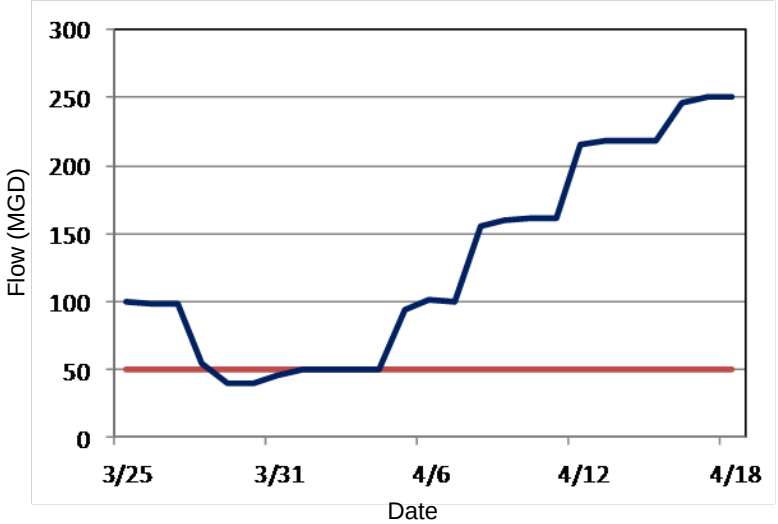


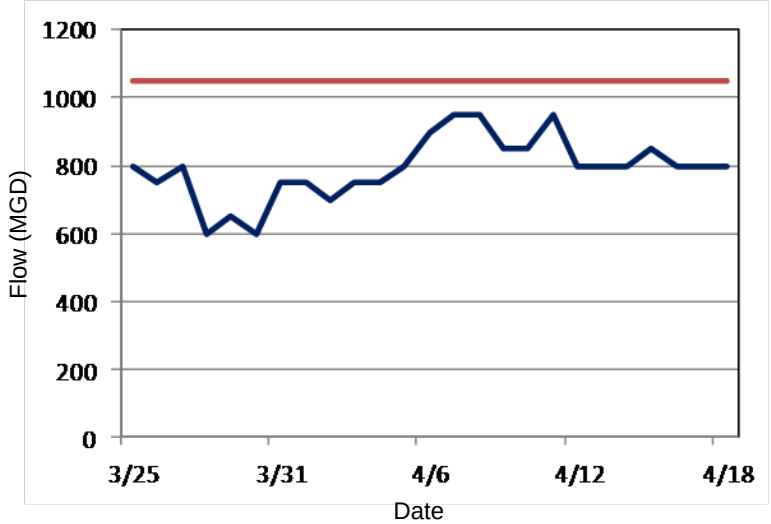


Data

Model Input

Inflows



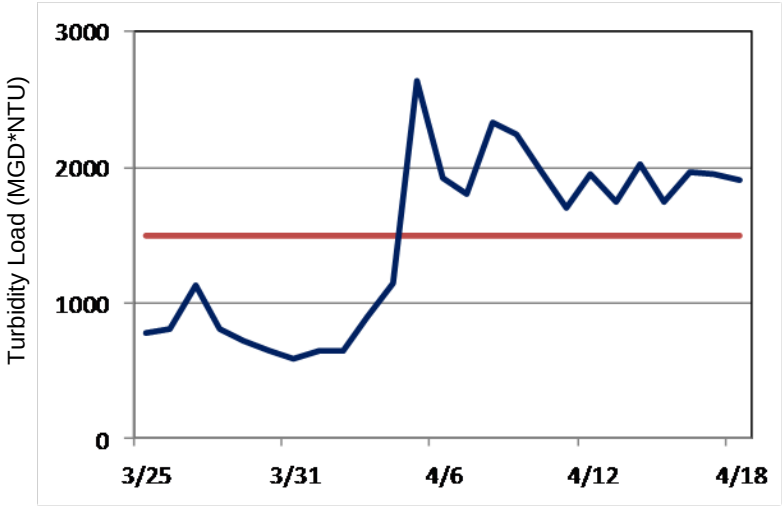


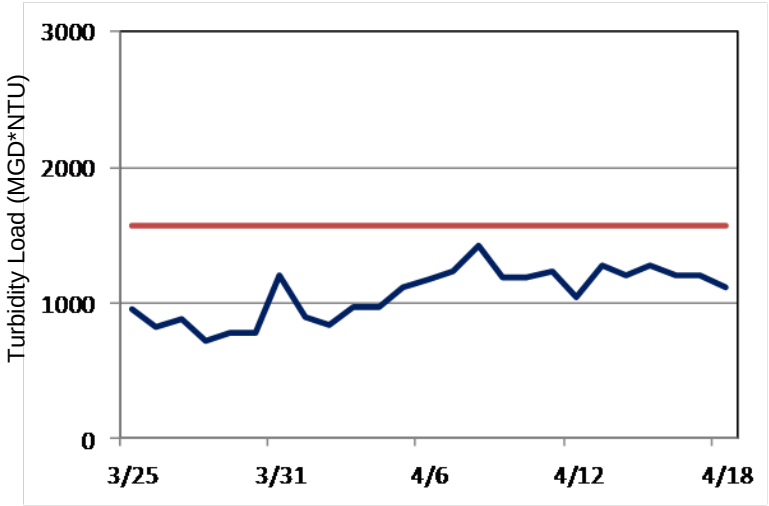
Kensico Results - Comparison

Catskill Aqueduct Input Chosen for Comparison: 30 NTU @ 50 MGD

Catskill Aqueduct | Delaware Aqueduct

Influent Turbidity Load

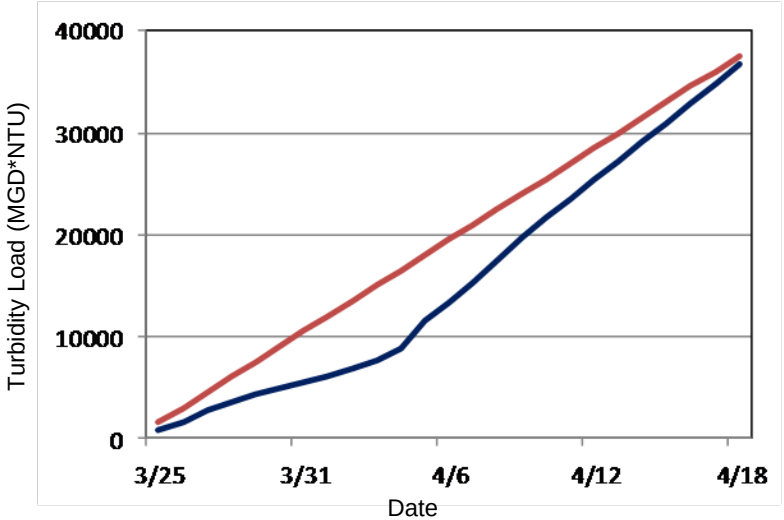


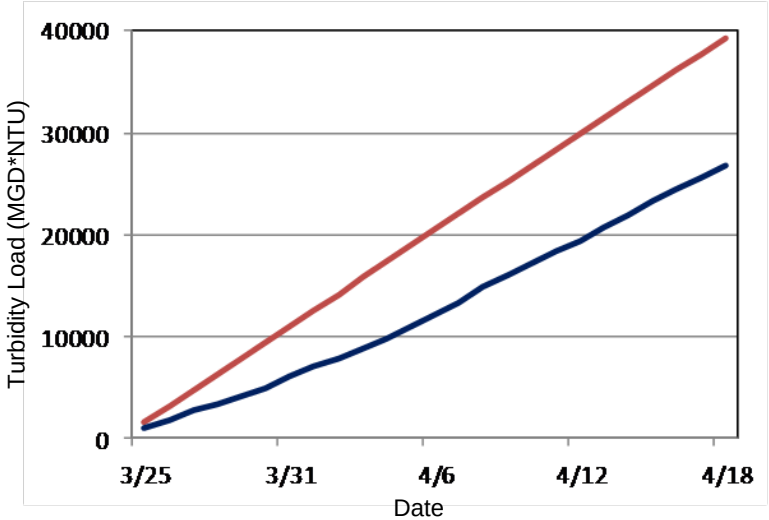


Data

Model Input

Cumulative Influent Turbidity Load



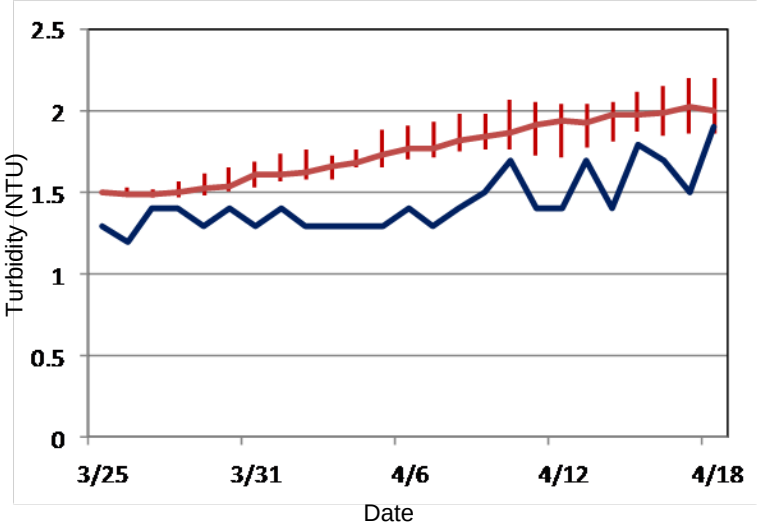


Kensico Results - Comparison

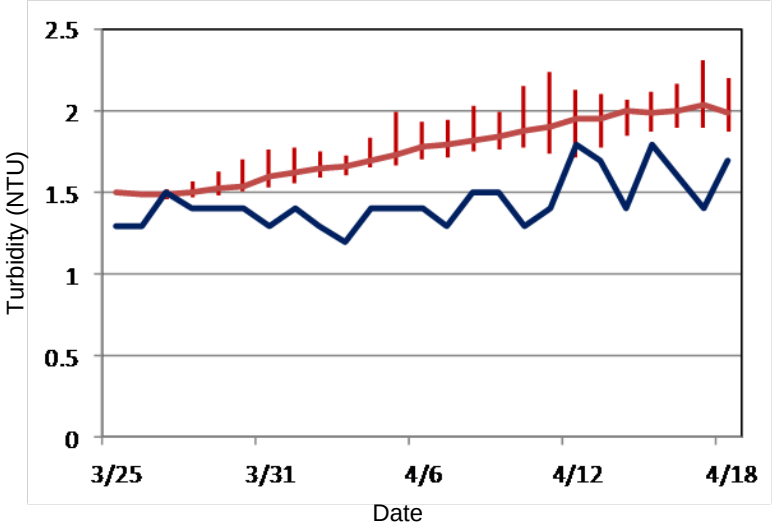
Catskill Aqueduct Input Chosen for Comparison: 30 NTU @ 50 MGD

Effluent Turbidity

Catskill Aqueduct



Delaware Aqueduct



Data

Model Output

Conclusions

- DEP has developed an extensive suite of water quality and water system models to analyze turbidity transport within the Catskill System Reservoirs.

- DEP's water quality models have been effectively used to help minimize turbidity within Kensico Reservoir.

- Uncertainties in modeling system results can arise from initial conditions, forecast inputs and model errors.

- Model output uncertainty tends to increase as the length of the model run increases.

- Tracing simulation results by comparison with measured data can indicate:
    - when model output no longer applies
    - when forecast may need to be redone
    - areas of improvement for the modeling system .