Application of an Estuary Model to Quantify Factors Contributing to Low Dissolved Oxygen Conditions in the San Joaquin River Deep Water Ship Channel

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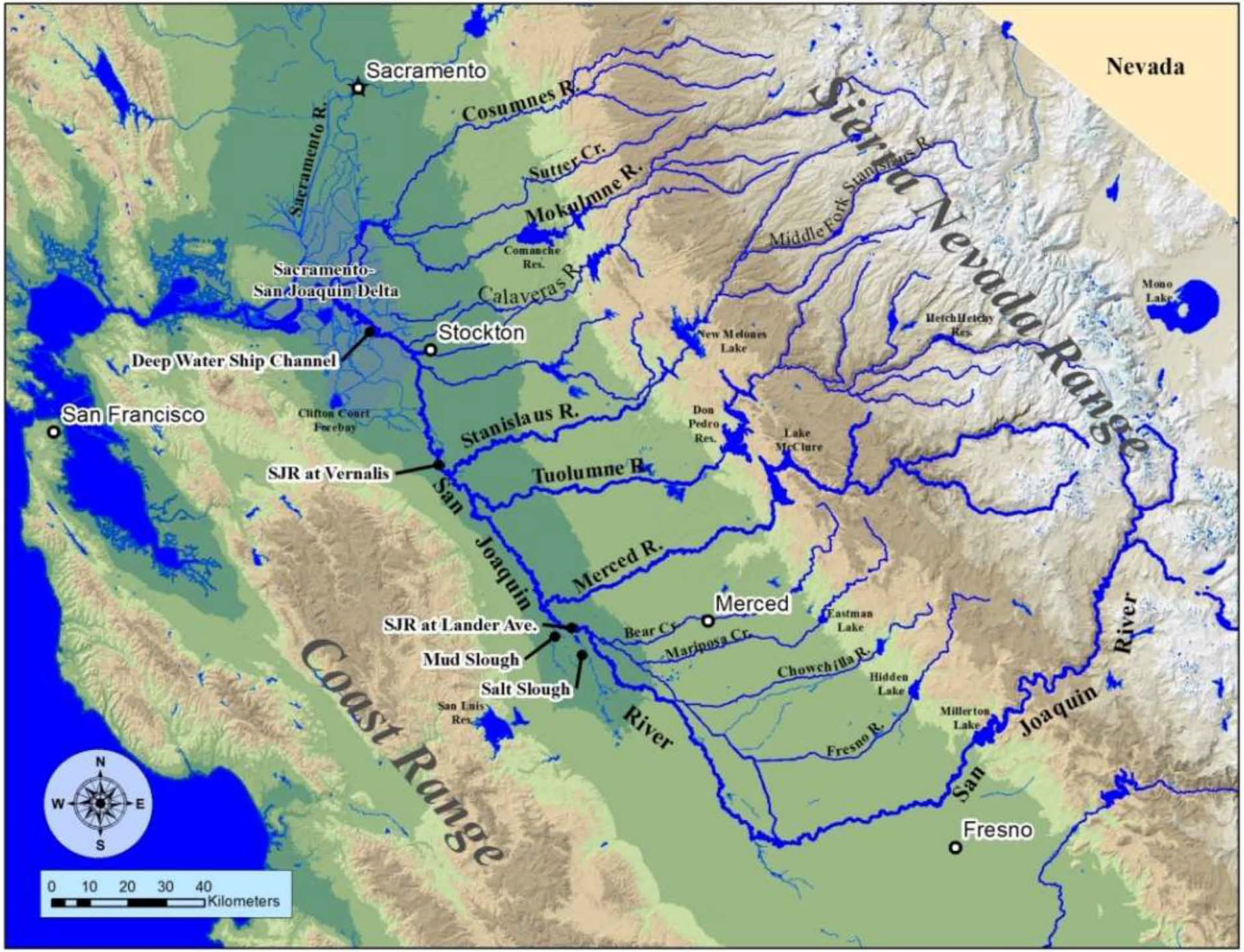
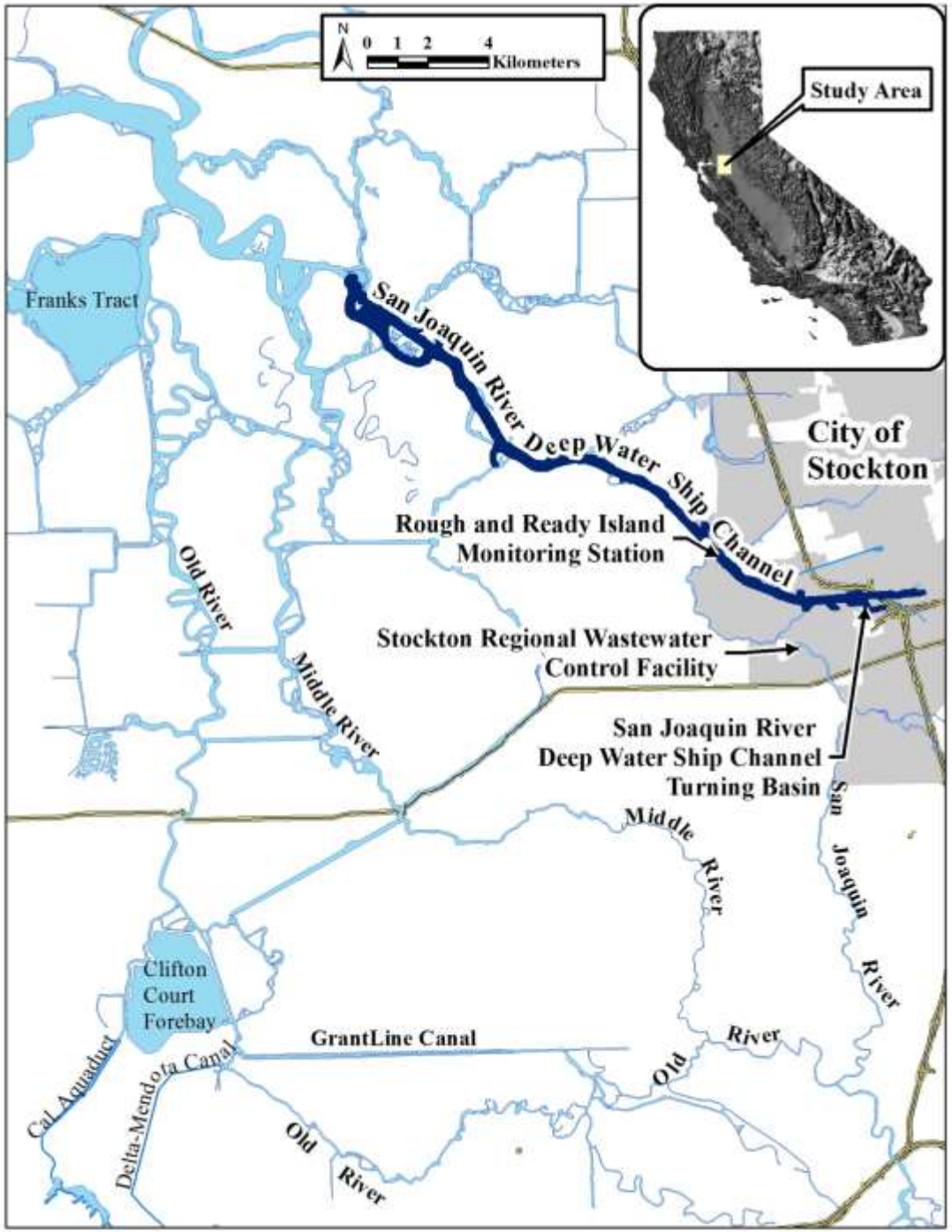
Project Scope: Model dissolved oxygen (DO) in the San Joaquin River Estuary

- Low DO problematic since the 1940s
- Low DO impacts ecosystem health, water supplies, aesthetics
- Total Maximum Daily Load (TMDL) project initiated
- Sources of low DO need to be quantified


Sacramento
Nevada
Cosumnes R.
Sacramento R.
Sutter Cr.
Mokulmne R.
Sierra Nevada Range
Middle Fork Stanislaus R.
Comanche Res.
Sacramento-San Joaquin Delta
Calaveras R.
Mono Lake
Hetch Hetchy Res.
New Melones Lake
Stockton
Deep Water Ship Channel
San Francisco
Clifton Court Forebay
Stanislaus R.
Don Pedro Res.
Lake McClure
SJR at Vernalis
Tuolumne R.
San Joaquin
Merced R.
Merced
SJR at Lander Ave.
Bear Cr.
Eastman Lake
Mariposa Cr.
Mud Slough
Chowchilla R.
Hidden Lake
Salt Slough
San Luis Res.
Millerton Lake
Fresno R.
San Joaquin River
Coast Range
Fresno
N
W
E
S
0 10 20 30 40
Kilometers

Location of Ship Channel within the San Joaquin River



Dissolved Oxygen (DO) in Water Bodies

DO added by:

- Photosynthesis
- Import from adjacent waters
- Atmospheric oxygen

DO removed by:

- Degassing
- Reactions with inorganic compounds (e.g. ammonia)
- Reactions with organic compounds (e.g. carbon associated with algae)

Oxygen-demanding substances

Factors Influencing Low DO – San Joaquin River Estuary

Oxygen-demanding substances from:

- Agricultural watershed
- Wastewater effluent
- Stormwater via urban tributaries

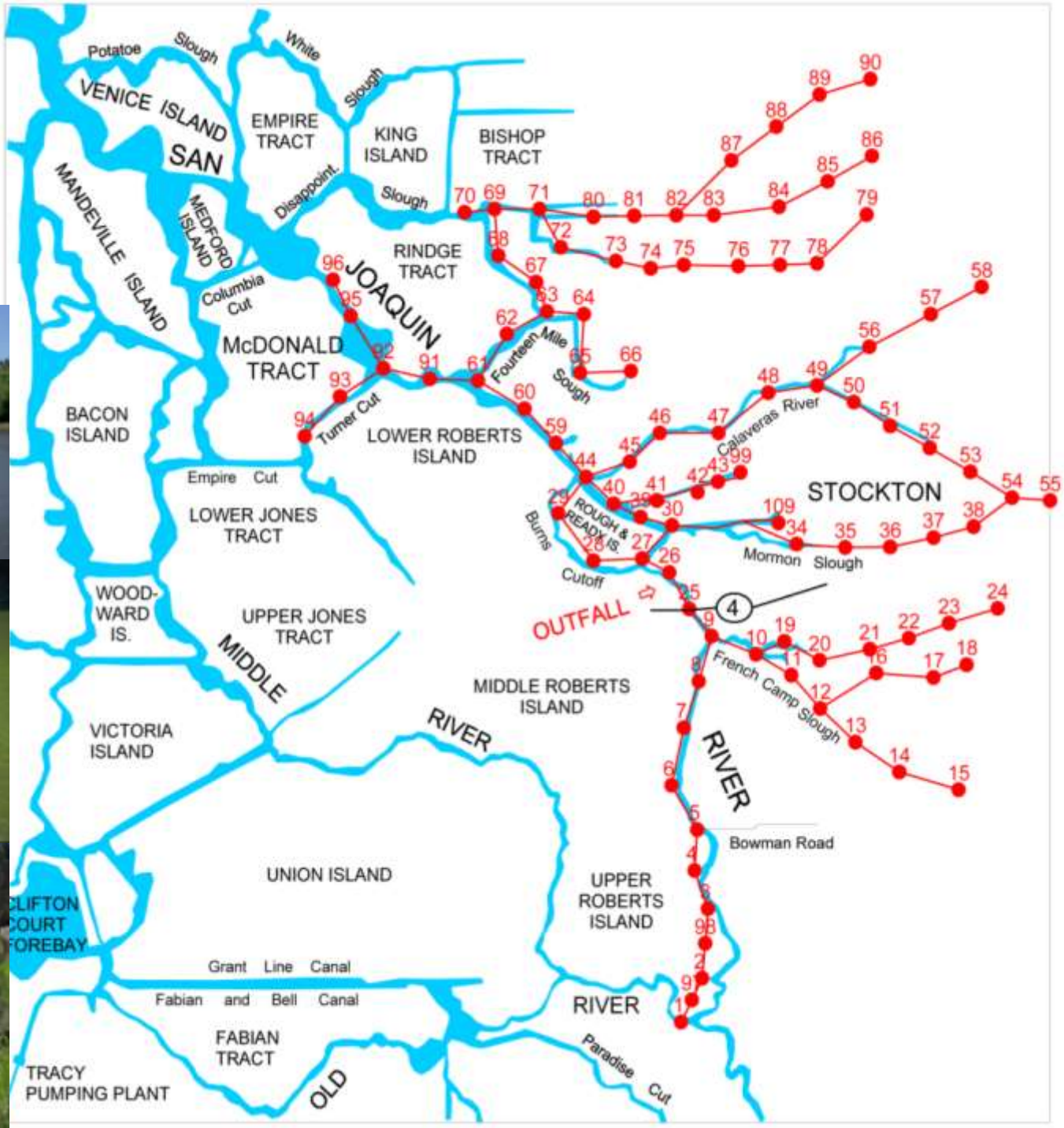
Deep Water Ship Channel geometry causes:

- Reduced photosynthesis
- Increased algae decay and respiration
- Reduced reaeration

Study Objectives

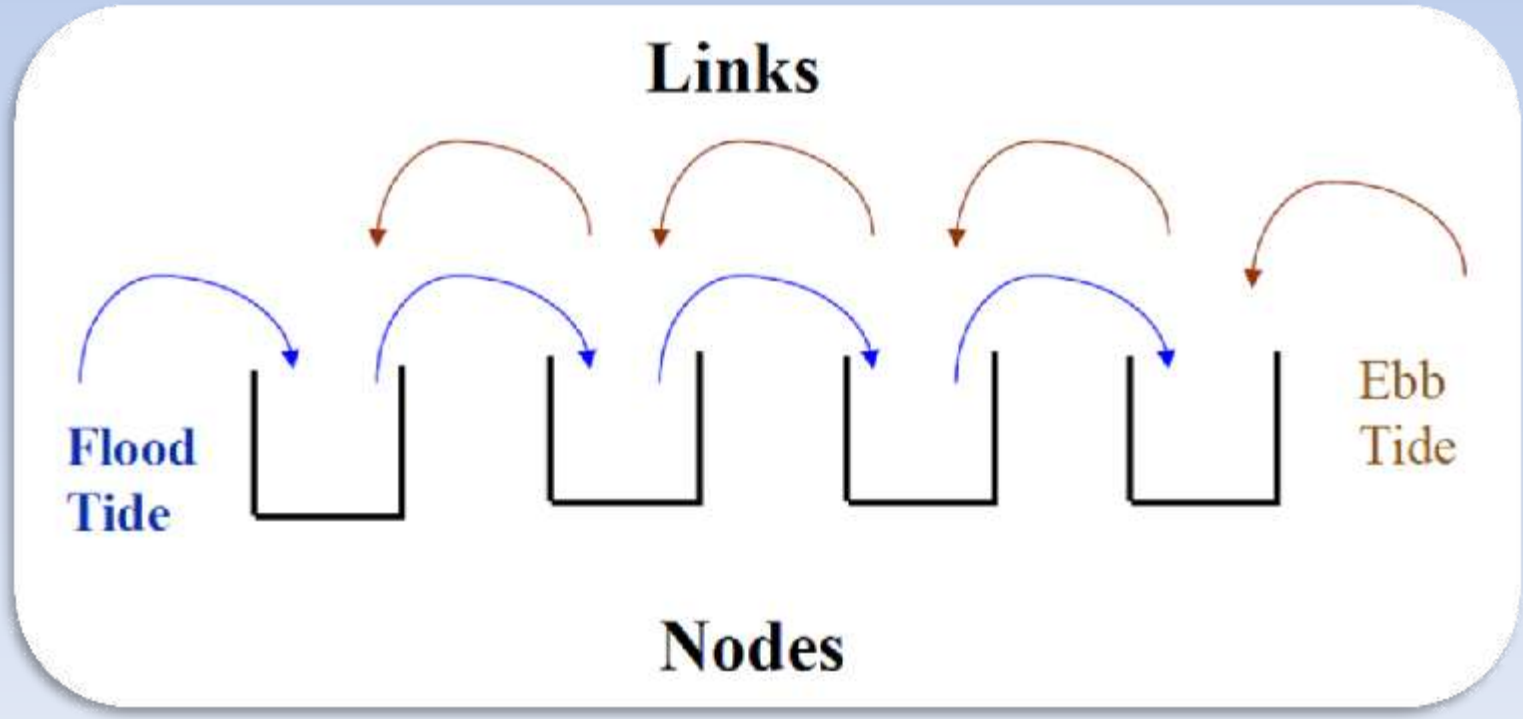
- Calibrate a 1-D link-node model
- Simulate management alternatives:
  1. Restoration of the ship channel to original depth.
  2. Elimination of oxygen-demanding substances (ODS) from the agricultural watershed.
  3. Elimination of ODS from wastewater effluent.
  4. Elimination of ODS from urban tributaries.

SJR-Link-Node Model Domain



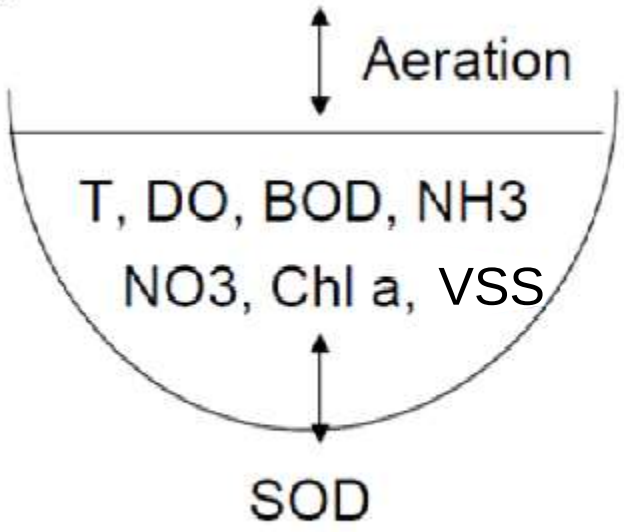
Model: Hydrodynamics

- Model calculates:
  - Velocity and flow @ Links
  - Water elevation and volume @ Nodes



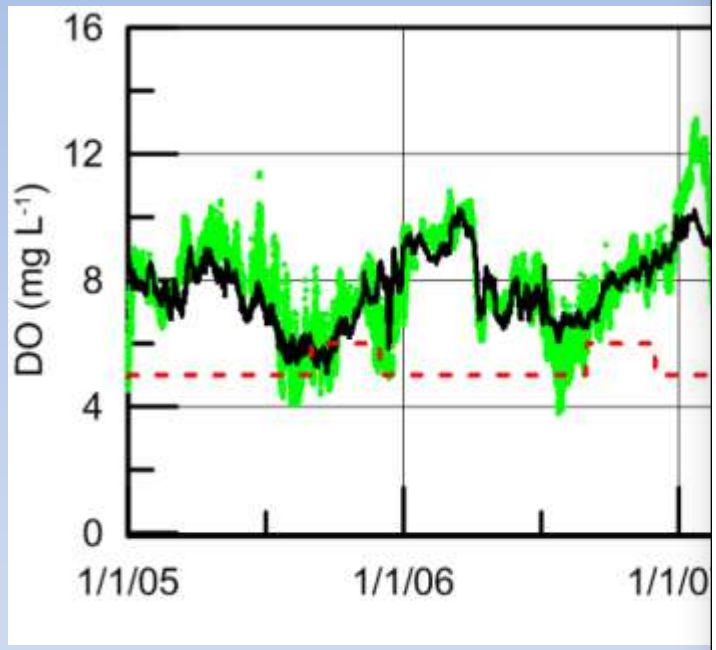
Model: Water Quality

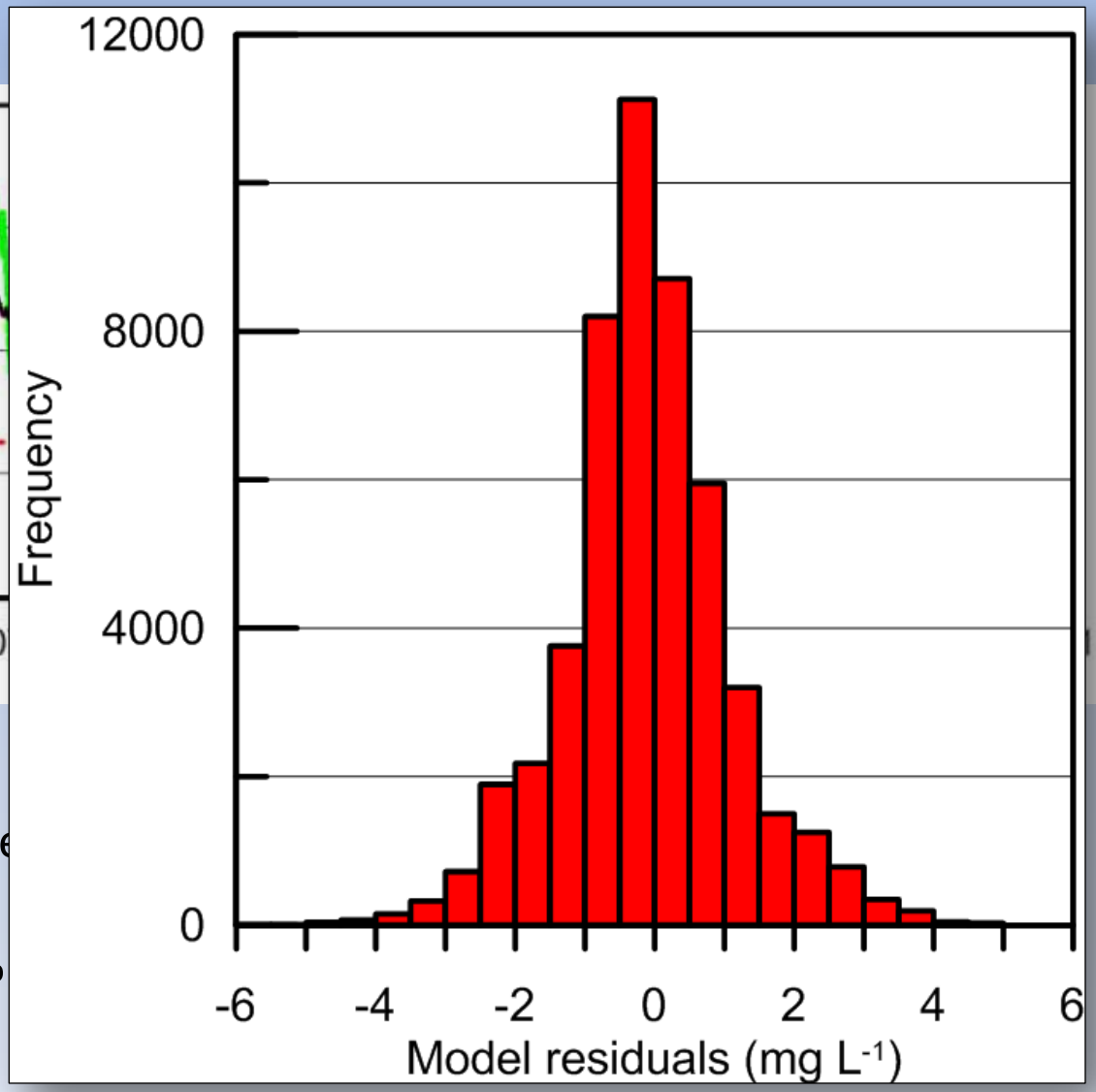
- Model calculates:
  - Water quality constituent concentrations based on mass balance with sources & sinks included
  - Sources & sinks for DO:



$O_2(s)=f(T)$
$Aeration=a(O_2(s)-O_2)$
$BOD+O_2=CO_2$
$NH_3+O_2=NO_3$
$SOD+O_2=CO_2$
$Chla+N+P+CO_2=Chla+O_2$
$Chla+O_2=Chla+CO_2$
$VSS+O_2=CO_2+NH_4$

Model Calibration

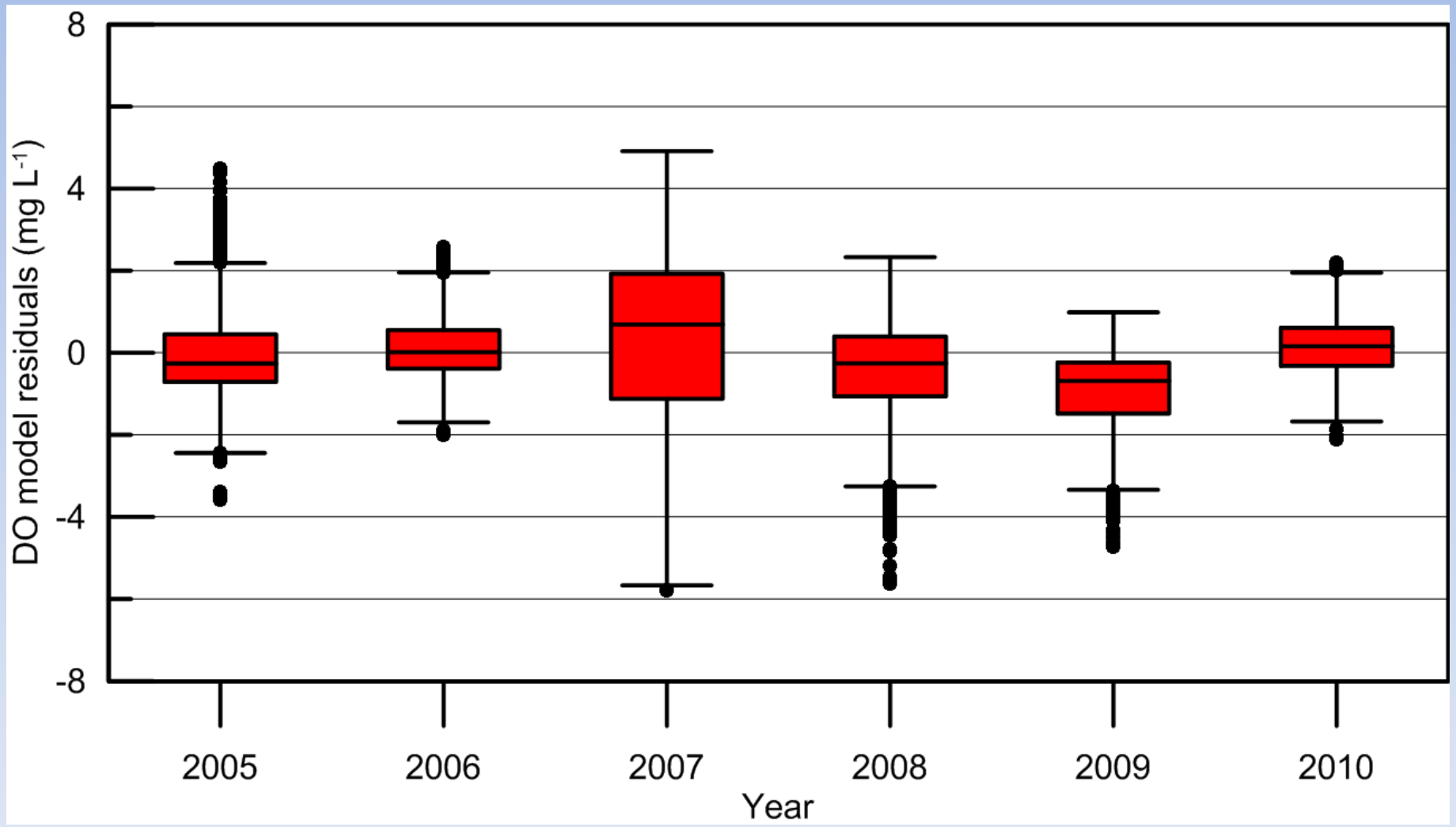




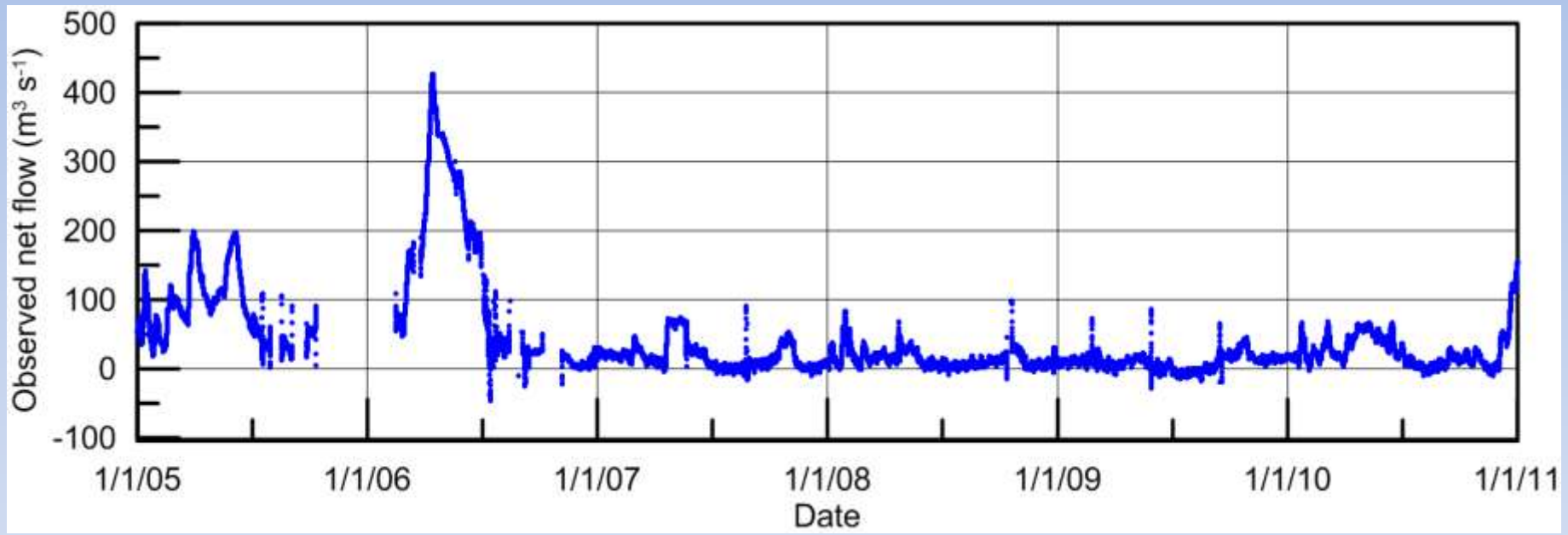
Mean error: -0.11 mg/L (1.4% re

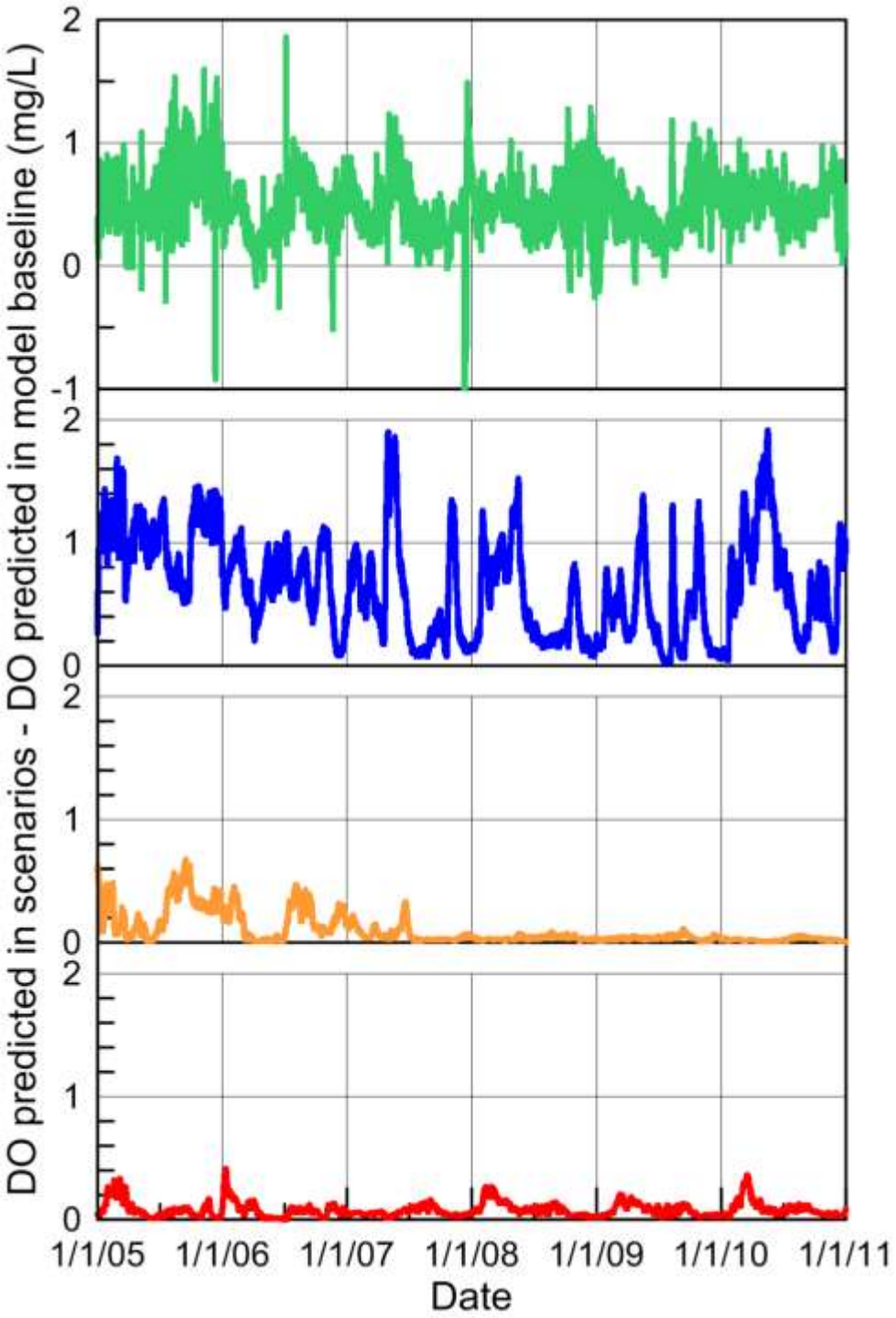
Absolute error: 0.90 mg/L (12%

Model Residuals by Year



Net Flow Rate in River





Model Simulation Results

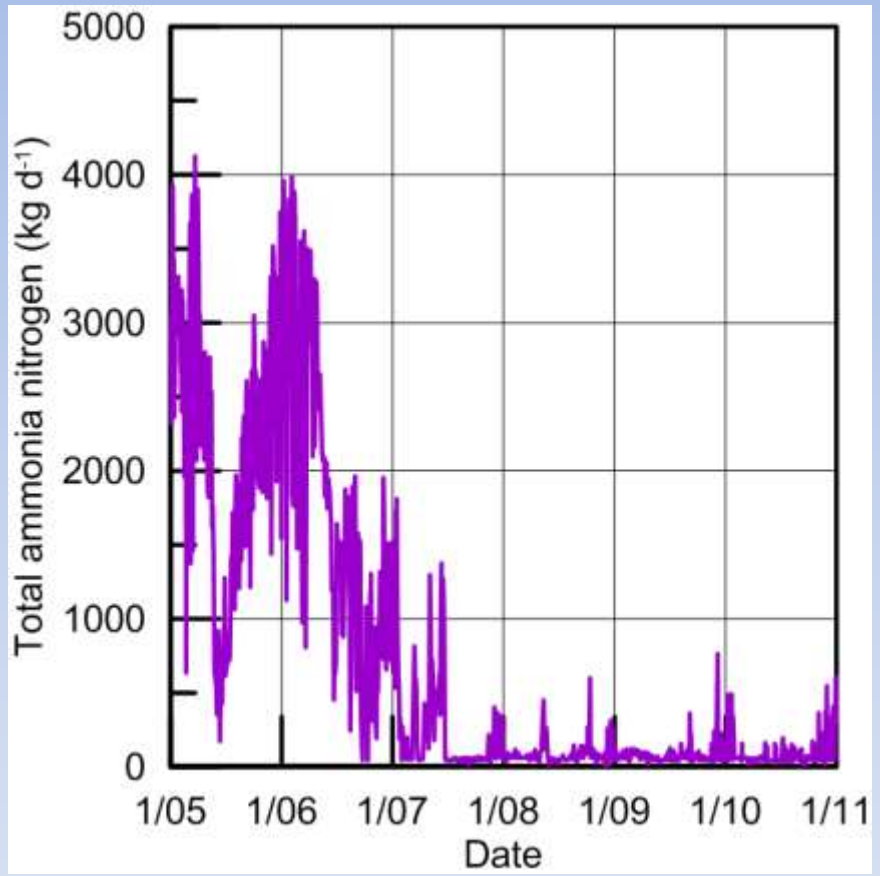
Restoration of channel depth

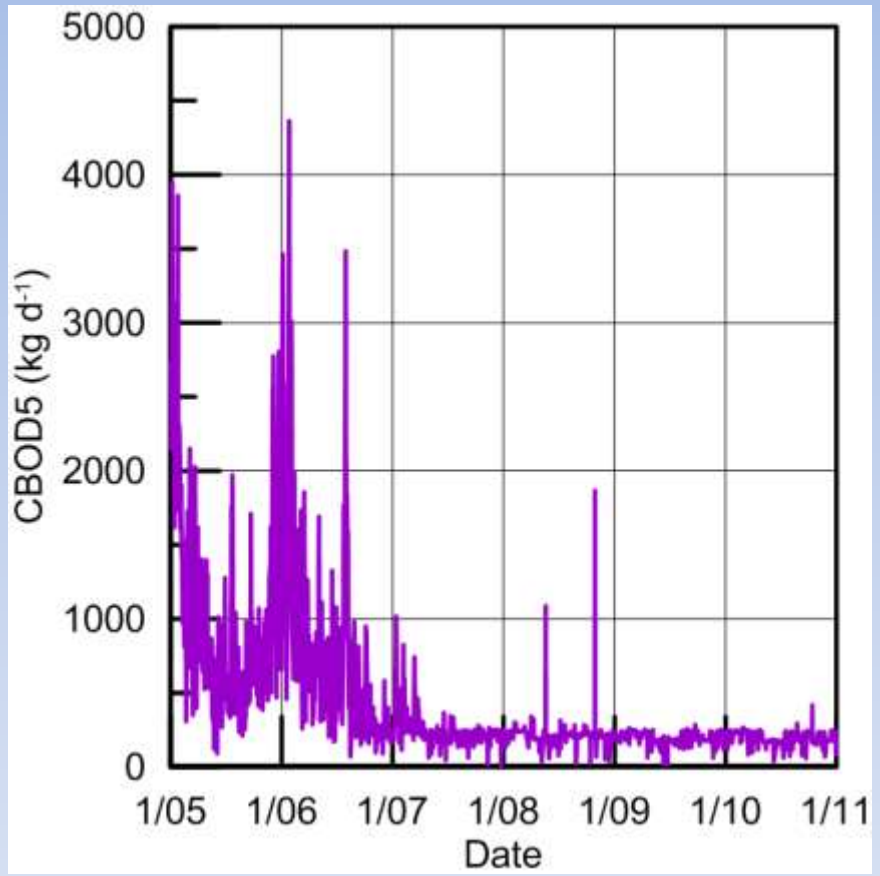
Elimination of oxygen-demanding substances (ODS) from the agricultural watershed

Elimination of ODS from the wastewater treatment plant

Elimination of ODS from the urban tributaries

Impact of Wastewater Treatment Plant Upgrade on DO





Before upgrade: River DO = 7.67 ± 1.85 mg/L DO (n=21,031), Violations 10.5% of time

After upgrade: River DO = 7.59 ± 1.54 mg/L (n=29,403), Violations 6.2% of time

Model Simulation Results

	Baseline	Model scenarios			
		Ship Channel	Agricultural Watershed	Treatment Plant	Urban Tributaries
DO (mg/L) when violations predicted by baseline (n=2007)	5.43 ± 0.34	6.08 ± 0.53	5.85 ± 0.54	5.68 ± 0.49	5.53 ± 0.33
Reduction in DO violations relative to baseline	--	62%	52%	36%	12%
Scenario responsibility for predicted violations	--	38%	32%	22%	7%

Conclusions

- Scenarios resulted in predicted increased DO and fewer violations
  - Restoration of ship channel had largest impact, followed by reduction of watershed ODS
  - Urban tributaries and wastewater had less effect
- Results assist policy decisions, support TMDL process, and engage stakeholders

Acknowledgements

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