QUAL2K Model Progress Update
Jordan River TMDL

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Why Model?

- Model approximates complex physical, chemical and biological processes through simplified representations
  - DO interactions
- Decision support tool for TMDL
  - Improve understanding of DO linkages
  - Support determination of the permissible load to the Jordan River
  - Support waste load allocation for selected flow scenario(s) (critical condition)

Modeling Steps

1. Model selection – QUAL2K
2. Model calibration – build confidence in model by most closely matching simulated to observed conditions
3. Calibration insufficient? → Additional data collection and recalibration
4. Calibration sufficient? → Decision support tool for TMDL

QUAL2K Capabilities

- Specifically developed to simulate DO conditions in river systems
- Capable of simulating the four DO processes
  - Physical: channel hydraulics, temperature and reaeration
  - Organic decomposition: BOD
  - SOD: proscribed or DiToro diagenesis model
  - Algal growth: diurnal time scale, nutrient cycle, free floating and benthic algae
- Other water quality kinetics: suspended solids, conductivity (TDS), pathogens

QUAL2K Fundamentals

- **Receiving water model** – only simulates stream flow and kinetics, not entire watershed.
- **One dimensional** - channel is well-mixed vertically and laterally.
- **Steady state** - non-uniform, steady flow is simulated.
- **Diurnal time scale** - heat budget and temperature are simulated as a function of meteorology. All water quality variables are simulated on a diurnal time scale.
- **Flow and concentration inputs** - Point and non-point loads and abstractions are simulated.
- **Water quality kinetics** – temperature, pH, conductivity, sediment, organics, nutrients, dissolved oxygen, pathogens, algae.

Initial Model Calibration

- Calibrated model to July 2004 conditions
- Validated model to January 2004 conditions
- Calibration constituents
  - Flow and travel time
  - Temperature
  - Conductivity
  - CBOD, DO, TP
  - TSS
  - E coli
  - Alkalinity and pH
- Calibration performance
  - Excellent for hydraulics (HEC-RAS)
  - Good for most water quality constituents

Initial Model Calibration

- Lack of observed data available on the following input/output water quality constituents
  - Nitrogen speciation (nitrate, ammonia, dissolved organic)
  - Phosphorus speciation (inorganic, dissolved organic)
  - Particulate organic matter (POM)
  - Free floating plants (phytoplankton)
  - Fixed plants (periphyton/benthic algae)
  - Sediment oxygen demand (SOD)
- Unable to calibrate plant growth kinetics and SOD

Additional Data Collection

- Seasonal synoptic sampling events
  - Data collected on Jordan and primary inflows
  - Aug 2006, Oct 2006, and Feb 2007
  - 3 day sampling period – travel time of Jordan
- SOD research study
- Periphyton sampling
- Reaeration measurement
- Shading analysis
- Sensitivity analysis on model parameters (completed 2008)

Next Steps

- Complete data collection (summer 2009)
- Recalibrate model (fall 2009)
  - Use data from seasonal synoptic sampling events
  - Adjust model parameters and evaluate the response in each season
  - Model parameters will be selected that result in best-fit between simulated and observed results for all seasons
- Use as decision support tool

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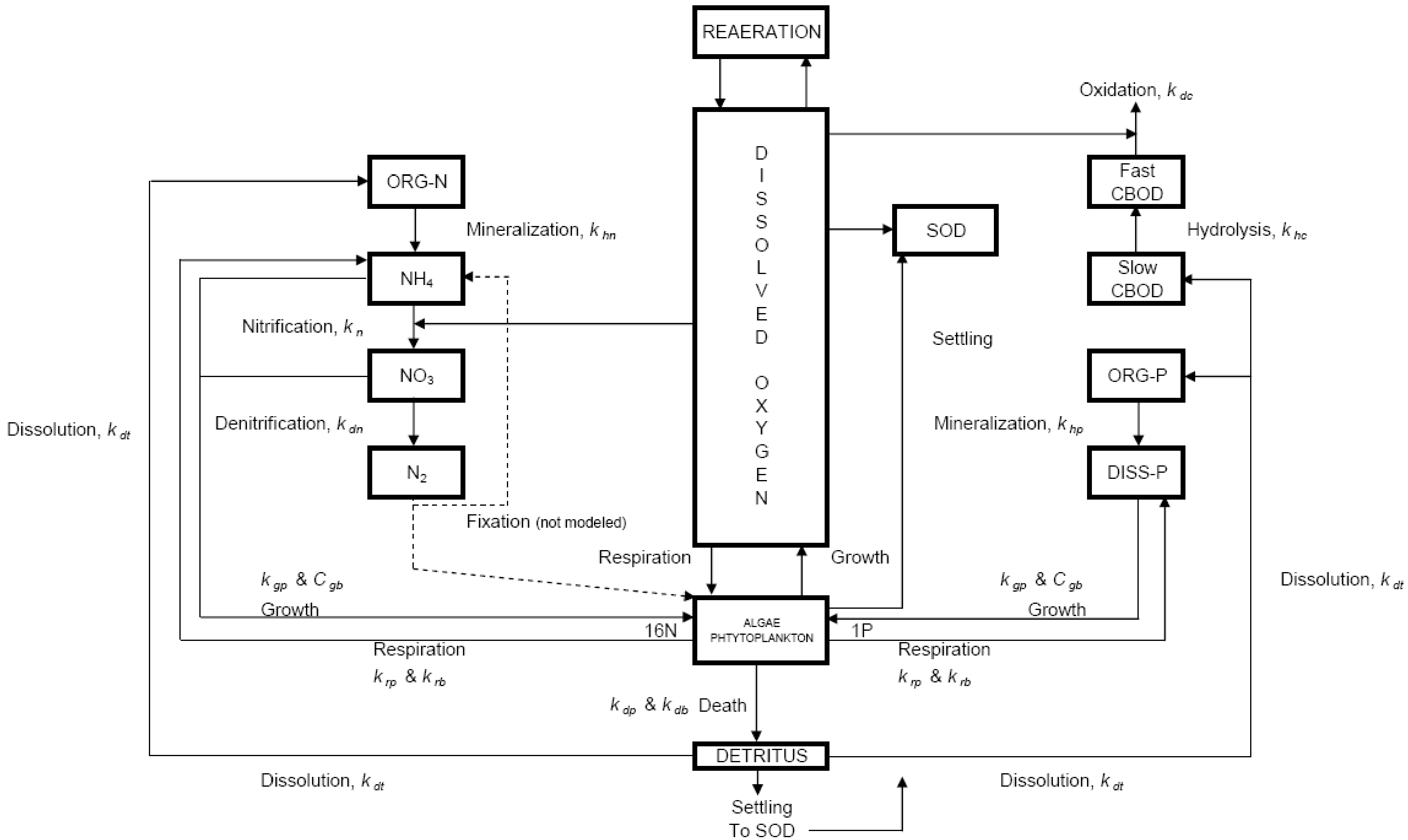
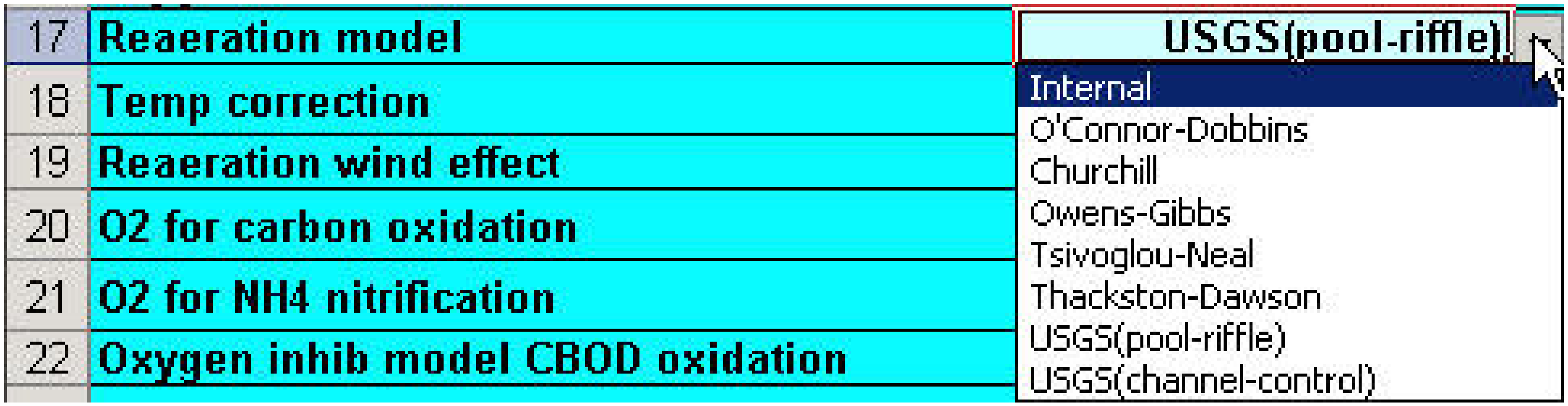
Dissolved Oxygen

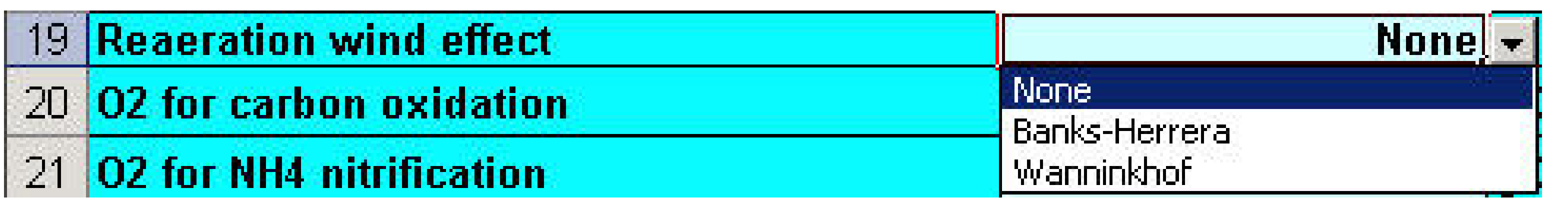


Reaeration

Effect of Water Velocity (8 formulas)



Effect of Wind (2 formulas)



Reaeration Formulas

O'Connor-Dobbins: most rivers

$$k_a = 3.93 \frac{U^{0.5}}{H^{1.5}}$$

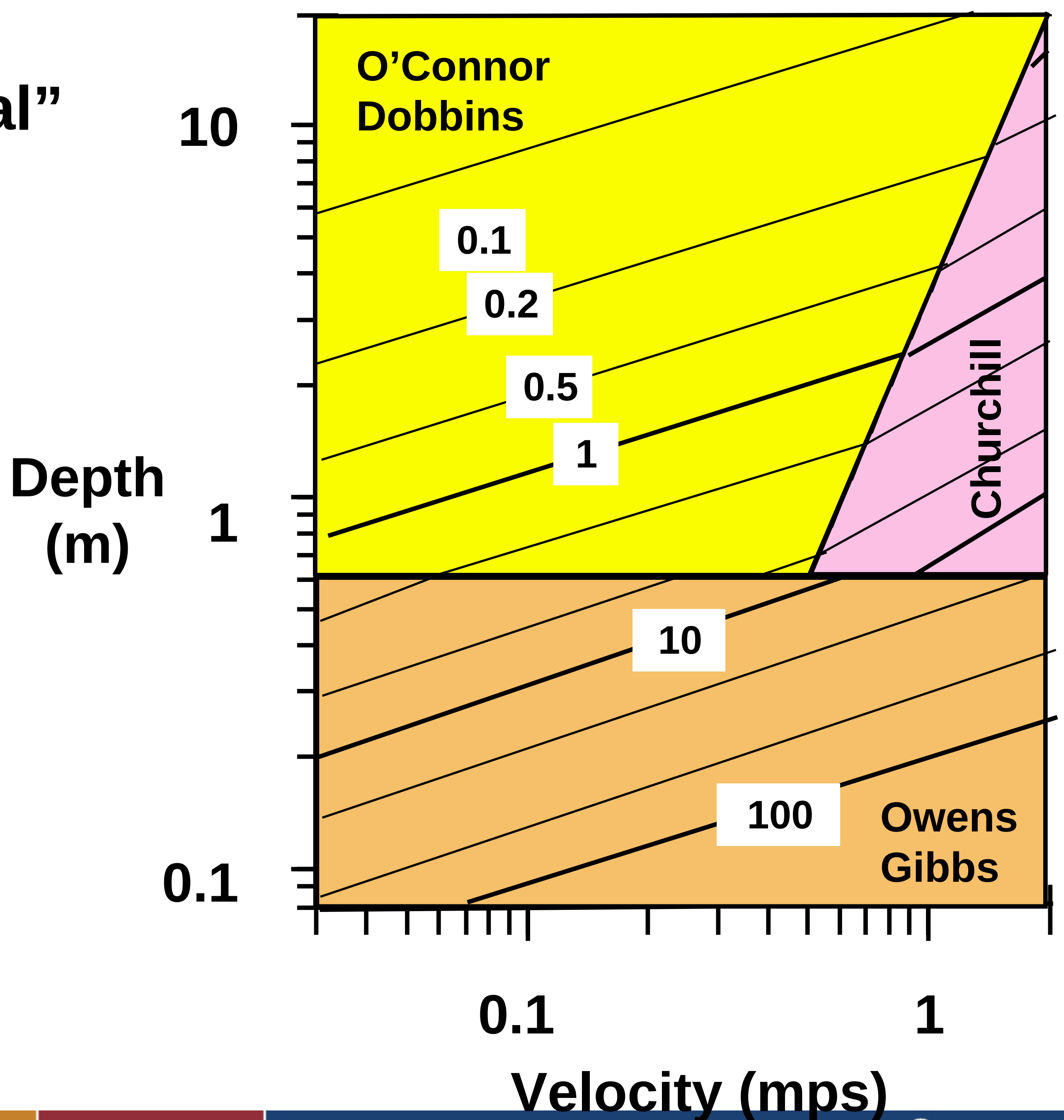
Owens-Gibbs: shallow streams

$$k_a = 5.32 \frac{U^{0.67}}{H^{1.85}}$$

Churchill: deeper, high velocity rivers

$$k_a = 5.03 \frac{U}{H^{1.67}}$$

Covar "Internal" Formula



Reaeration Formulas

Tsivoglou-Neal

$$k_a = 15{,}308US$$

Thackston-Dawson

$$k_a = 2.16 * (1+9F^{0.25})\ U_*/H$$

USGS: pool-riffle

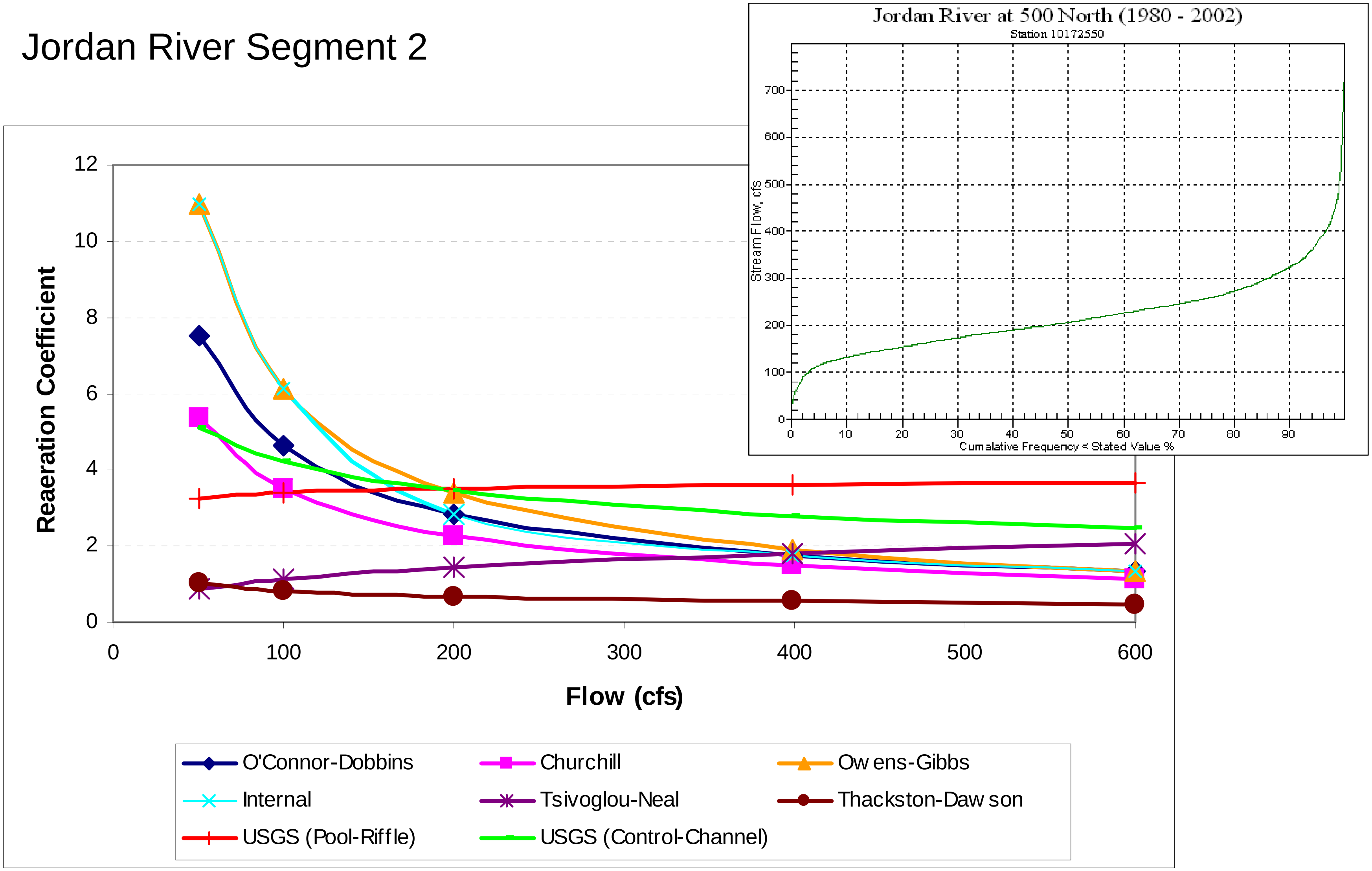
$$k_a = 596(US)^{0.528}Q^{-0.136}$$

USGS: channel-control

$$k_a = 142(US)^{0.333}H^{-0.66}B_t^{-0.243}$$

Reaeration Model Sensitivity

Jordan River Segment 2



Reaeration Verification

Difference between reaeration coefficients estimated using the formulas in QUAL2K and the Approximate Delta Method (McBride and Chapra, 2005)