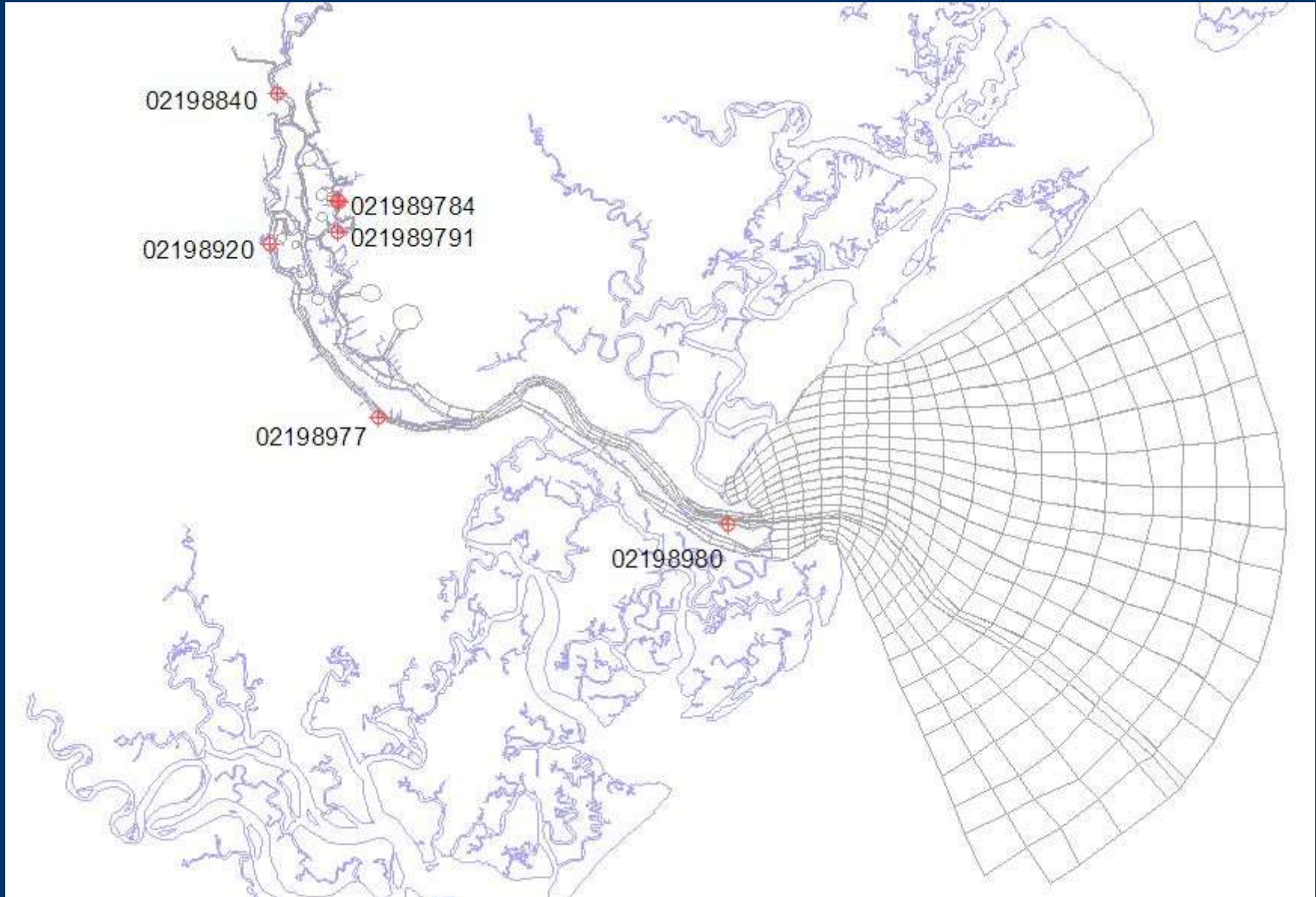


# TMDL Model Uncertainty Analysis



***Kinetic Analysis Corporation***

Advanced numerical modeling and analysis to solve problems  
in science, engineering, commerce, and public policy.

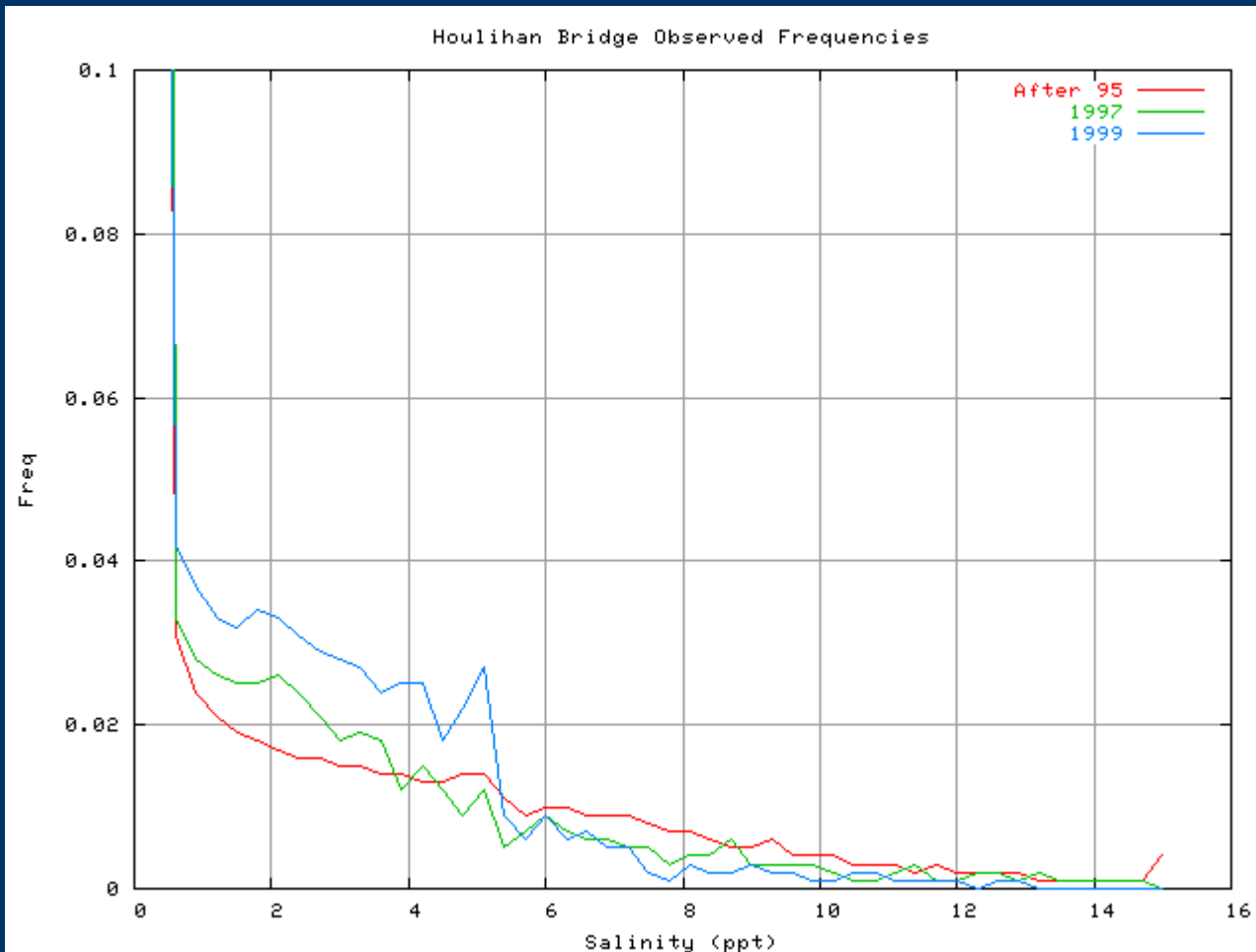
# Objectives

- Evaluate the quality and quantity of data available for the development of the hydrodynamic and salinity and water quality models
  - Evaluate the uncertainty of the TMDL configuration of the EFDC model (aka the TMDL model)
  - Make recommendations for the development of the enhanced grid model.
  - Concentrated on salinity – good data, checks mass transfer.
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# Methodology

- KAC runs made on Linux using code supplied by TetraTech (in March 4 2004 Report)
  - Updated input files from FTP site.
  - Seven sets of simulations:
    - 1) *Baseline*
    - 2) *+1m Bathymetry*
    - 3) *-1m Bathymetry* *Italic: analysis completed.*
    - 4) *Friction bias to 0.0*
    - 5) *Friction bias to 0.1*
    - 6) Bathymetry set to 1992
    - 7) Randomly perturbed bathymetry (10 at 10%)
  - Used “R” package for automated analysis and plot generation, spot checked manually using JMP (from SAS Institute)
- 
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# Data Overview

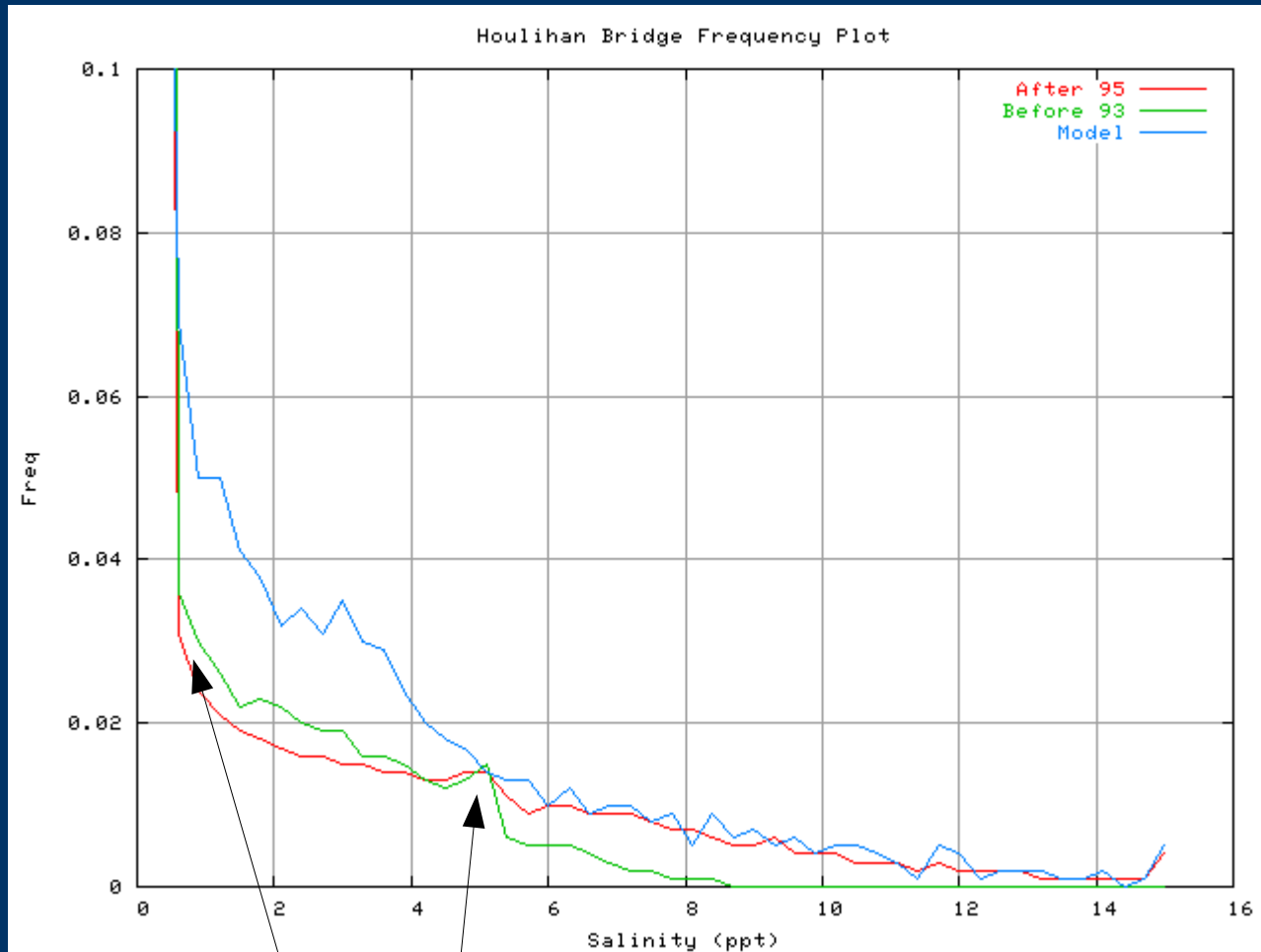


For discussion will concentrate of Houlihan Bridge site – other data available in report.

Note that 1997 and 1999 are significantly different than the long term data in the high frequency range of 0.8 and 5 ppt.

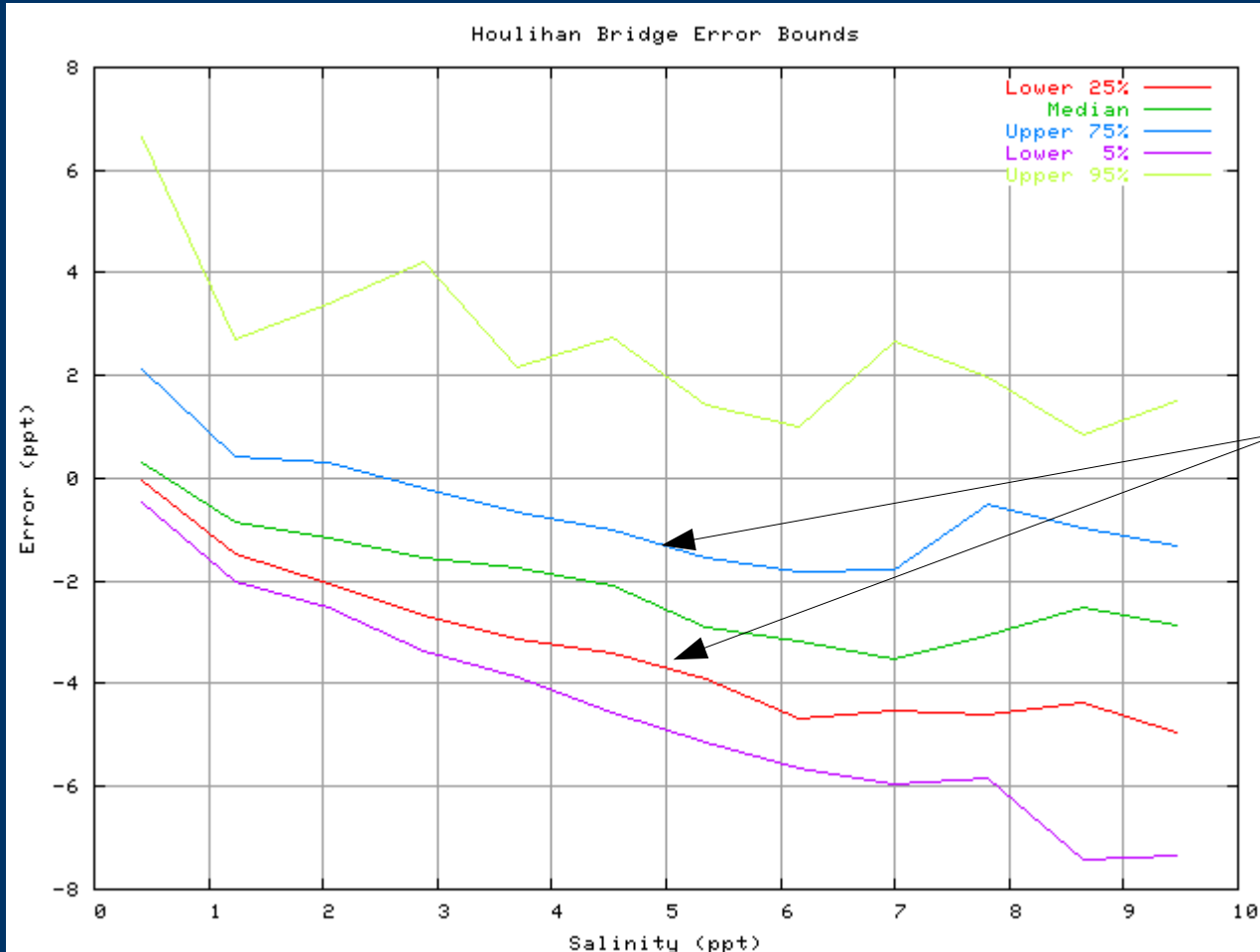
This could bias models calibrated to the two detailed collection periods.

# Houlihan Bridge Baseline



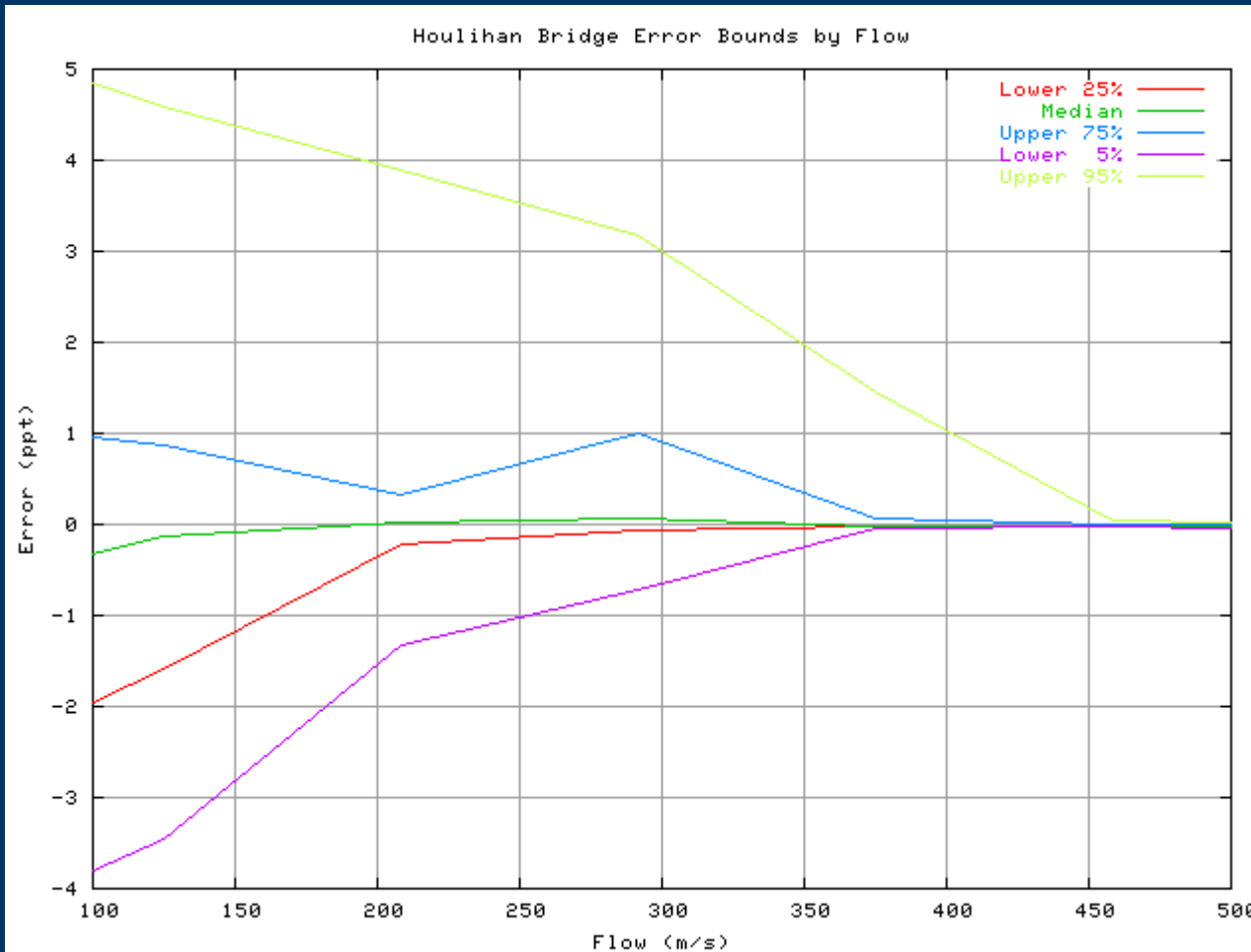
Note bias in 0.8 – 5ppt range – same as calibration periods, and larger than difference between pre94 and post94 frequencies

# Houlihan Bridge Baseline Error Bands



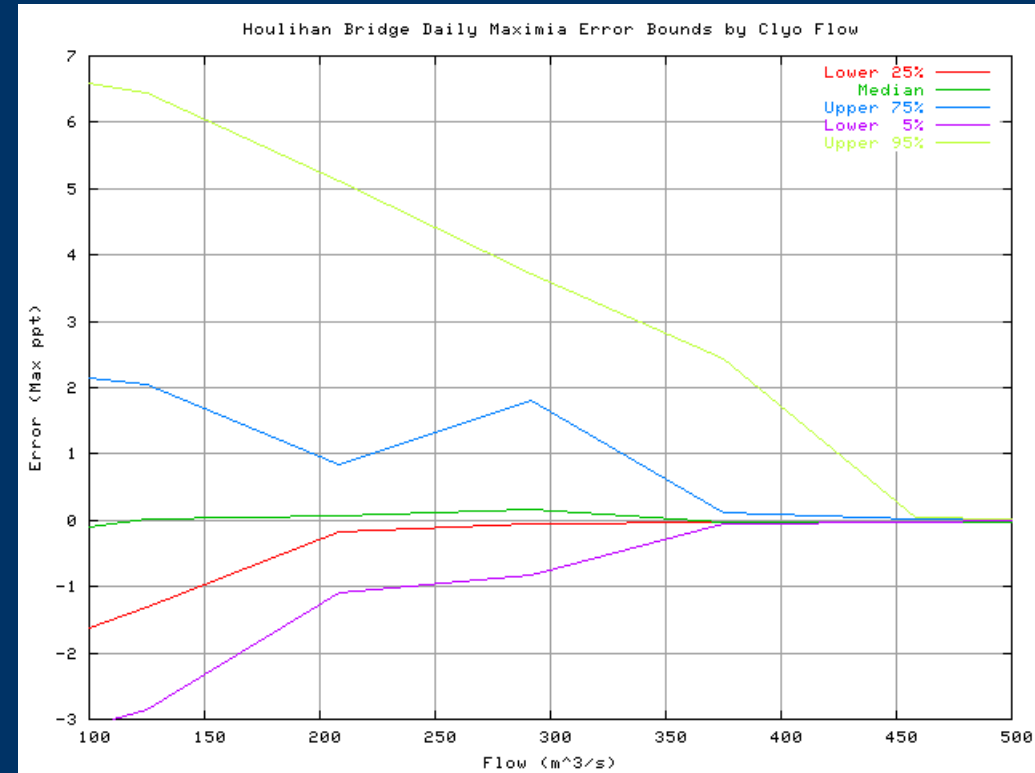
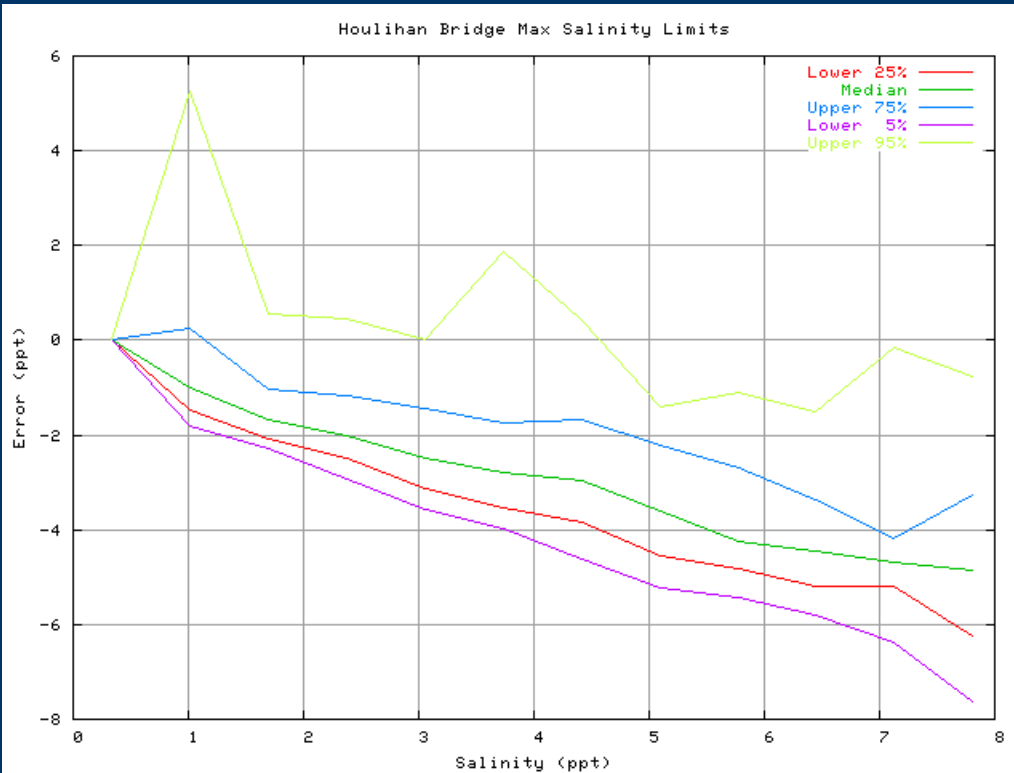
For observed 5ppt, median prediction was 2.5ppt, with 50% of predictions between 1.2ppt and 4.2ppt.

# Houlihan Baseline Error by Flow



Another way of looking at error is by flow. At 250 cubic meters/sec, median error is near zero, but 50% of forecasts are off from between  $-0.2$  and  $0.8$  ppt.

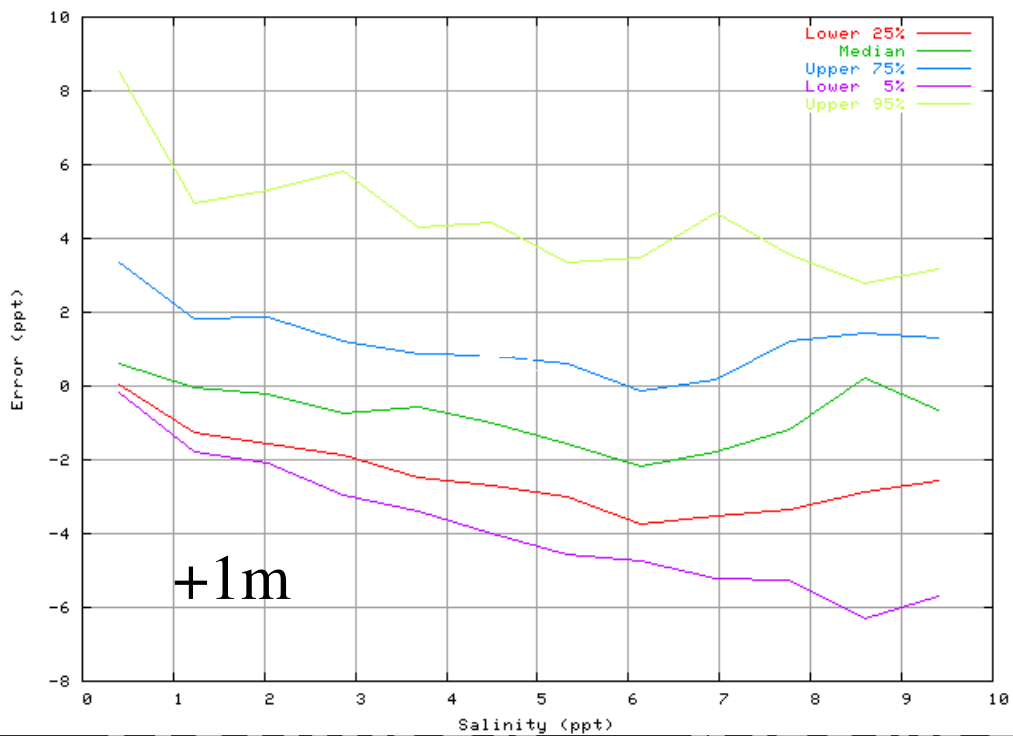
# Houlihan: Daily Maxima



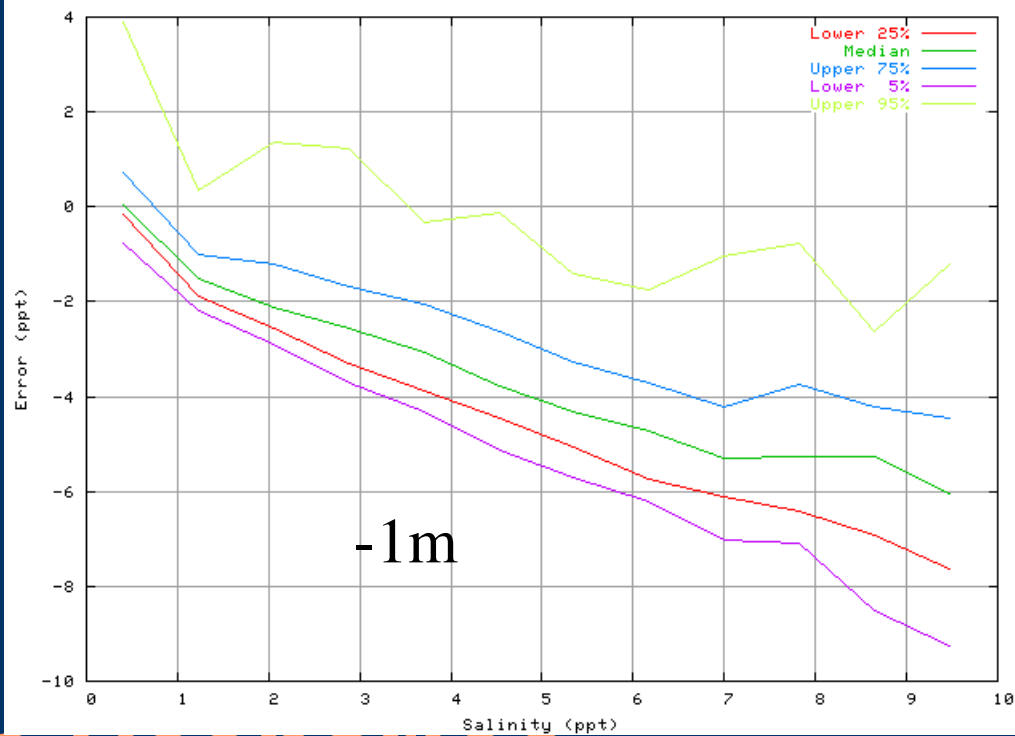
Daily maxima are “more fair” to the model as it overlooks small errors in timing (phase) of events.

Daily maxima appear to be biased high at low to mid salinities. This is probably due to the overcalibration issue mentioned earlier.

Houlihan Bridge Error Bounds

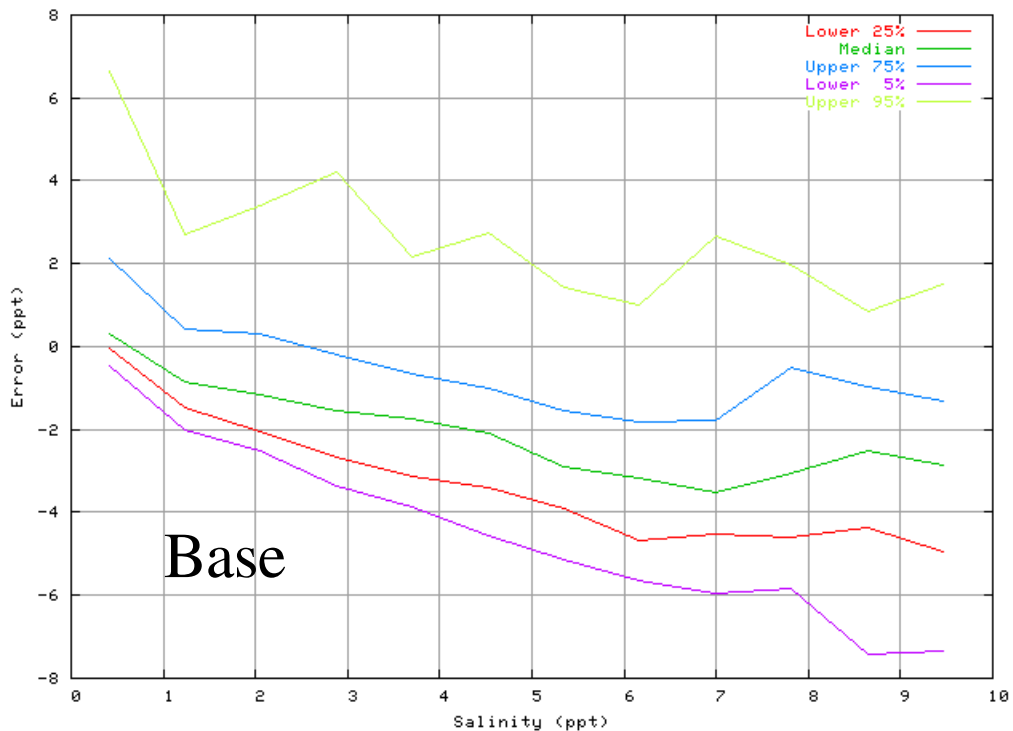


Houlihan Bridge Error Bounds

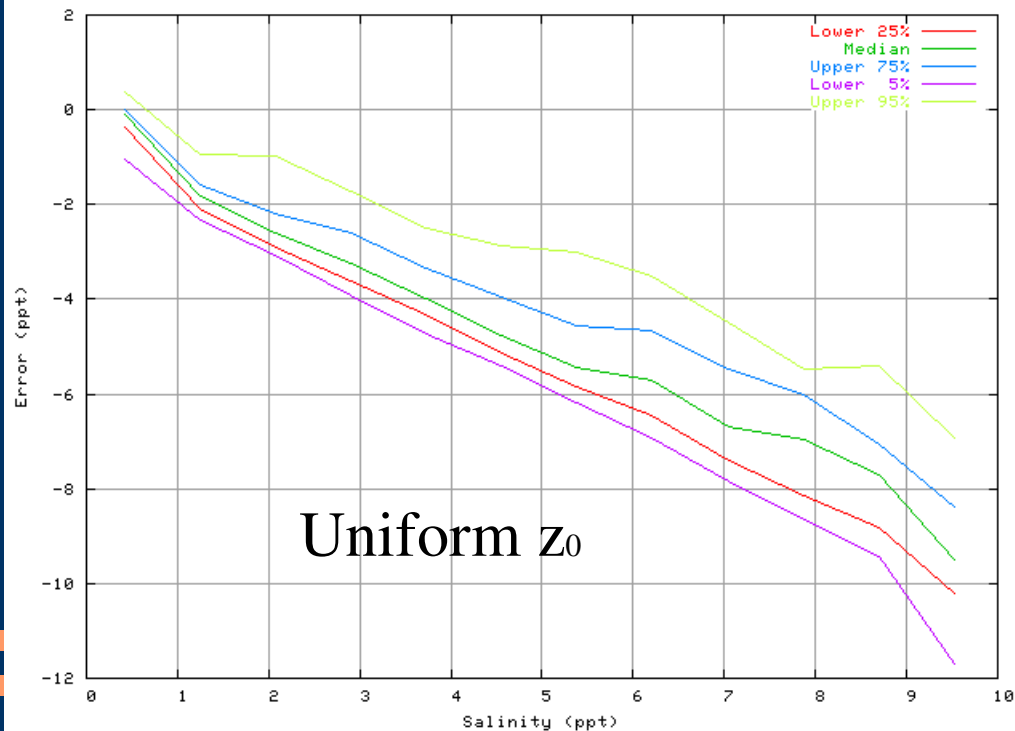


# Houlihan - Alternate Scenarios

Houlihan Bridge Error Bounds

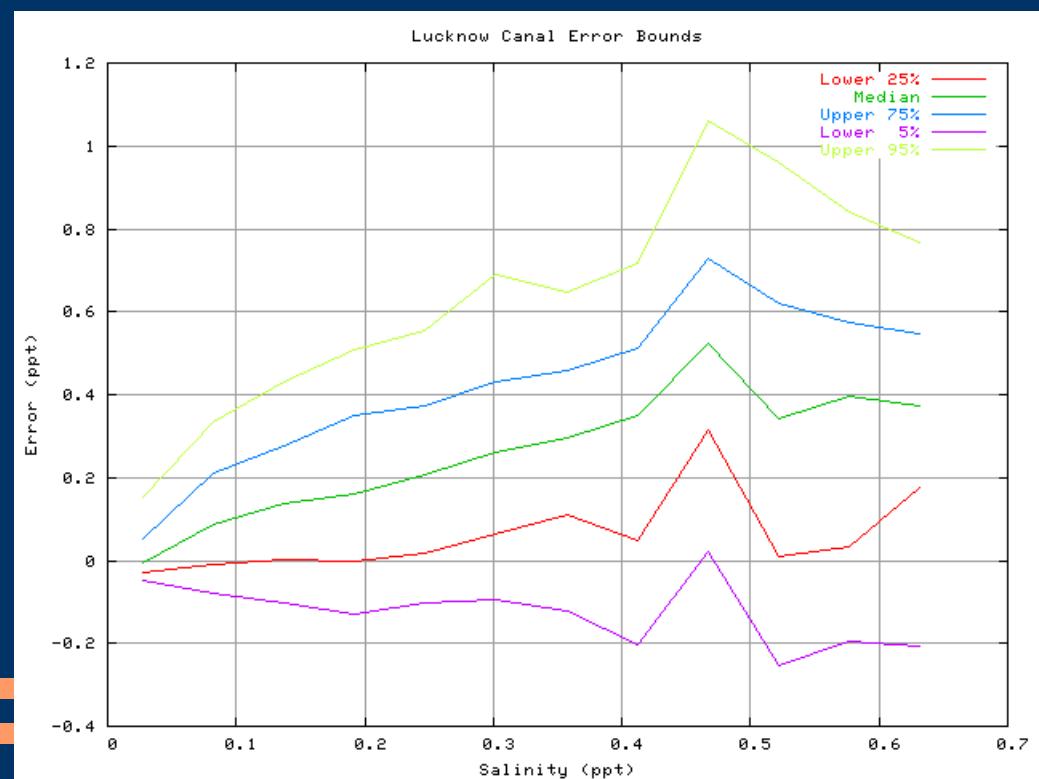
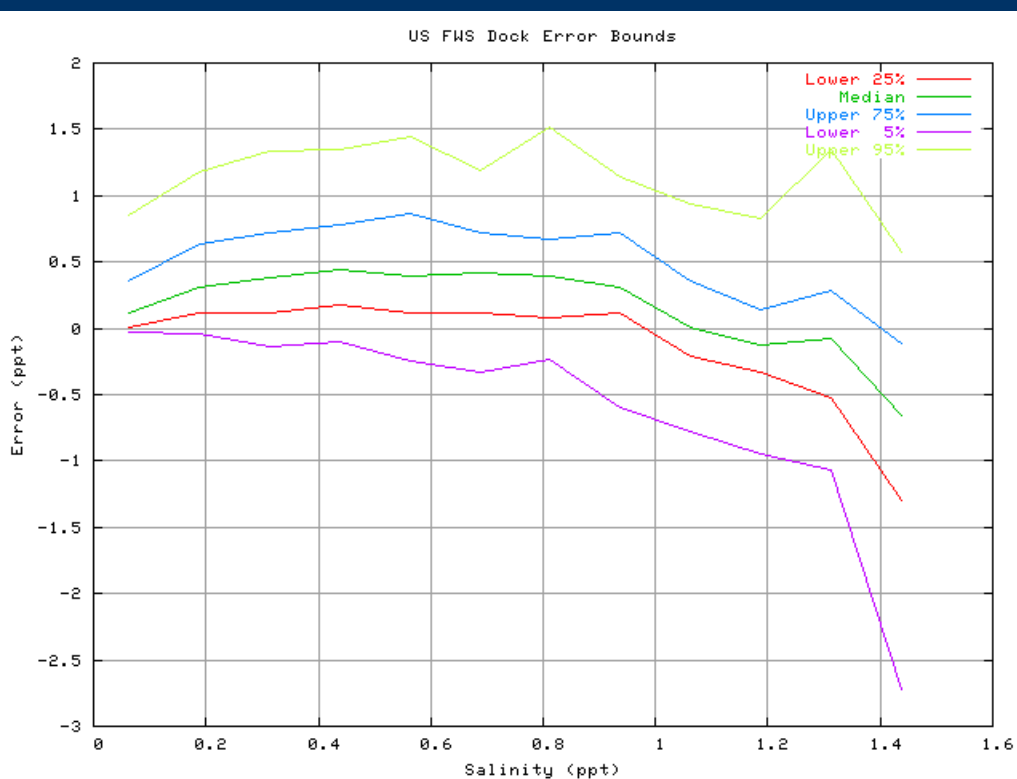
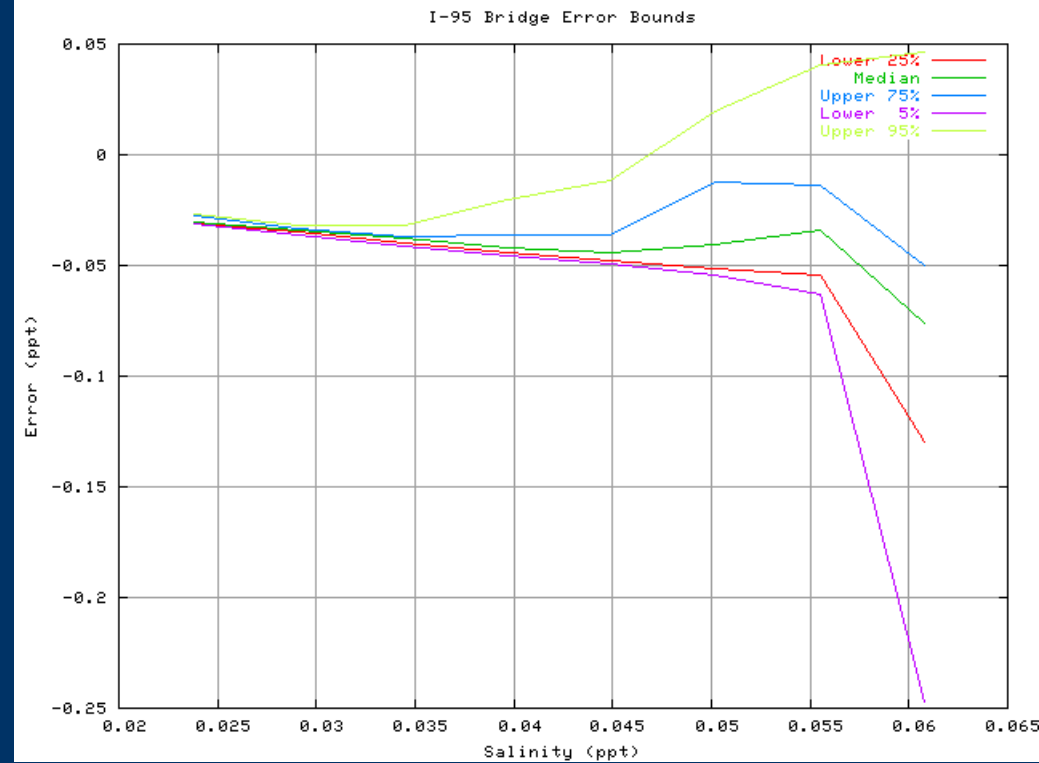


Houlihan Bridge Error Bounds



# Other Sites

Created numerous plots and data tables for various perspectives and input scenarios.



# Conclusions

- 1) Available data is adequate, but precautions must be taken to avoid over calibration to 1997/1999 conditions.
- 2) TMDL model demonstrates qualitative skill – variables change in the directions expected, tracks flow, tide cycle, etc.
- 3) TMDL model does not demonstrate qualitative skill – in other words, values are significantly over or underestimated for specific predictions.

Variations in the model from observed often exceed the differences noted before and after the 1994 project. Therefore, while the model is useful for predicting trends in variables, it is recommended that the TMDL model not be used in cases where the exact values or magnitude of forecast changes of variables are critical.

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# *Recommendations*

Enhanced grid model calibration should take care to avoid over calibration to 1997/1999 conditions. Long term data should be partitioned to include both calibration and blind test (verification) runs.

Use of bottom roughness should be carefully examined to ensure additional uncertainty is not being introduced in the calibration process.



# *Enhanced Grid Model*

KAC made additional suggestions to TetraTech via email.

Draft EG files received by KAC last week; analysis started.

7-10 days after final files will create draft final report.

Creating additional metrics to compare model performance  
assess the improvements (or not) in the enhanced grid.

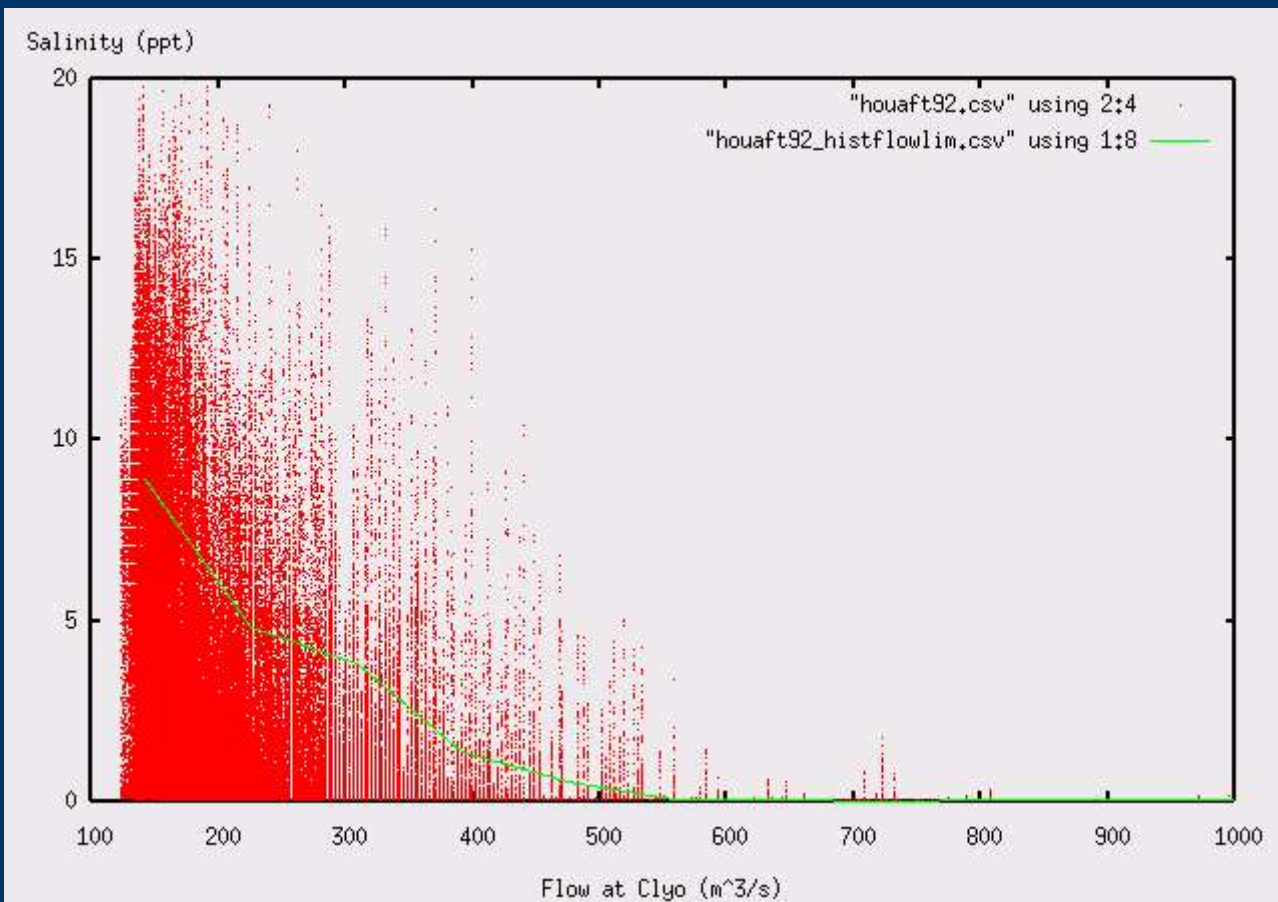
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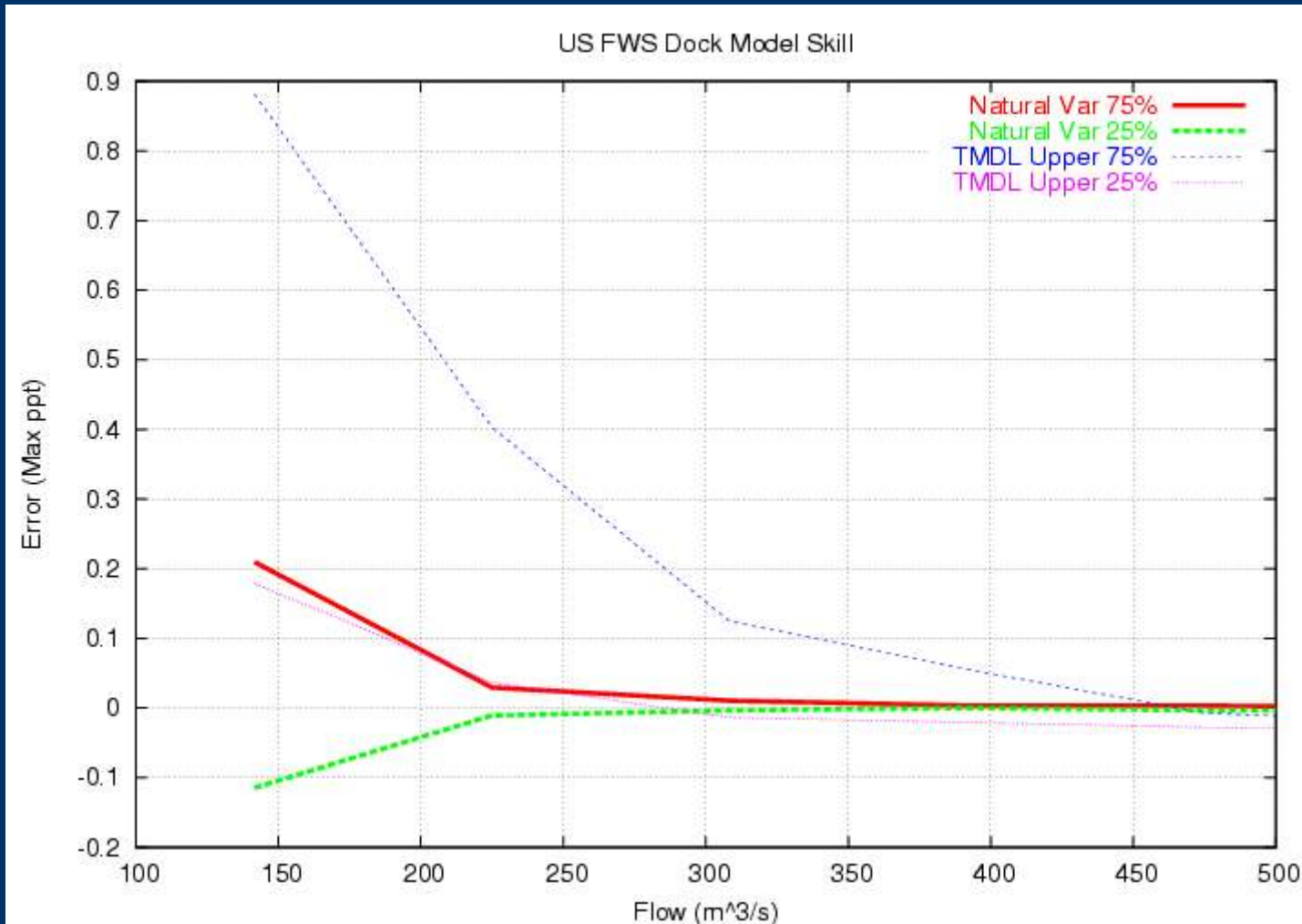
# *Skill: how good does a model need to be?*

Skill: ability of the model compared to simple (no-skill) methods.

The primary factor in salinity at a given station is the flow of the Savannah River. Here the flow at Clyo is plotted against salinity at Houlihan Bridge. There is a large natural range of variation around the median (shown in green)



# Skill Comparisons

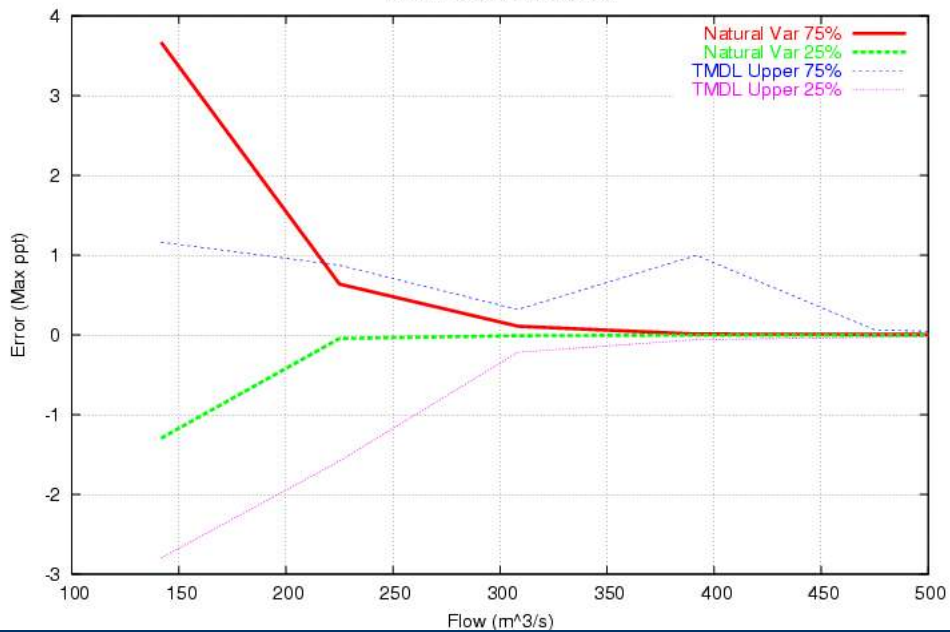


Natural range is shown in red and green.

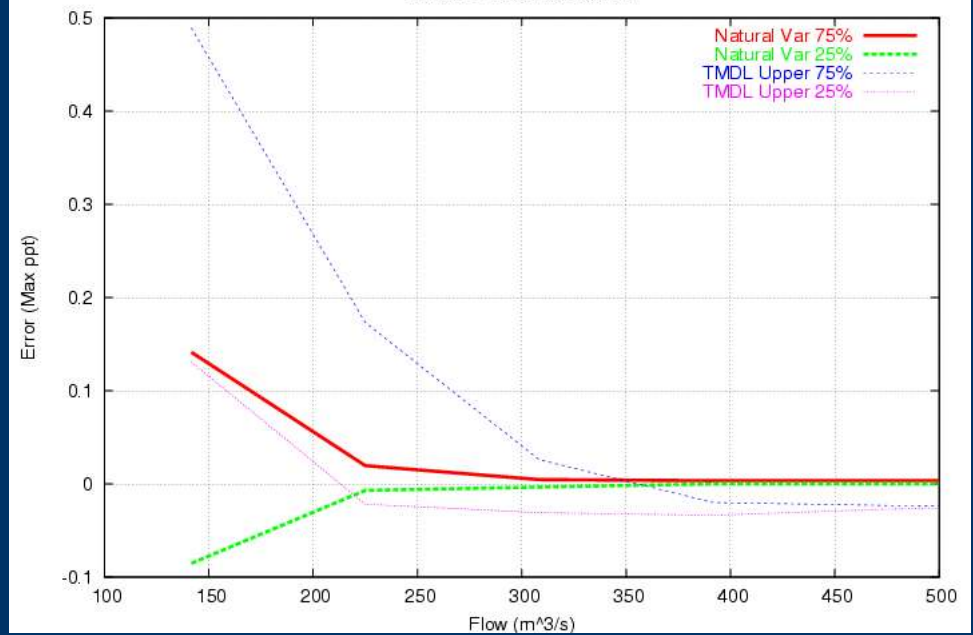
Models should be within these limits in order to have confidence in the prediction.

# Skill at other stations

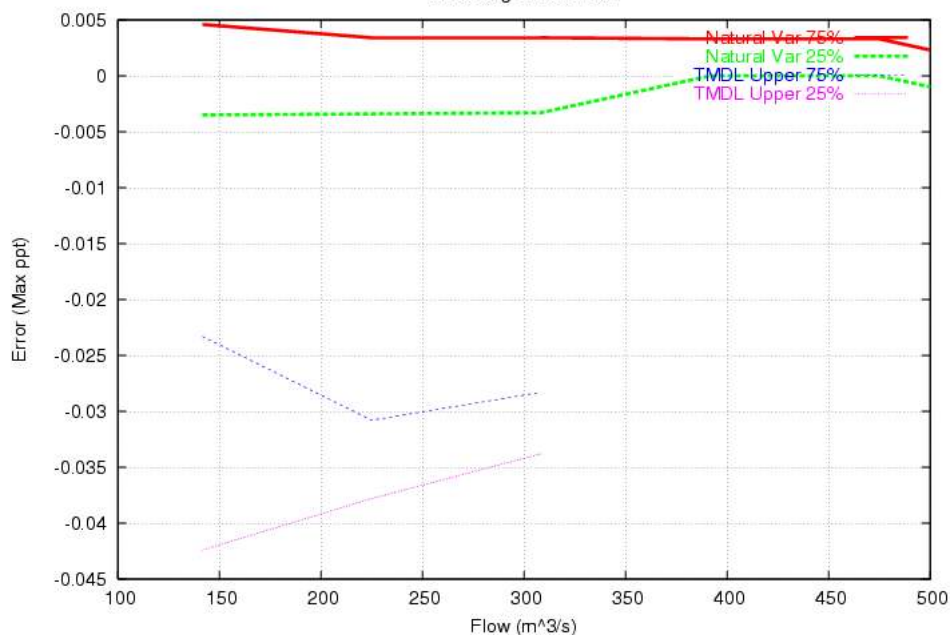
Houlihan Bridge Model Skill



Lucknow Canal Model Skill



I-95 Bridge Model Skill



Reinforces conclusion that TMDL Model is not demonstrating predictive quantitative skill. Provides a benchmark for assessing the amount of improvement we are seeing in the Enhanced Grid.

# *Follow-up on Recommendations*

The TetraTech calibration process appeared to be introducing “noise” into the modeling process. Based on KAC recommendations, TetraTech has created new bathymetry data sets, and is not using bottom friction to compensate for bathymetric errors/uncertainty in the enhanced grid model. *(critical improvement)*

Calibration/Verification: would be good to have more data, especially water quality (DO) and blind validation. Spot checks, real time runs, and longitudinal surveys would greatly improve confidence in the modeling. *(not yet a formal recommendation)*

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# *Documents*

Copies of this presentation, as well as the reports, are  
available at:

<http://www.methaz.org/shep/>

