

Hydrologic Modeling Validation & DWR's use of WaterFALL

November 27, 2012

Ecological Flow Science Advisory Board

**Tom Fransen
Division of Water Resources
NC Department of Environment and Natural Resources**



Modeling and Ecological Flows Issues/Concerns

- **Historically the models have focused on water supply (municipal and industrial) reliability.**
 - **Larger streams and rivers that support or the potential to support withdrawal and discharges of 100,000 gpd or greater.**
 - **Calibration and validation is concentrated on normal and low flow periods, when the water supplies are stressed.**
 - **Normal 25th to 75th percentiles**
 - **The 20th Percentile to the Low Flow Minimum of Record (20th percentile is the beginning of D1 – Moderate Drought conditions.)**

Terminology

- **Calibration** is the estimation and adjustment of model parameters and constants to improve the agreement between model output and a data set. Models contain variables and constants that need to be parameterized. Calibration improves the parameterization of a model. Calibration can occur as part of either verification or validation.
- **Validation** is a demonstration that a model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model, refers to its performance. It refers to the processes and techniques that are used to assure that the model represents the real system (or proposed real system) to a sufficient level of accuracy. *Validation compares simulated system output with real system observations using data not used in model development.*
- **Certification** encompasses calibration and validation and includes such things as documentation, quality assurance, and version control. Certification is intended to put a "seal" of credibility on a model. Certification means that a certain standard has been satisfied which offers some high level guidance on verification and validation of the model.

How good is good enough?

We're not making watches.

To answer the question “How good is good enough” depends upon the intended uses of a model. DWR’s models are planning tools for water resources planning, NOT a regulatory tool for water allocation.

How good is good enough?

Is the model good enough to meet the requirements of SL 2010-143:

- **Locations the yield may be inadequate to meet all needs or meet all essential water uses:**

- **Determine the yield of reservoirs?**
- **Determine the yield of run-of-river intakes?**
- **Determine the yield of wells?**

Groundwater resources within the river basin to the extent known by the Department.

- **Determine the location ecological flows are adversely impacted?**

How good is good enough?

Is the model good enough to meet the non-SL 2010-143 uses of the model?

- **Water resources planning issues (not covered in SL 2010-143):**
 - **Screening of alternative water supplies?**
 - **Are water shortage response plan triggers adequate & how to improve the triggers?**
 - **Hydroelectric generation impacts?**
 - **Recreational impacts – river and lake?**
- **Real-time drought management – forecasting?**

DWR's New Validation Approach

The inflow datasets are created using gage extension techniques on monthly USGS streamflow data. Since the planning efforts are focused on the larger streams, rivers, and reservoir that can support a 100,000 gpd or larger withdrawal, having a good annual and monthly validation is adequate. DWR includes the daily analyzes to check to be sure there is nothing outline that will impact the model results. Analyzes are done at streamflow nodes with good long-term USGS records and existing reservoirs with good operations records.

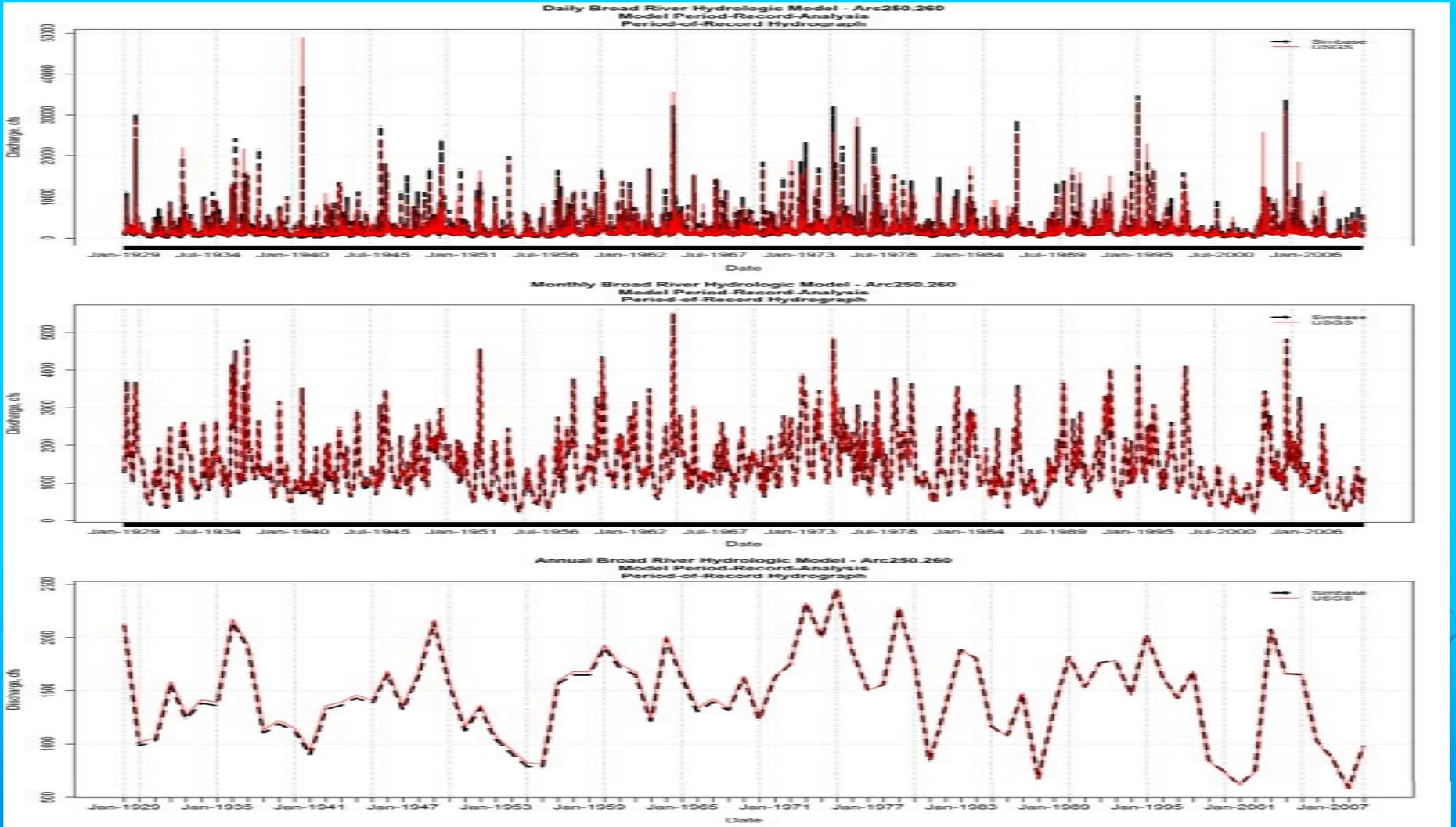
Overall Goodness-Of-Fit (GOF)

- **Standard Model Goodness-Of-Fit Statistics**
 - Nash-Sutcliffe efficiency (NSE) – satisfactory $NSE > 0.50$
 - Ratio of the root mean square error to the standard deviation of the measured data (RSR) – satisfactory ≤ 0.70
 - Percent bias (PBIAS) – satisfactory $PBIAS \leq \pm 25\%$
 - Coefficient of determination (R^2) – satisfactory $R^2 > 0.5$
- **Qualitative**
 - *Hydrograph*
 - *Frequency Curve* – full range and low-flow ($\leq 30\%$)
 - Residuals – normalized as a percent difference
 - Scatter Plot – gage vs. model data

S.L. 2010-143 & Water Resources Planning GOF Measures

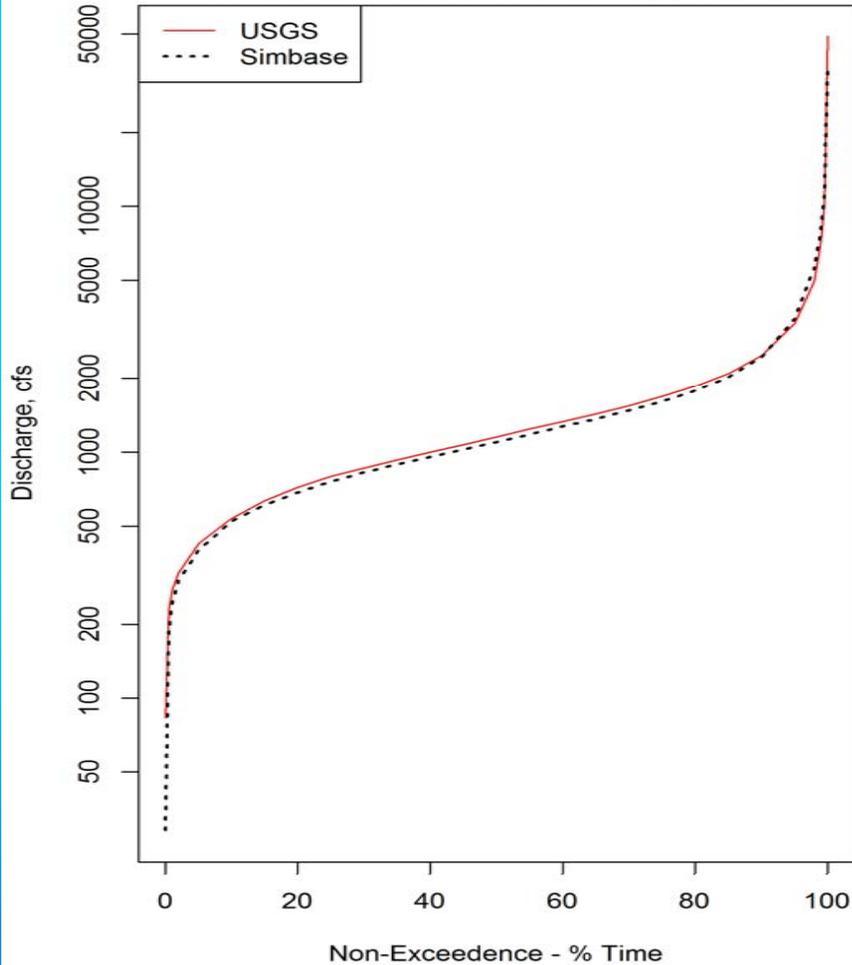
- **Reservoir and Run-Of-River Intake Yield**
 - Period-Of-Record mass curve analysis
- **Ground Water Yield**
 - Baseflow analysis
- **Ecological Flows (place holder)**
 - Low-Flow Log-Pearson III 7-Day
 - *Depending upon the SAB's recommendation, we probably will need to rethink the normal – low-flow approach.*
- **Drought Planning**
 - Low-Flow Log-Pearson III 30-Day
 - Drought Period Analysis based on National Drought Monitor

Overall Goodness-Of-Fit (GOF) *Hydrograph*

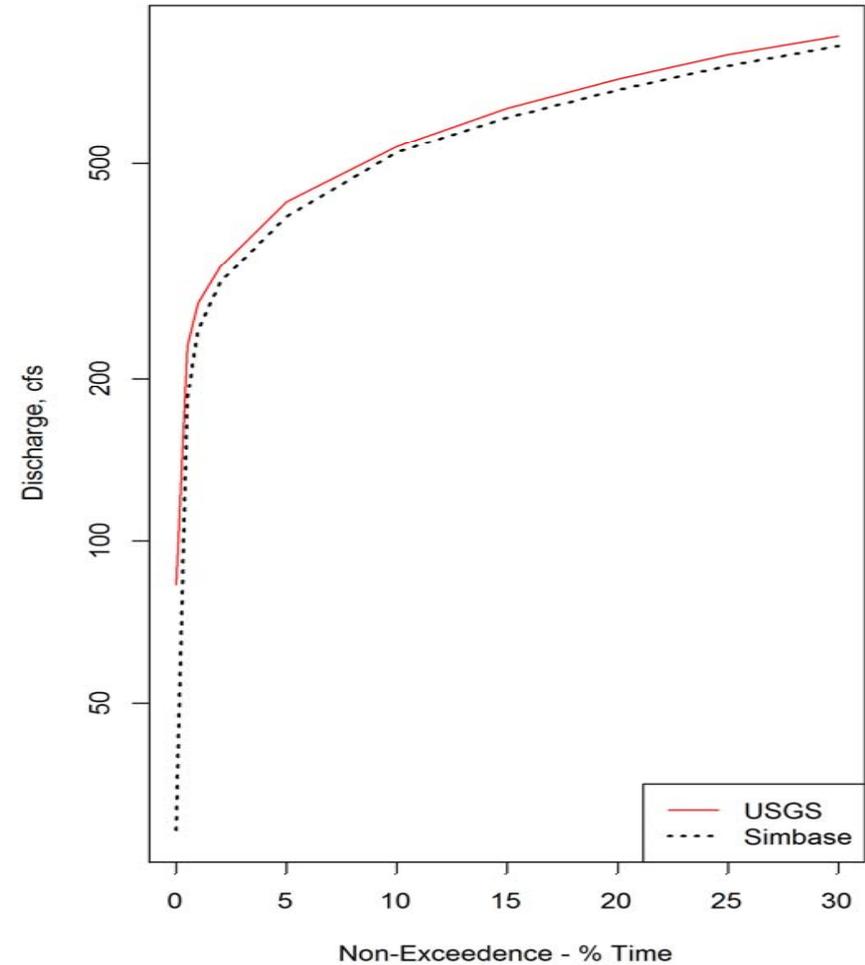


Overall Goodness-Of-Fit (GOF) *Frequency Curve*

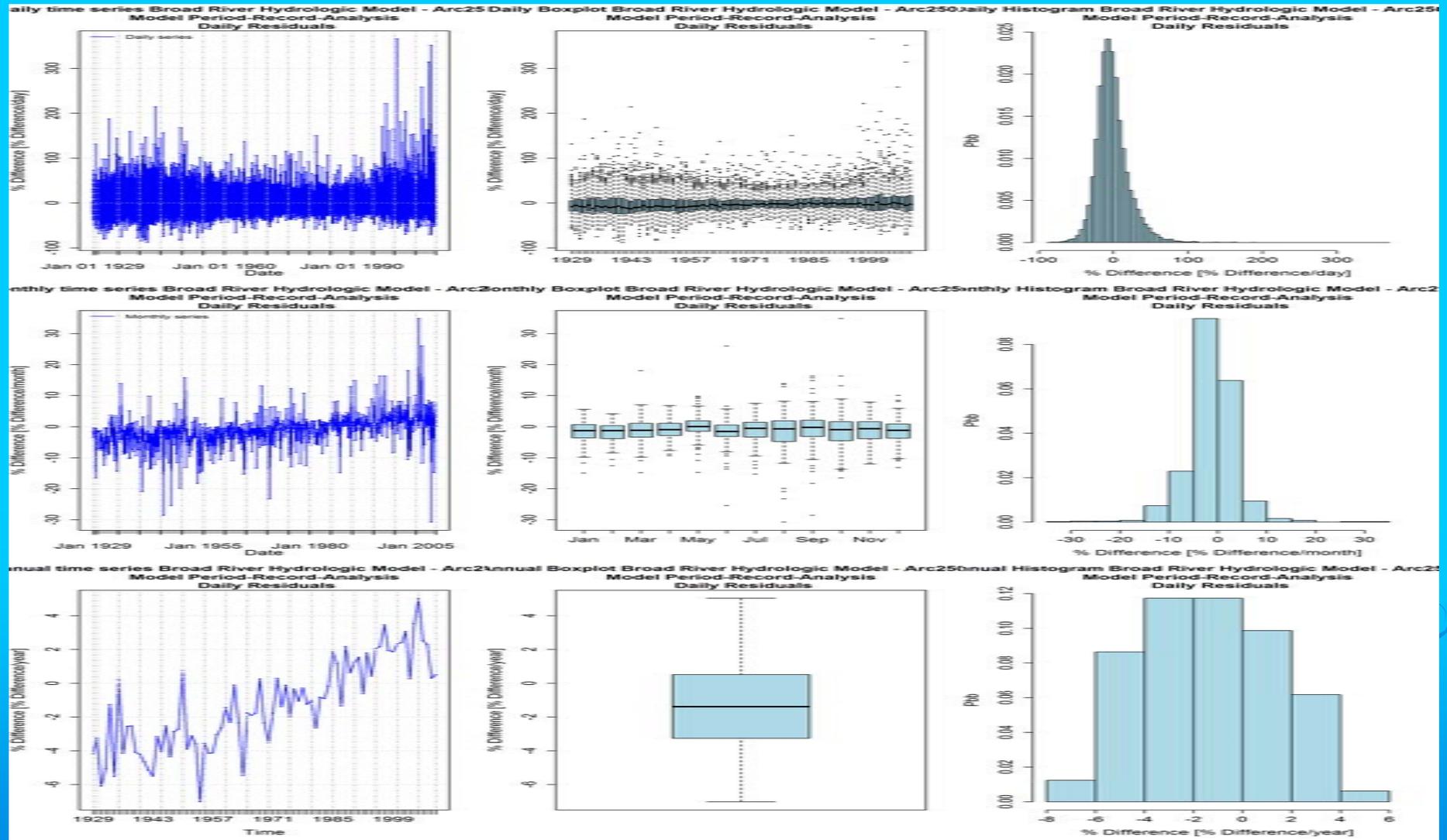
Broad River Hydrologic Model - Arc250.260
Model Period-Record-Analysis
Period-Of-Record - Frequency Curve



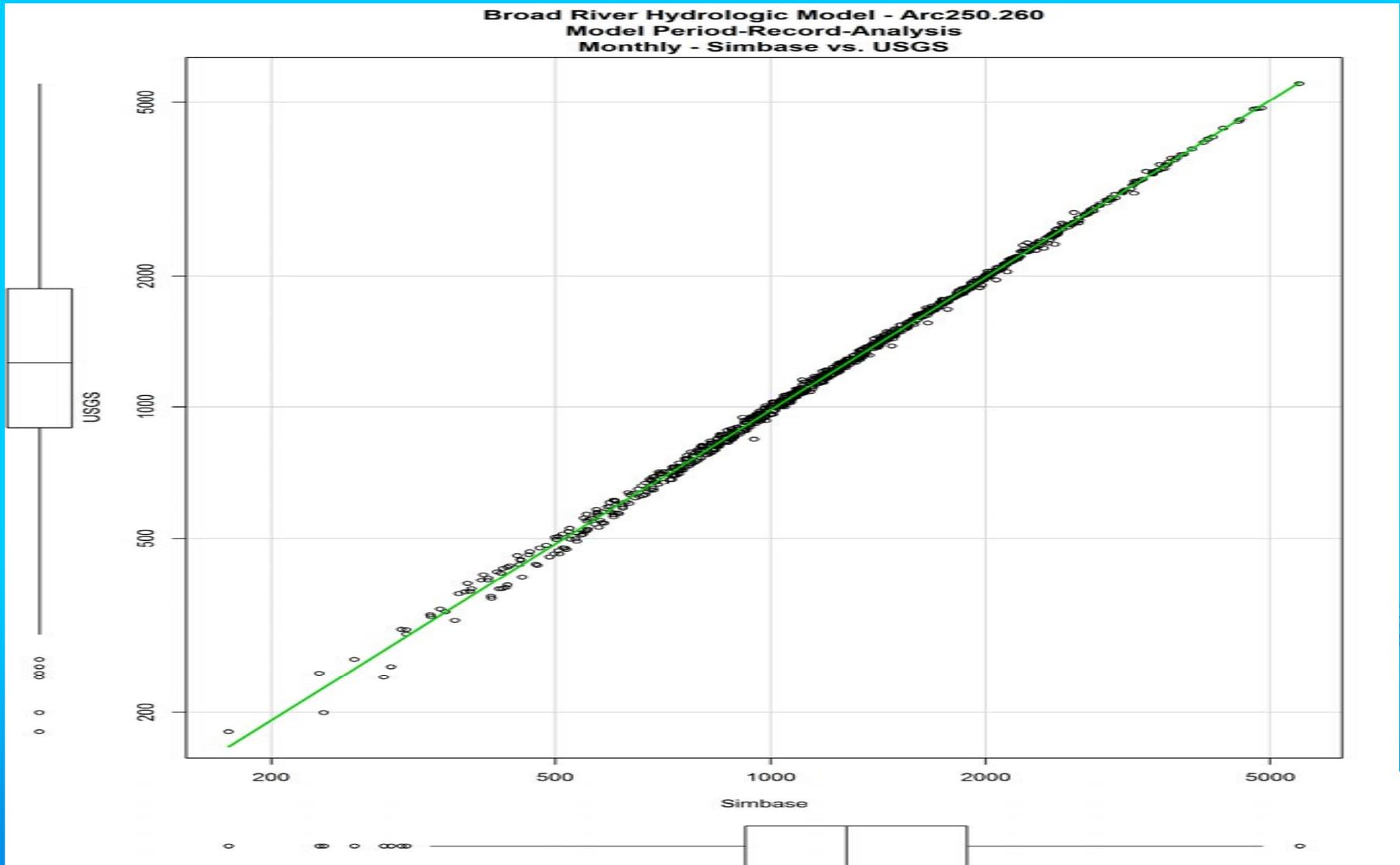
Period-Of-Record - Low-Flow Frequency Curve



Overall Goodness-Of-Fit (GOF) Residuals

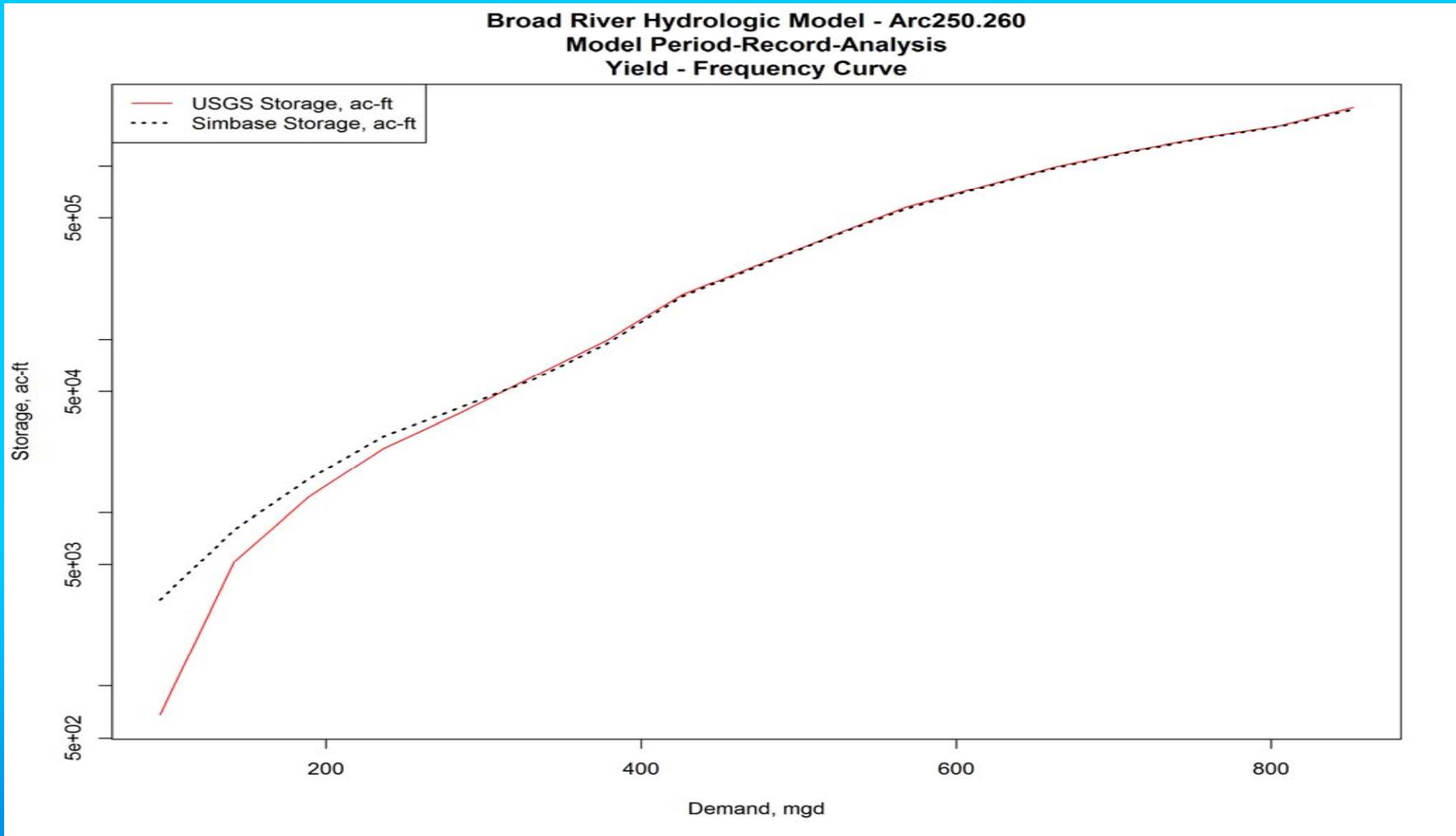


Overall Goodness-Of-Fit (GOF) Scatter Plot



Water Resources Planning GOF Measures

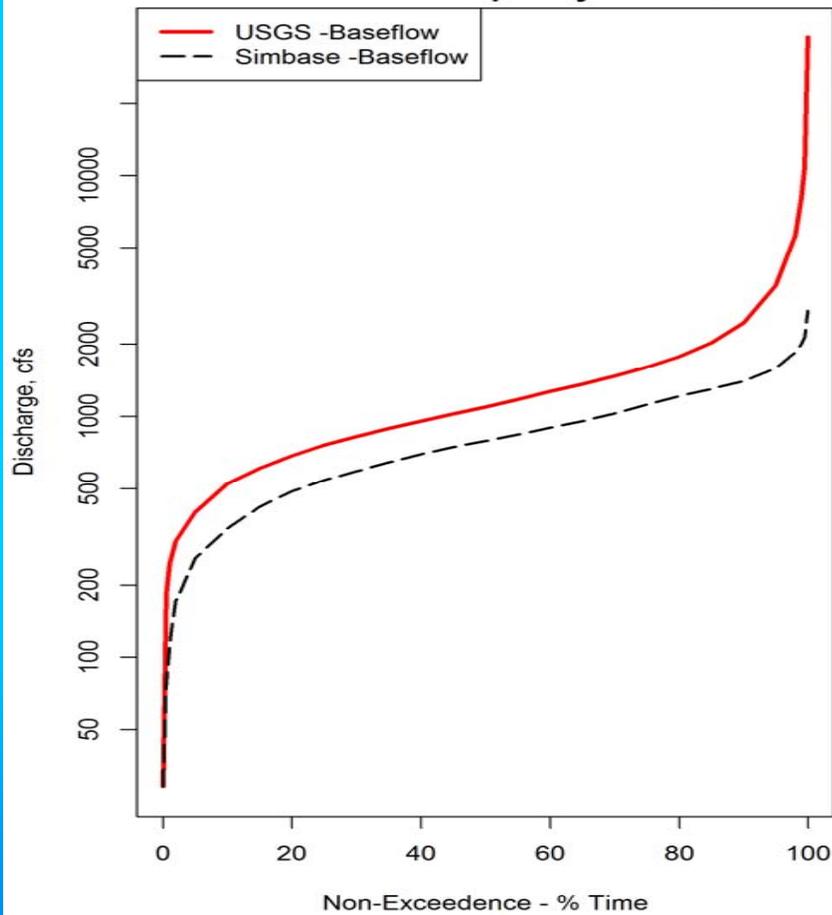
Period-Of-Record mass curve analysis



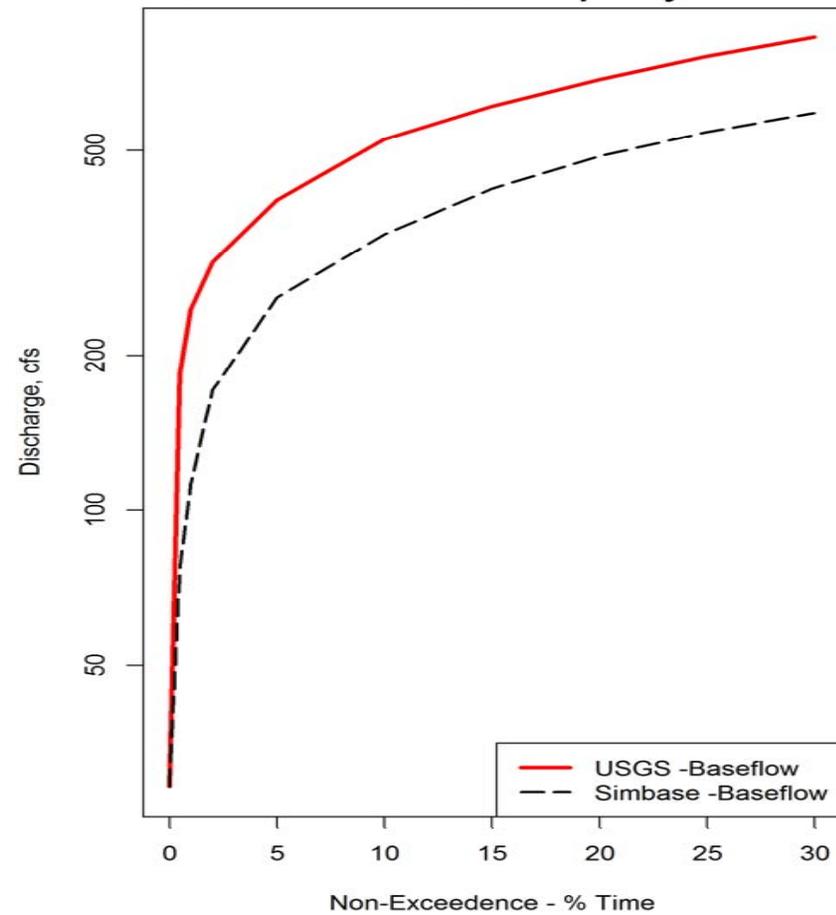
Water Resources Planning GOF Measures

Baseflow analysis

Broad River Hydrologic Model - Arc250.260
Model Period-Record-Analysis
Baseflow Frequency Curve



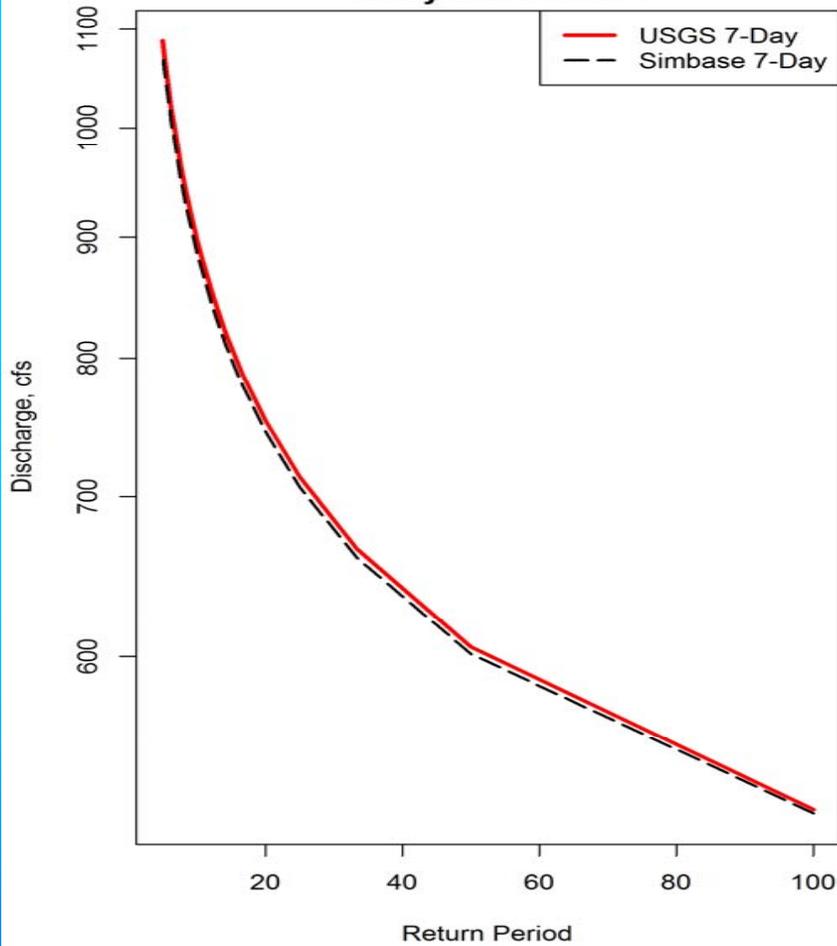
Broad River Hydrologic Model - Arc250.260
Model Period-Record-Analysis
Low-Flow Baseflow Frequency Curve



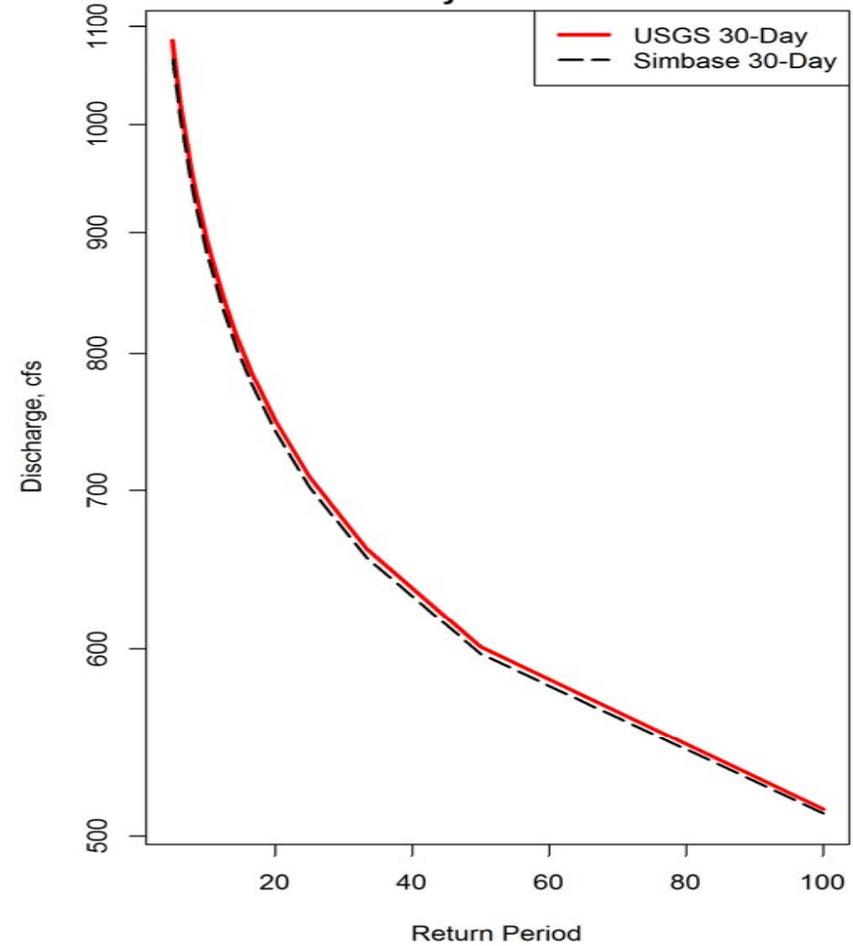
Water Resources Planning GOF Measures

Low-Flow Log-Pearson III 7-Day & 30-Day

Broad River Hydrologic Model - Arc250.260
Model Period-Record-Analysis
7-Day Low Flows



Broad River Hydrologic Model - Arc250.260
Model Period-Record-Analysis
30-Day Low Flows



DWR's use of WaterFALL

- **DWR is still working with RTI to determine if WaterFALL is adequate to meet the requirements of SL 2010-143.**
- **If WaterFALL is determined to be adequate, DWR use will be to generate alterative inflow scenarios for OASIS:**
 1. **Climate Change**
 2. **Land use change**

DWR's use of WaterFALL

- RTI and Hydrologics have demonstrated that WaterFALL can provide the output needs to create the alternative inflows that can be used in OASIS.
- One practical unanswered question is how much will RTI charge?

Questions

Contact Information

Tom Fransen, Deputy Director
Tom.Fransen@ncdenr.gov
919-707-9015