Oregon DEQ TMDL Program

Mid-Coast dissolved oxygen Technical Work Group #5

September 26, 2017

Newport, Oregon

Dan Sobota | Oregon Department of Environmental Quality

Since last TWG meeting

- Task 1: Modeling work plan completed
- Task 2: Calibrated QUAL2Kw models for the Upper Yaquina in July 2016 & contractor provided a calibrated watershed model (HSPF) for the Upper Yaquina
- Task 3: DO monitoring coordinated for the Siletz, Salmon, and Siuslaw during summer and fall

Presentation objectives

- Provide overview and results of the HSPF watershed model in the Upper Yaquina

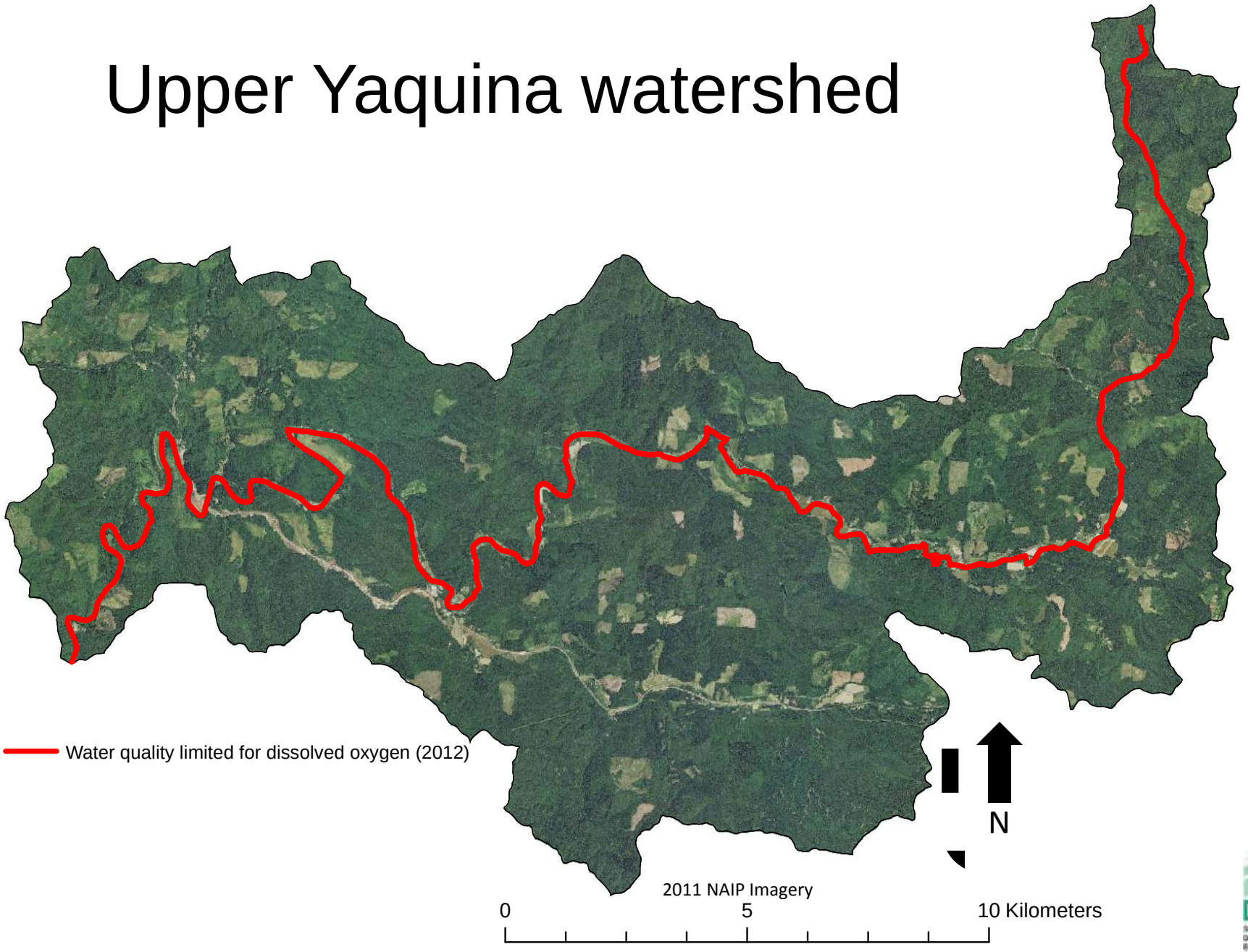
- Provide results from the Upper Yaquina QUAL2Kw model for July and October 2016

Questions for the TWG

- What specific practices may be affecting riparian conditions, organic matter, and nutrient loading in the Upper Yaquina?

- What scenarios and management actions should be modeled?

Upper Yaquina watershed



Upper Yaquina watershed dissolved oxygen 303(d) listings

- Salmonid spawning, October 15 – May 15
  - Not less than 11.0 mg/L or 95% saturation
- Year Round (Non-spawning)
  - Not less than 8.0 mg/L or 90% saturation

Total Maximum Daily Load (TMDL) for dissolved oxygen

- TMDLs ~ pollution budgets for water bodies
- Dissolved oxygen is a physical-chemical condition, not a pollutant
- Need to identify and quantify surrogate measures (pollutants) that affect DO

Key factors that interact to influence dissolved oxygen concentrations:

- Flow
- Temperature
- Channel morphology
- Biological Productivity:
  - Nutrients
  - Primary production
  - Decomposition

For Mid-Coast dissolved oxygen TMDLs:

- QUAL2Kw v.6 (Pellitier et al. 2006)
  - Reach scale tool for estimating effects of physical, chemical, and biological processes on DO

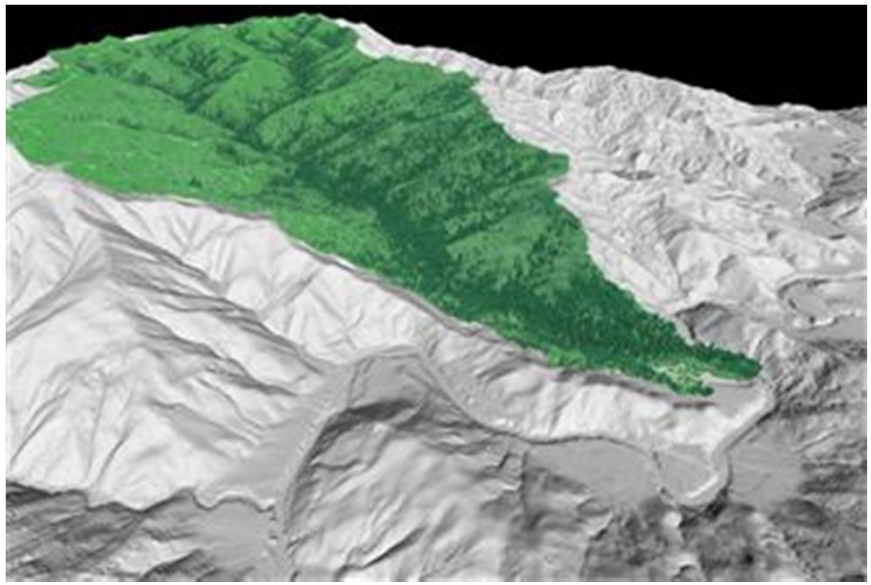
- HSPF v.12.2 (Hydrological Simulation Program – Fortran; Bicknell et al. 2005)
  - Watershed tool for estimating flow, organic matter, and nutrients

Why HSPF in addition to QUAL2Kw?

- Watershed level estimates needed for flow and nutrient inputs along the QUAL2Kw reach
- QUAL2Kw estimates *in-stream* water quality processes only

First half of the presentation:

Hydrologic Simulation Program-Fortran (HSPF) overview



Why is HSPF useful?

- Temporally and spatially explicit
- Can be used to look at different landscape scenarios and management conditions

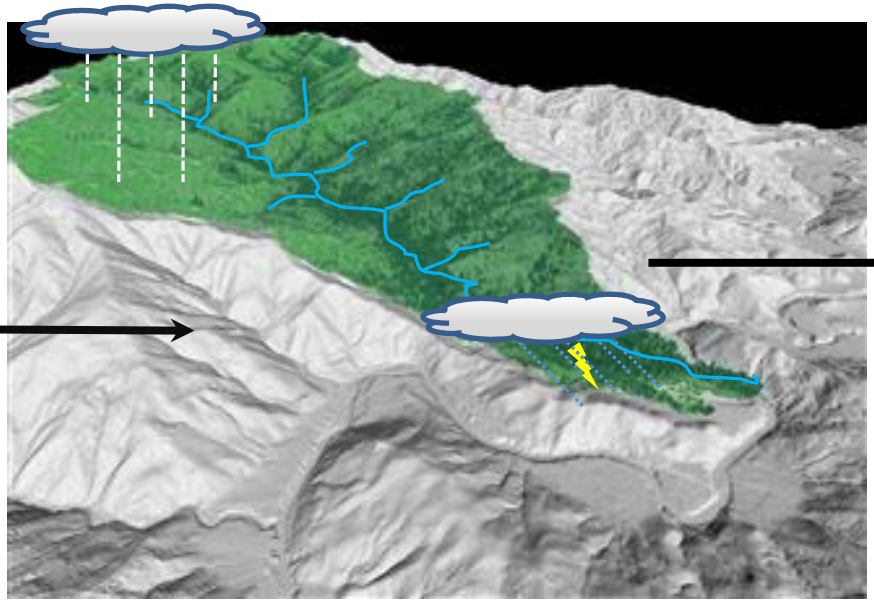
Why HSPF specifically?

- Well-supported EPA model
- Used in EPA-approved TMDLs (like QUAL2Kw)
- Linked to QUAL2Kw for TMDL development in other states
- Being used for bacteria TMDLs in the Mid-Coast

Conceptualization

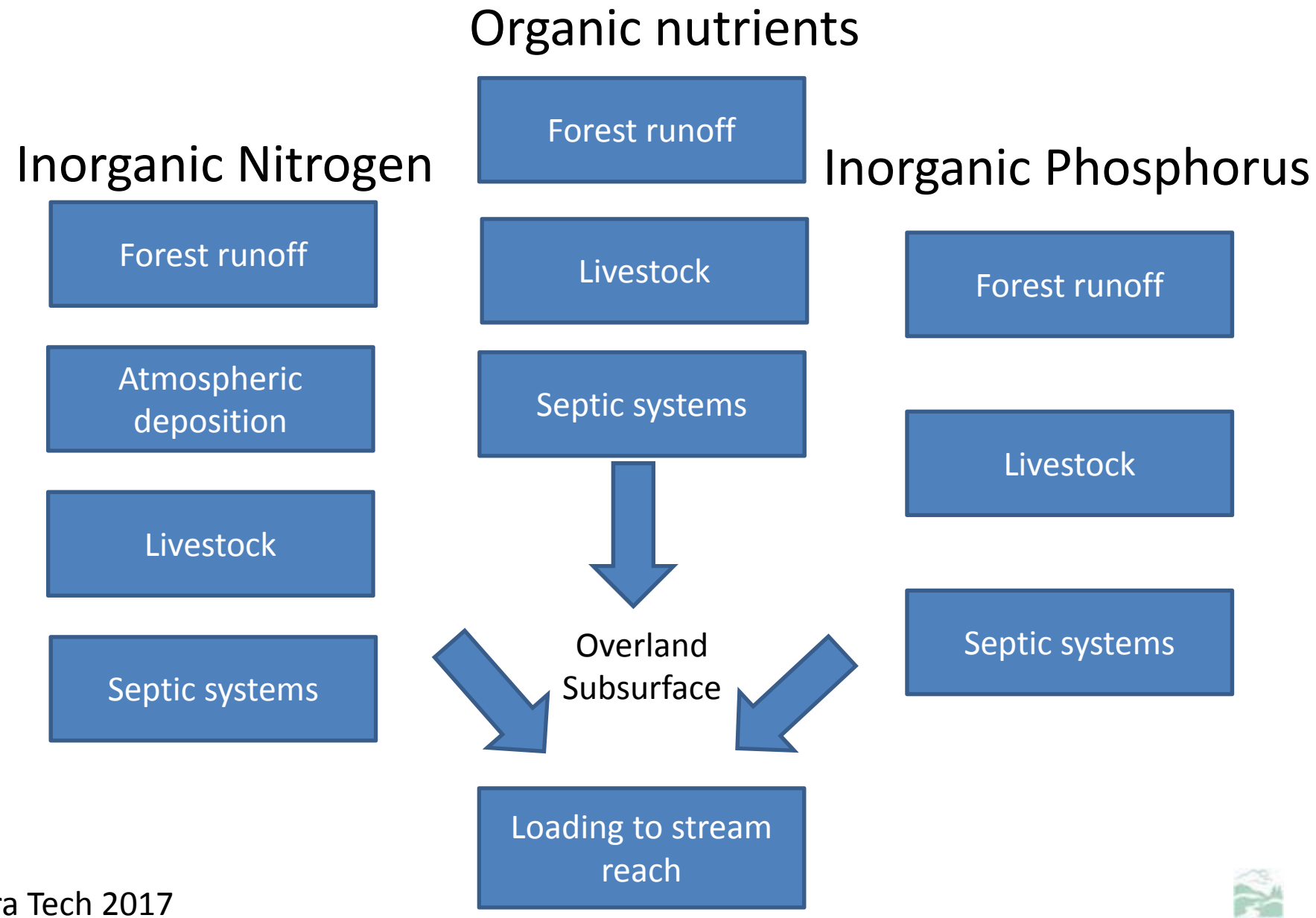
HSPF Inputs:

- Meteorology
- Land use
- Management
- Population
- Topography
- Soils
- Geology
- Hydrography



HSPF Outputs:

- Flow
- Inorganic N
- Inorganic P
- Organic N
- Organic P



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Literature for estimating organic matter and nutrients

- Compton, J.E., M.R. Church, S.T. Larned, and W.E. Hogsett. 2003. Nitrogen Export from Forested Watersheds in the **Oregon Coast Range**: The Role of N2-fixing Red Alder. Ecosystems. 6: 773-785

- Hatten, J.A., M.A. Goñi, and R.A. Wheatcroft. 2012. Chemical characteristics of particulate organic matter from a small mountainous river system in the **Oregon Coast Range**, USA. Biogeochemistry. 107:43-66.

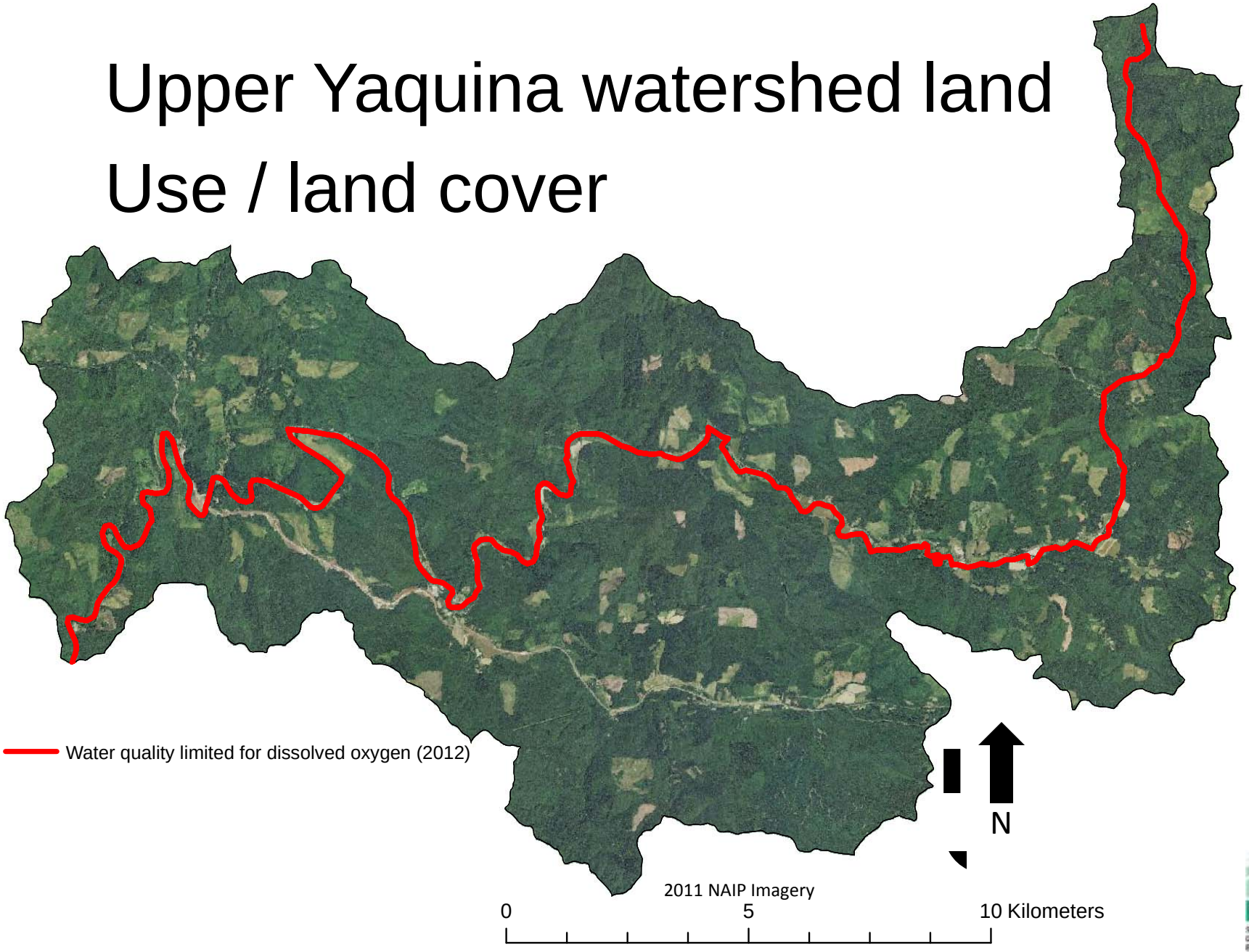
- Goñi, M.A., J.A. Hatten, R.A. Wheatcroft, and J.C. Borgeld. 2013. Particulate organic matter export by two contrasting small **mountainous rivers from the Pacific Northwest**, USA. Journal of Geophysical Research: Biogeosciences. 118: 112-134.

- Sigleo, A C. and W. E. Frick. 2003. Seasonal Variations in Nutrient Concentrations and River Flow in a **Northwestern USA Watershed**. Presented at First Interagency Conference on Research in the Watersheds, Benson, AZ, October 28-30, 2003.

- Tetra Tech. 2006. Lake Maumelle Watershed and Lake Modeling – Model calibration Report. Prepared for Central Arkansas Water, Little Rock, Arkansas.

- Zeckoski, R. W., Benham, B. L., Shah, S. B., Wolfe, M. L., Brannan, K. M., Al-Smadi, M., . . . Heatwole, C. D. (2005). BSLC: A Tool for Bacteria Source Characterization for Watershed Management. *Applied Engineering in Agriculture, 21*(5), 879-889. doi:10.13031/2013.19716

Upper Yaquina watershed land Use / land cover



Upper Yaquina land use/land cover

National Land Cover Database (2011)	HSPF Land use/land cover input	% watershed area
Water, Barren, Forest Deciduous, Forest Mixed, Forest Evergreen, Shrub, Woody Wetland, Herbaceous Wetland	Forest	87.7
Dev Open, Dev Low, Dev Med, Dev High	Developed Pervious	6.6
Grassland, Pasture, Crops	Grassland/pasture	5.1
Impervious	Impervious	0.6

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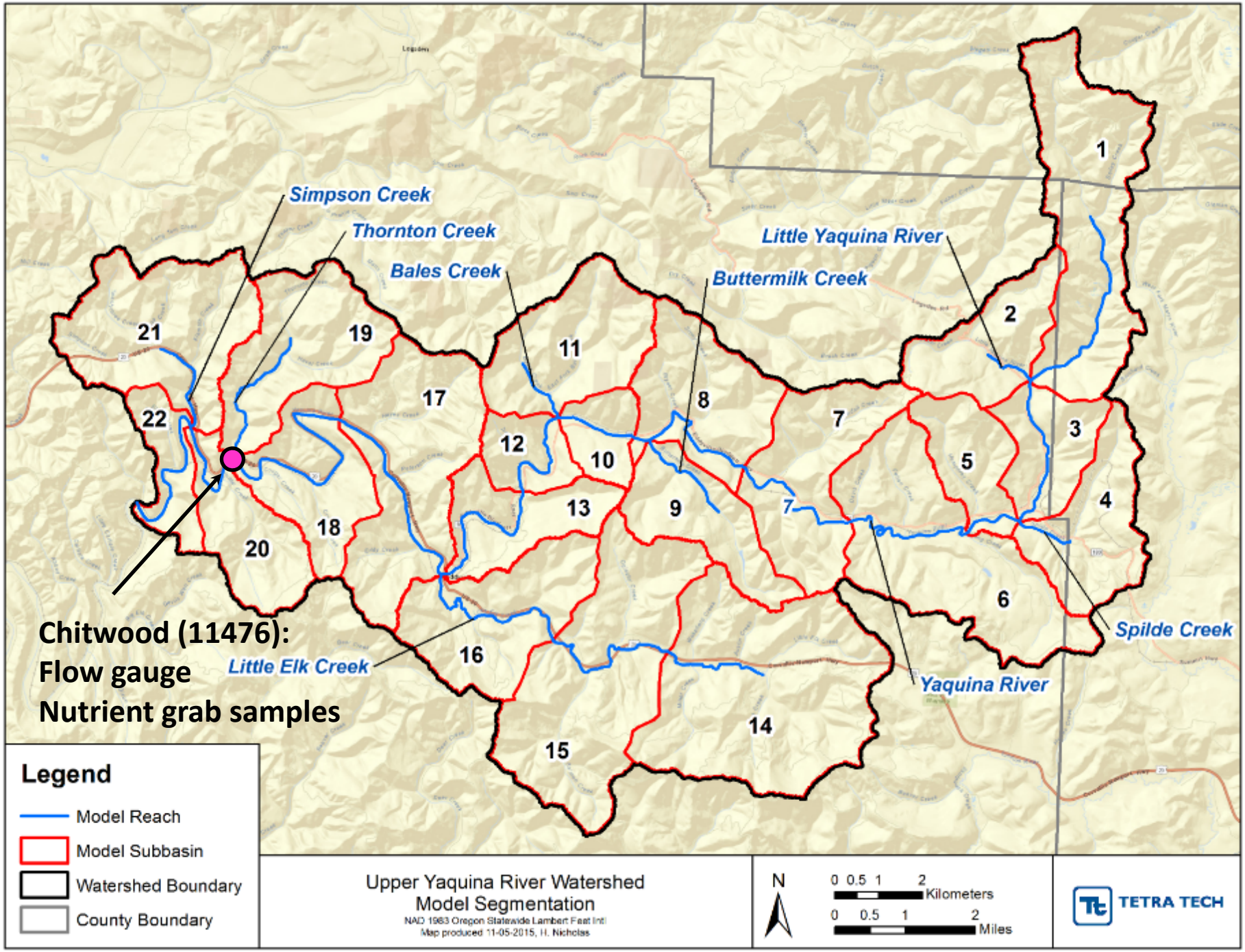
Upper Yaquina – Meteorology

- Used disaggregated data from PRISM (www.prism.oregonstate.edu)
- Used 4 km grid cells for precipitation and potential evapotranspiration
- Spatially- and temporally- explicit climate data sets developed from weather monitoring networks and rigorous spatial modeling techniques


Simpson Creek
Thornton Creek
Bales Creek
Little Yaquina River
Buttermilk Creek
Spilde Creek
Little Elk Creek
Yaquina River
1
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4
5
6
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11
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Chitwood (11476):
Flow gauge
Nutrient grab samples
Legend
Model Reach
Model Subbasin
Watershed Boundary
County Boundary
Upper Yaquina River Watershed
Model Segmentation
NAD 1983 Oregon Statewide Lambert Feet Intl
Map produced 11-05-2015, H. Nicholas
N
0 0.5 1 2 Kilometers
0 0.5 1 2 Miles
TETRA TECH

Calibration: adjusting model parameters to fit measured data

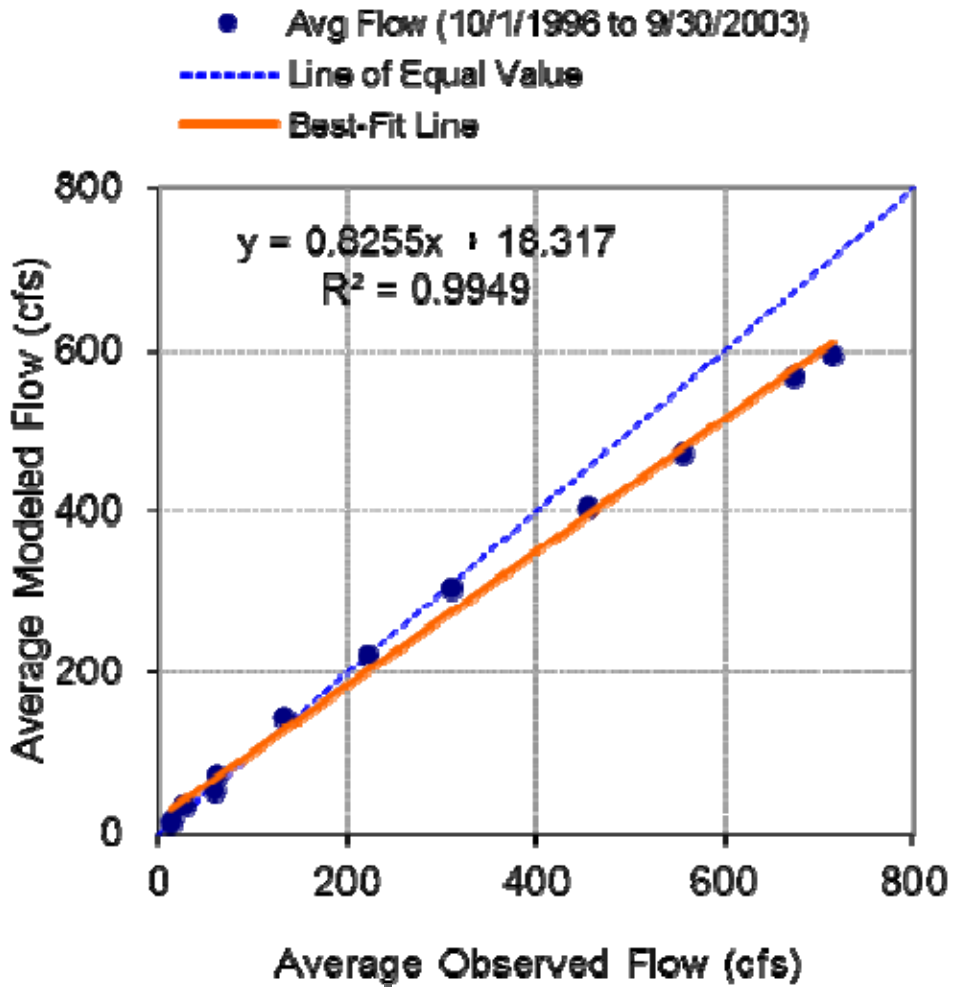
(1996 - 2005)

Validation: comparison of calibrated model with data not used for calibration

(2006 - 2014)

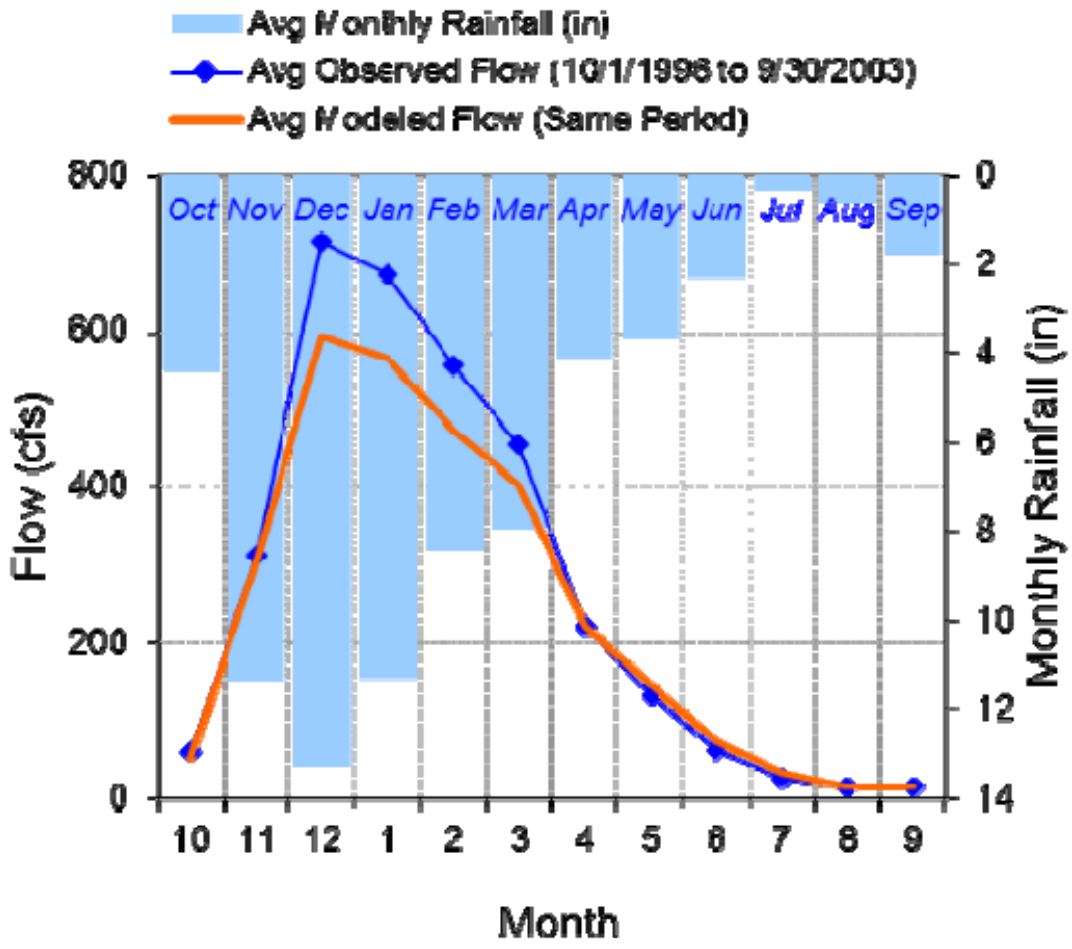
Flow, Yaquina River near Chitwood

Post-calibration validation

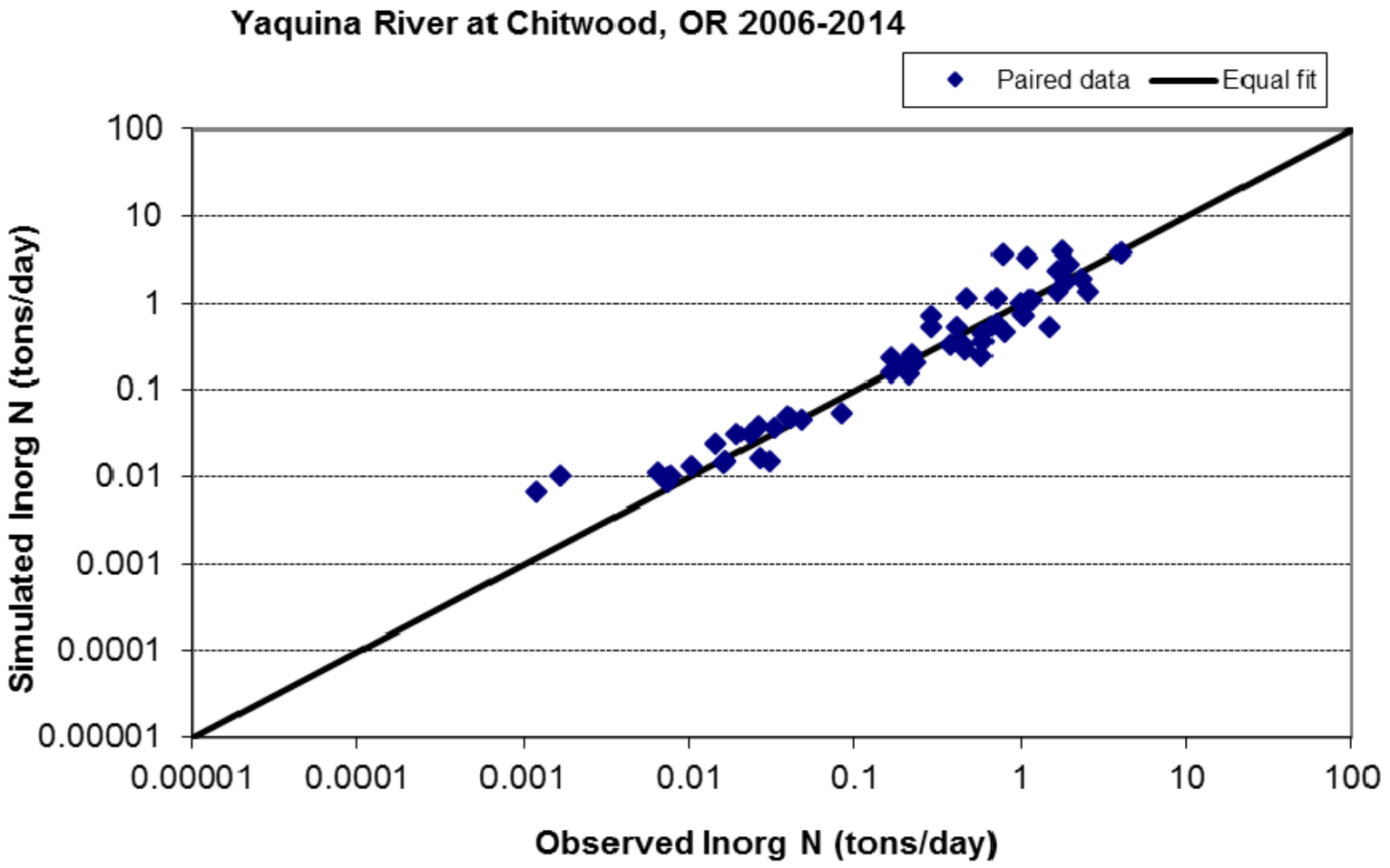


Flow, Yaquina River near Chitwood

Post-calibration validation



Inorganic Nitrogen, Yaquina River near Chitwood – Post-calibration validation



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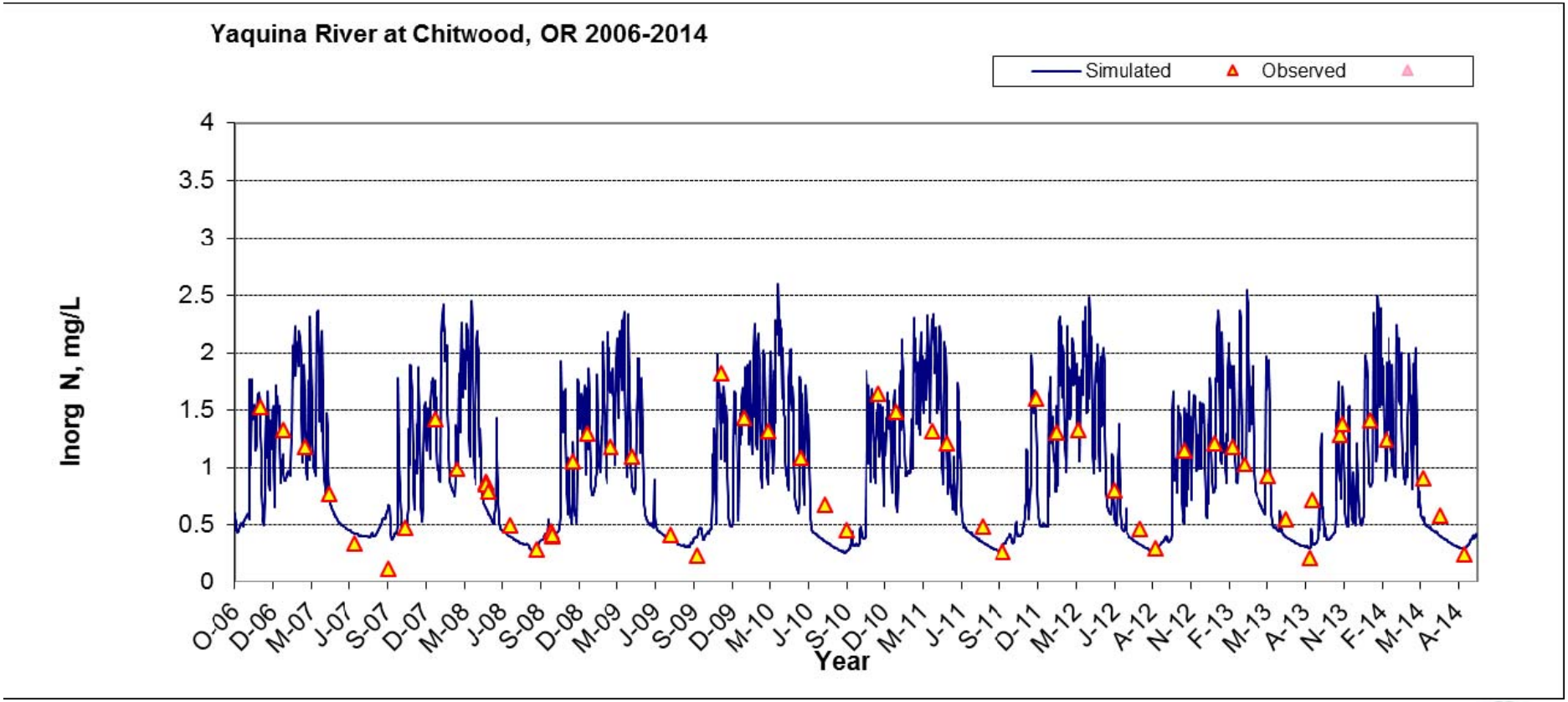
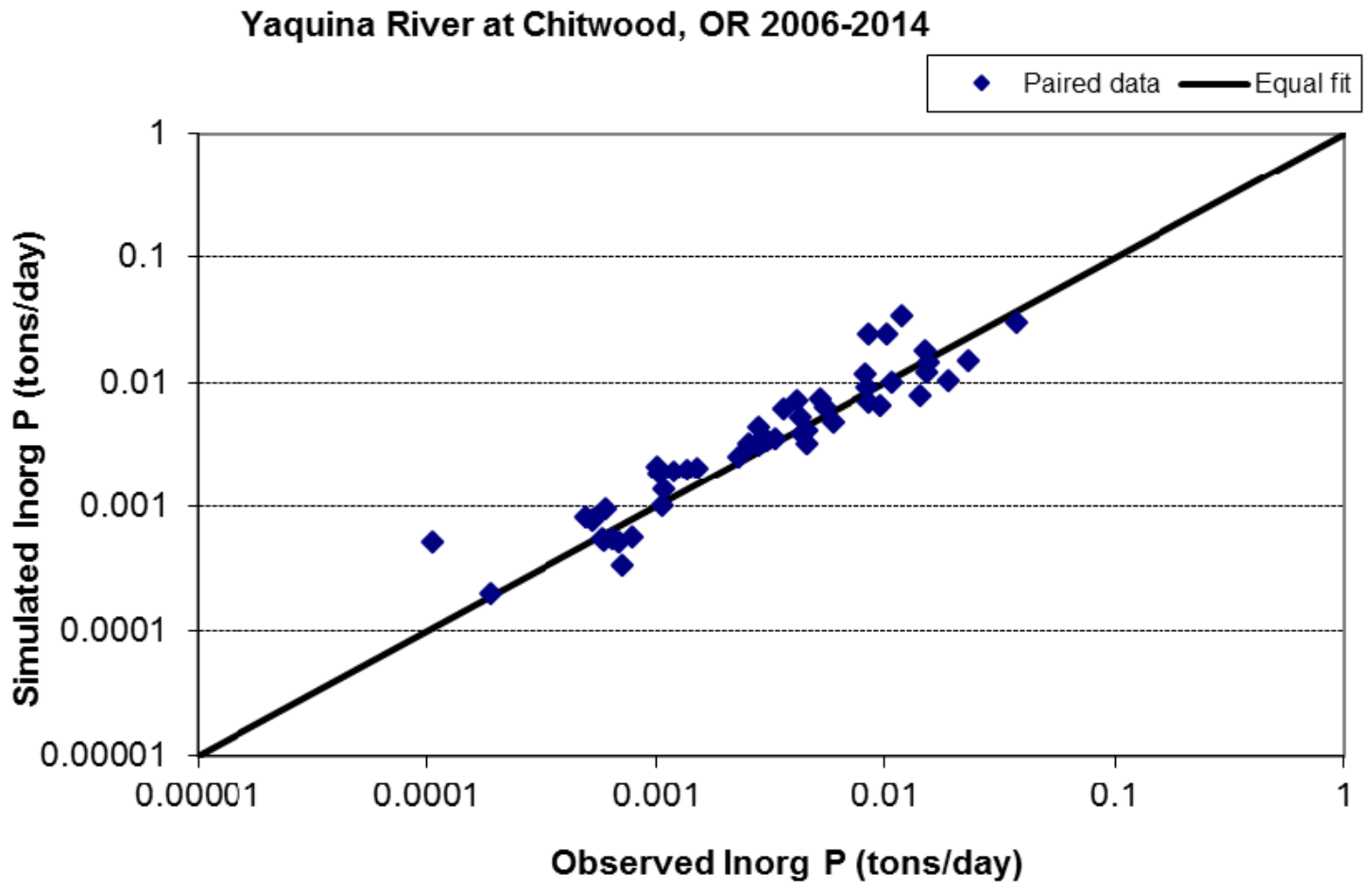
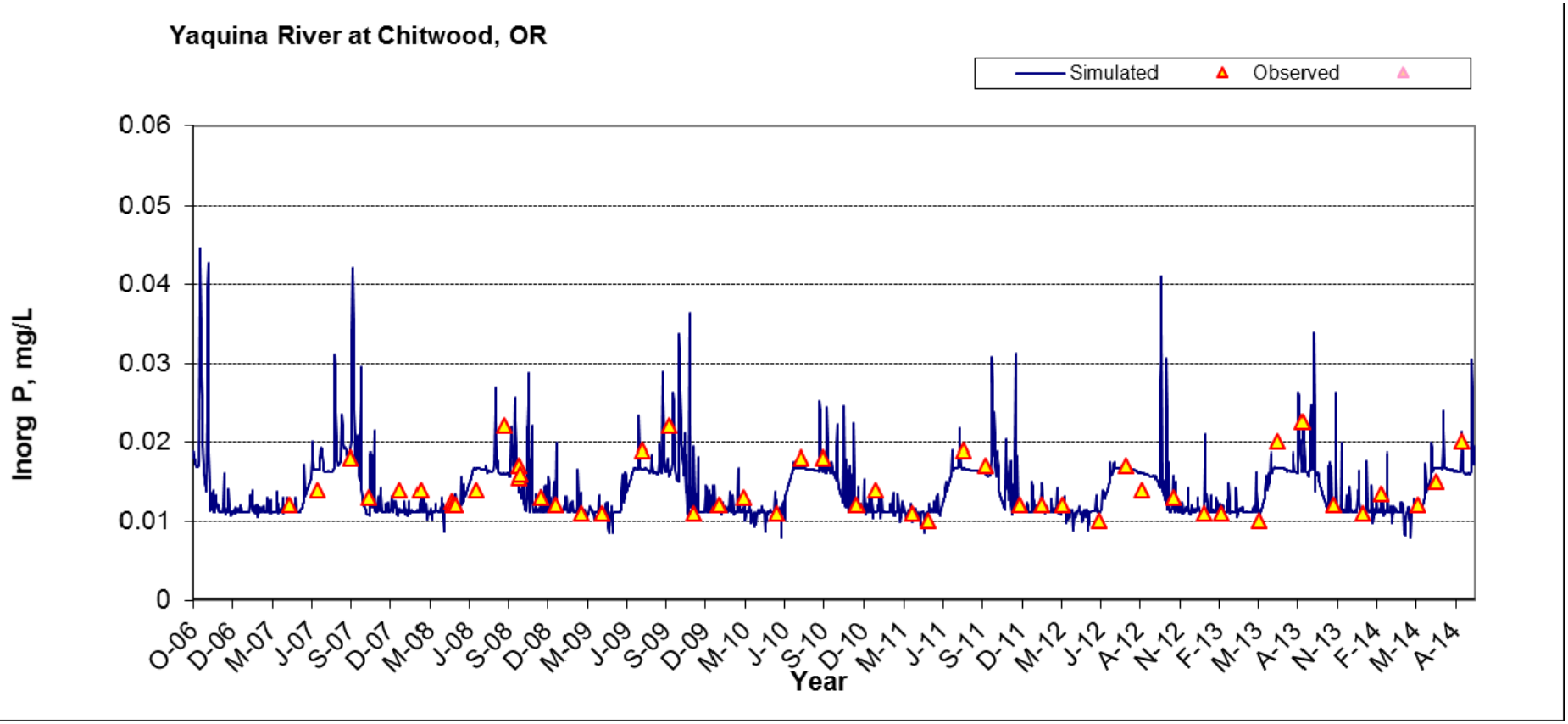


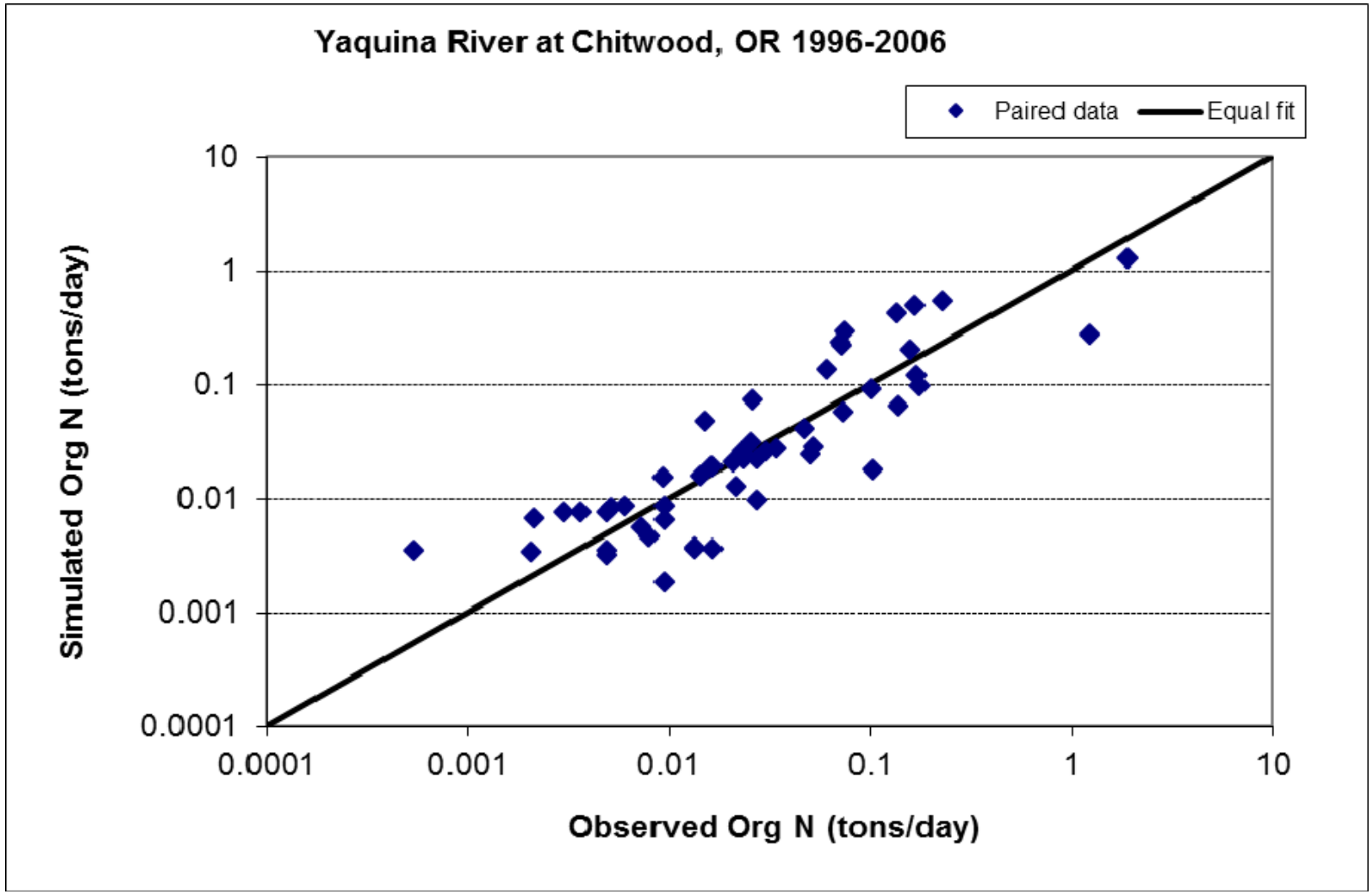
Inorganic Phosphorus, Yaquina River near Chitwood - Post-calibration validation



Inorganic Phosphorus, Yaquina River near Chitwood - Post-calibration validation



Organic Nitrogen, Yaquina River near Chitwood – Calibration*



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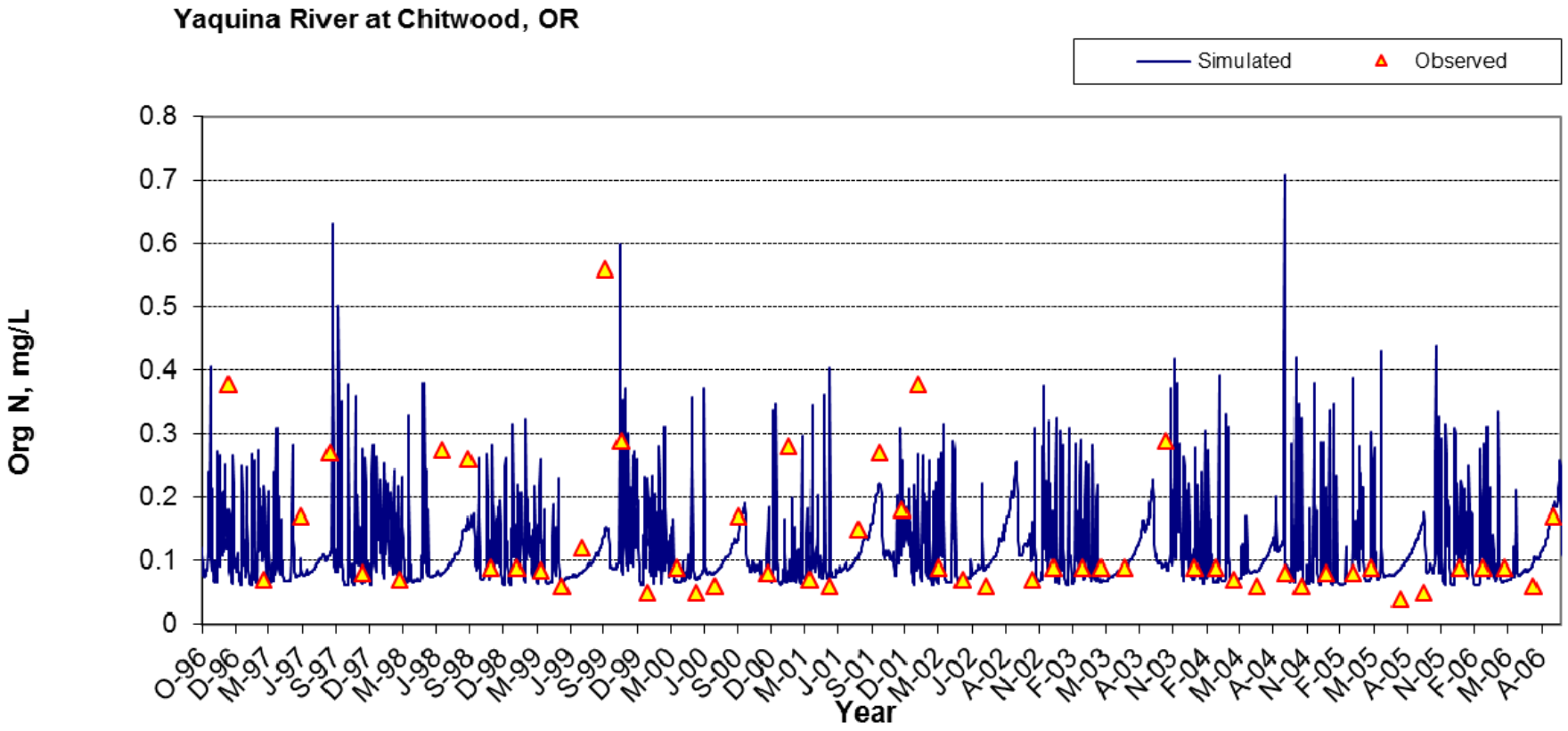
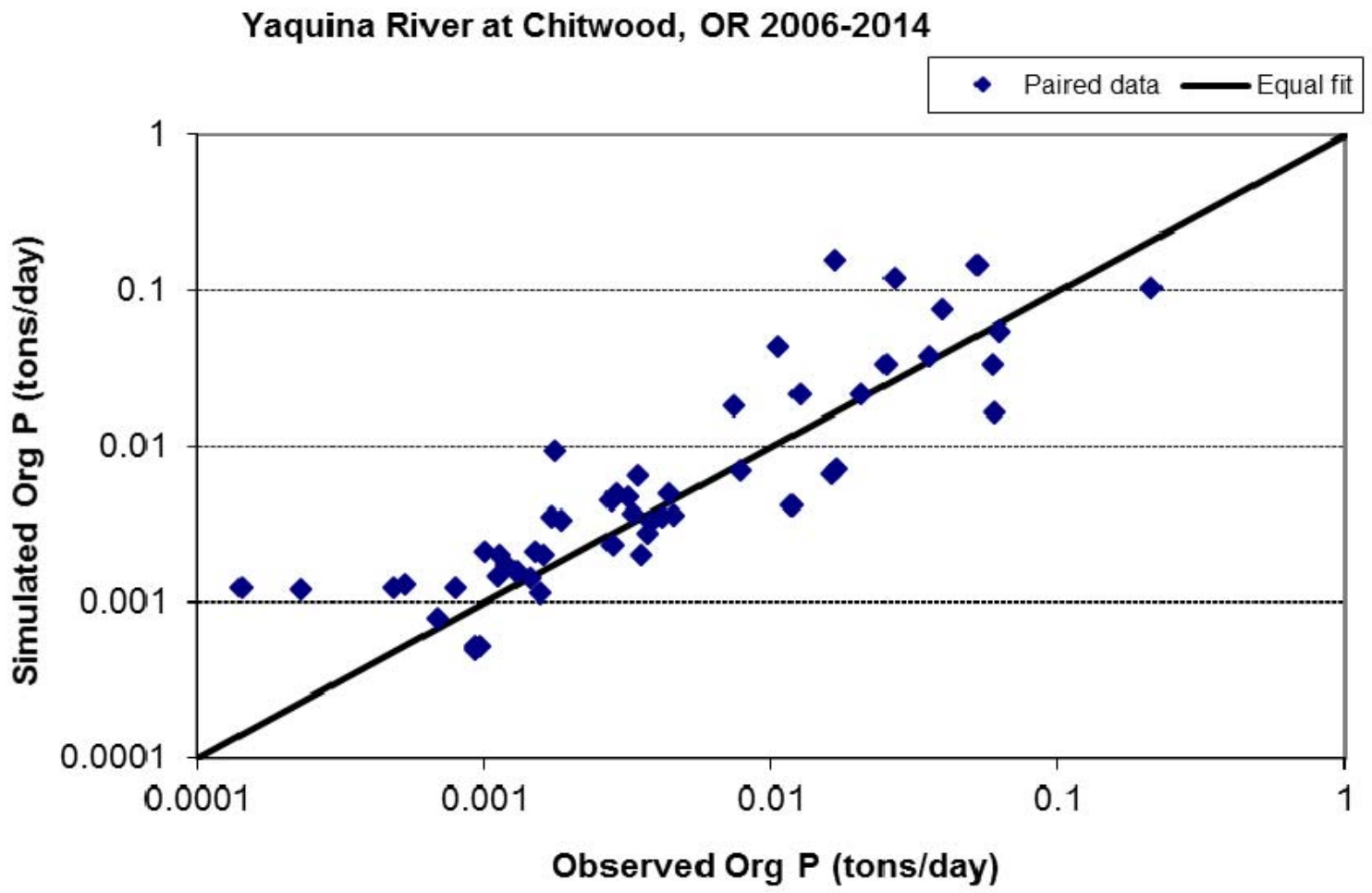


Organic Phosphorus, Yaquina River near Chitwood – Post-calibration validation



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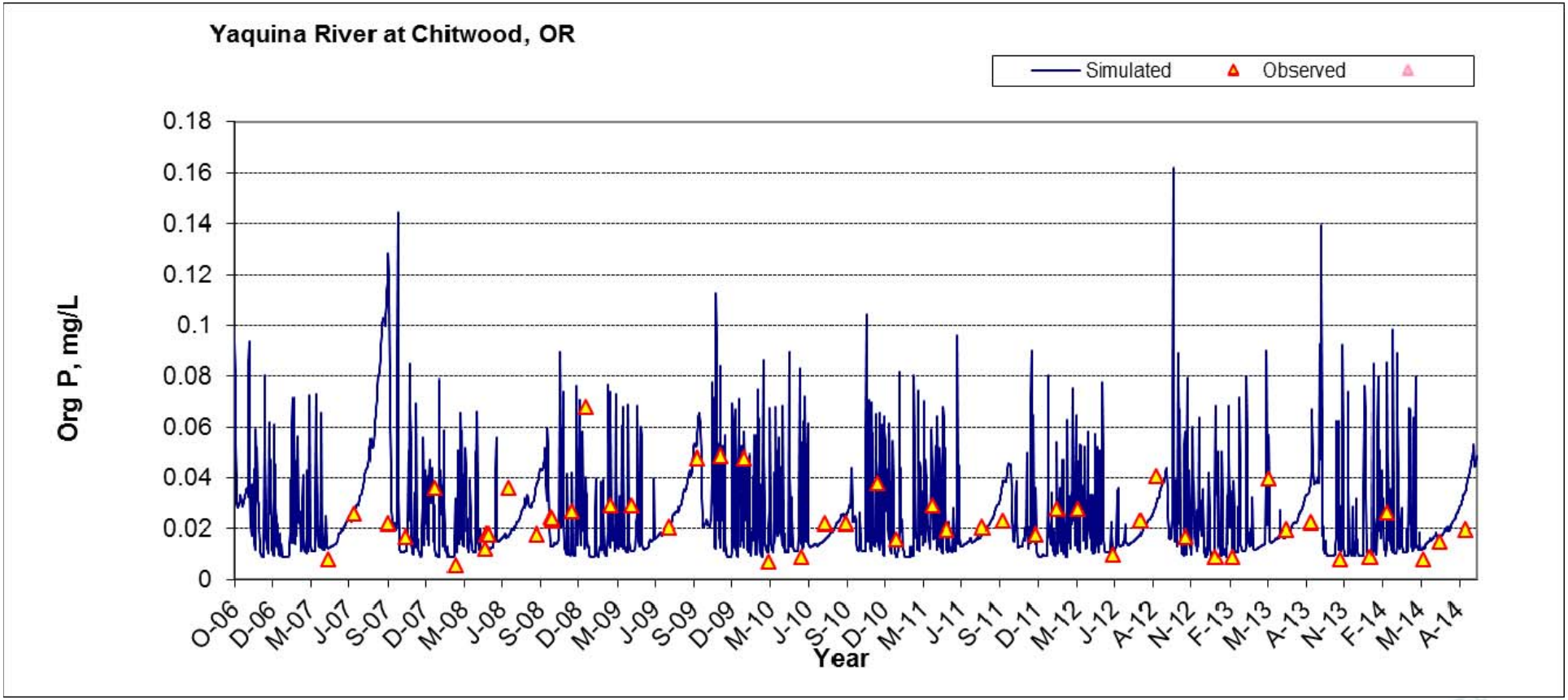

Takeaways - Upper Yaquina HSPF

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- Flow and nutrient loading simulated particularly well during low flow (TMDL) periods
- Watershed segments can be directly linked to QUAL2Kw for estimating processes affecting DO

BREAK

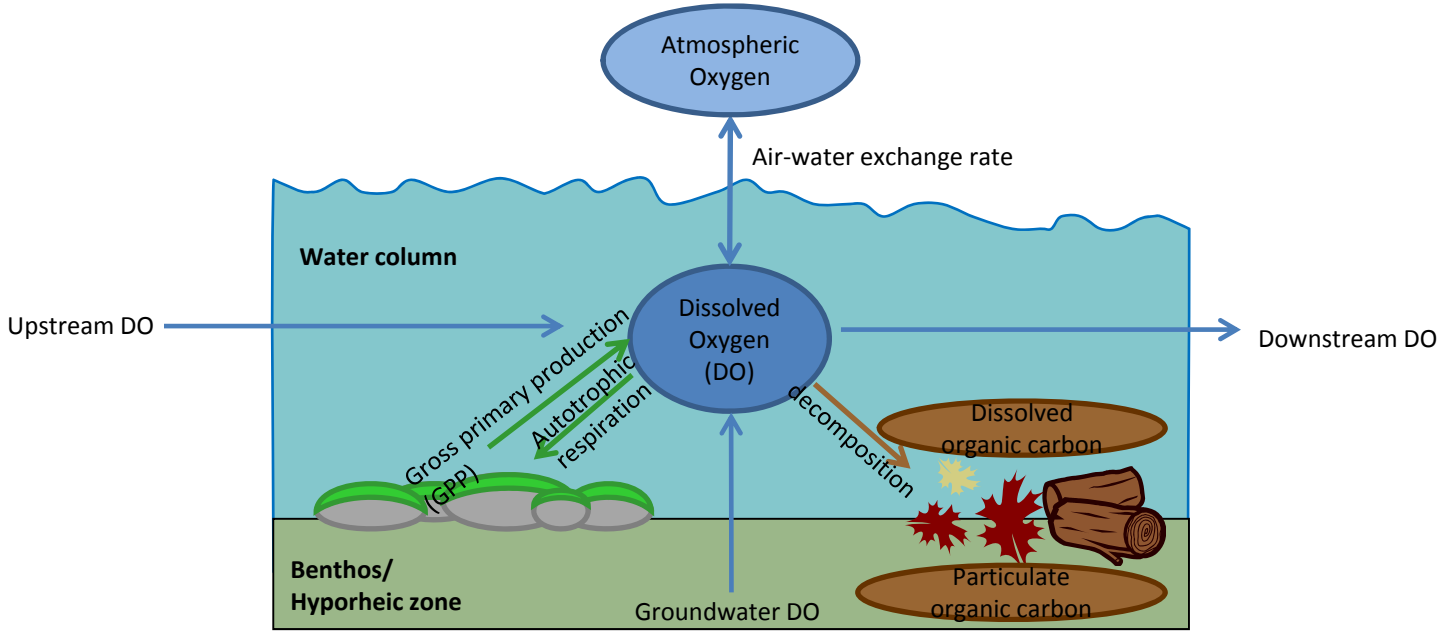
Second half of the presentation:

QUAL2Kw calibration results from the Upper Yaquina River

QUAL2Kw refresher

- EPA-approved, mechanistic modeling tool (http://www.ecy.wa.gov/programs/eap/models.html)

- Used for TMDLs in Oregon and Washington



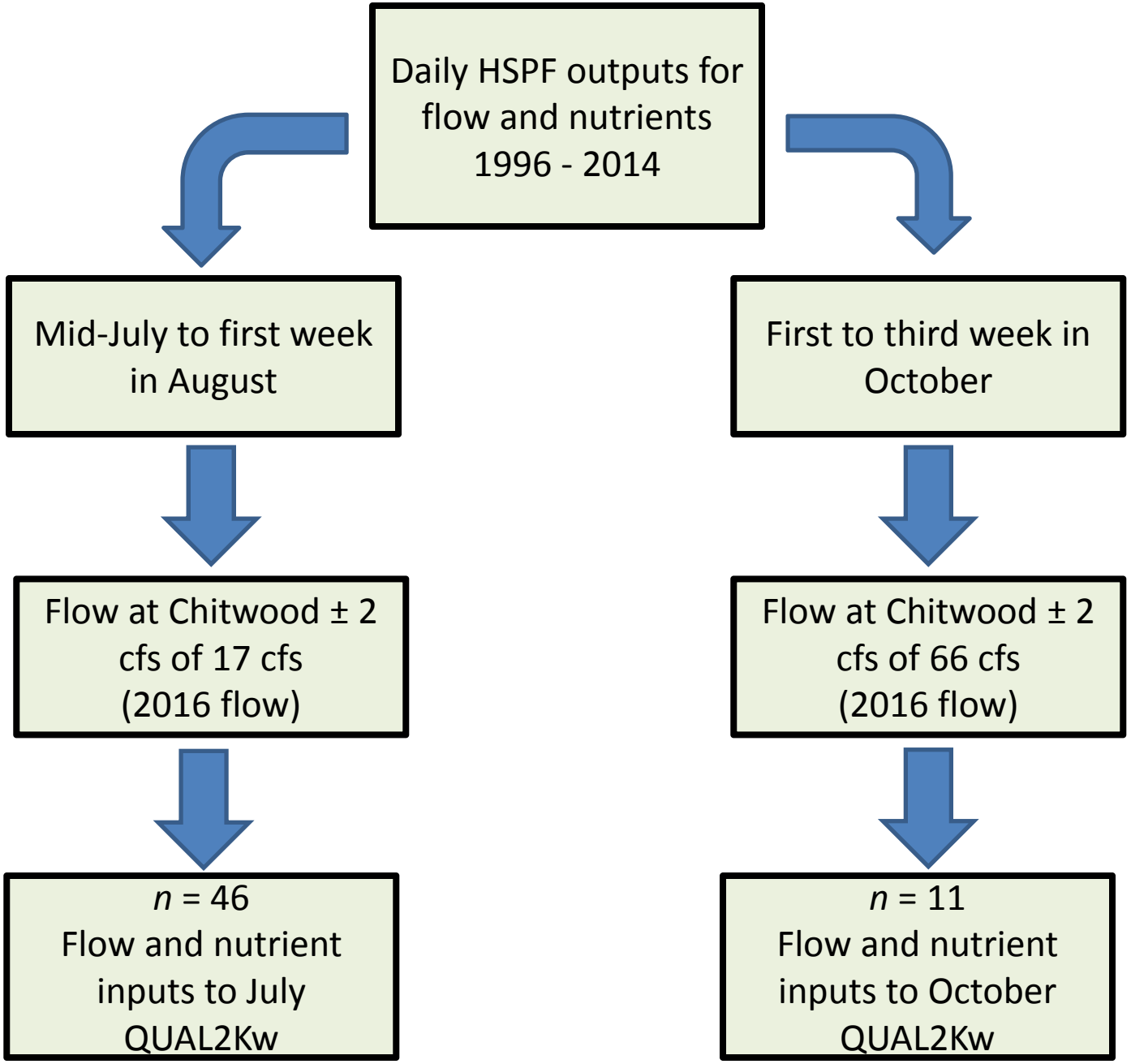
QUAL2Kw parameters measured in the field in the Upper Yaquina River

- Continuous data (every 15 minutes for >2 days)
  - Temperature
  - Dissolved oxygen
  - pH

- Grab samples (2x daily for >2 days)
  - Nutrients (nitrate, ammonia, phosphate, organics)
  - Biological oxygen demand (BOD)
  - Particulate organic matter (POM)

QUAL2Kw inputs estimated from other models or GIS data

- Parameters affecting temperature
  - Riparian shade from LiDAR
  - Weather data from disaggregated PRISM outputs
  - Sediment thermal characteristics from literature
- BOD and heat inputs
  - Averaged from field measurements and scaled to flow inputs (most objective)
- Flow and nutrient inputs (diffuse and tributary)
  - HSPF outputs


Daily HSPF outputs for flow and nutrients 1996 - 2014
Mid-July to first week in August
First to third week in October
Flow at Chitwood ± 2 cfs of 17 cfs (2016 flow)
Flow at Chitwood ± 2 cfs of 66 cfs (2016 flow)
n = 46 Flow and nutrient inputs to July QUAL2Kw
n = 11 Flow and nutrient inputs to October QUAL2Kw

Calibration parameters in QUAL2Kw

- Air-water exchange coefficients
- Parameters affecting rates of primary production
- Parameters affecting rates of decomposition
- Channel morphology parameters

Auto-calibration in QUAL2Kw

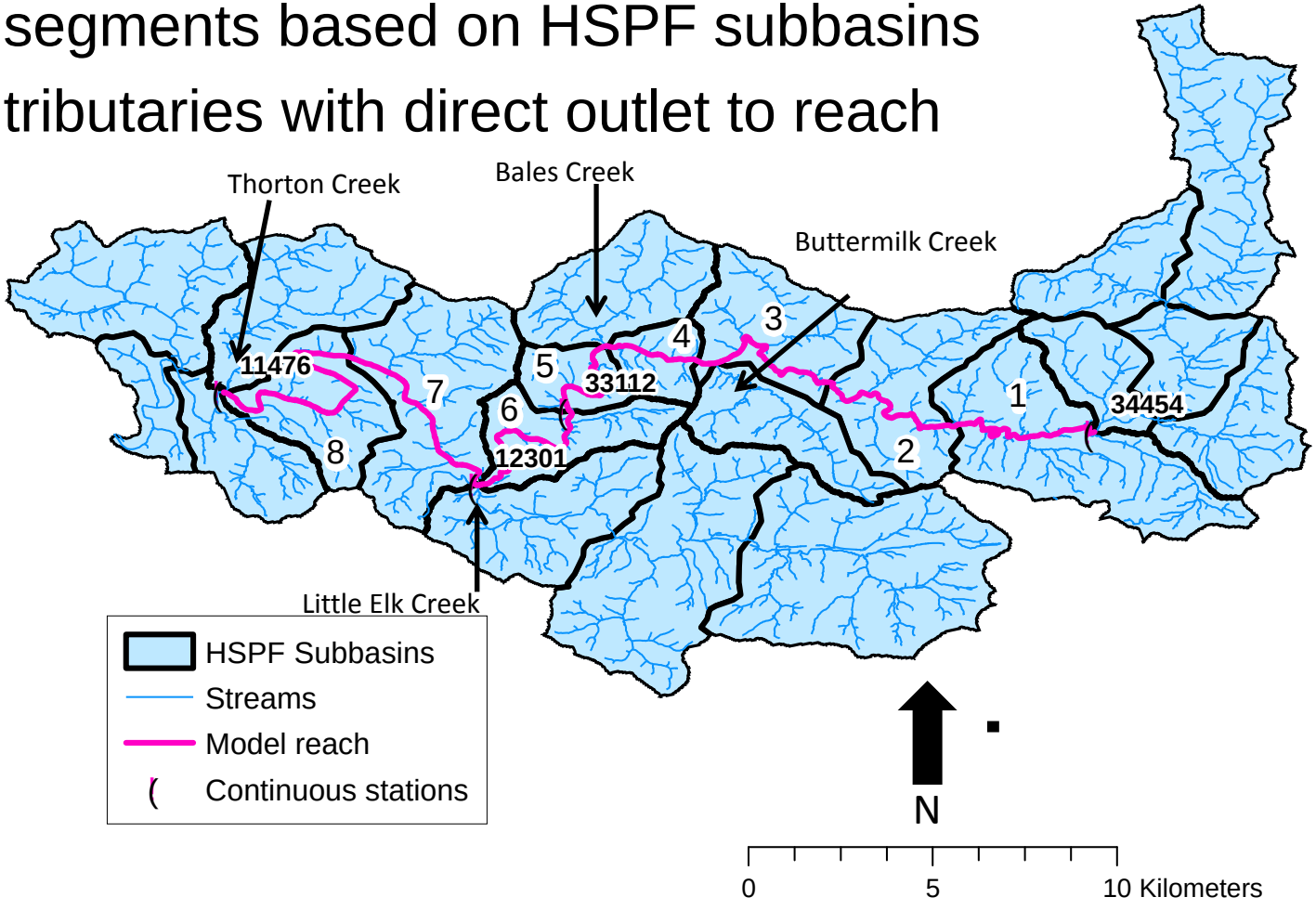
- Parameters given an expected range of values based on literature and previous measures
- Genetic algorithm used to optimize model fit
- Used normalized root mean square error (NRMSE) as fit measure
  - Standard deviation between predicted and observed divided by the mean of the observed (%)

QUAL2Kw in the Upper Yaquina

33.95 km total length (21 miles)

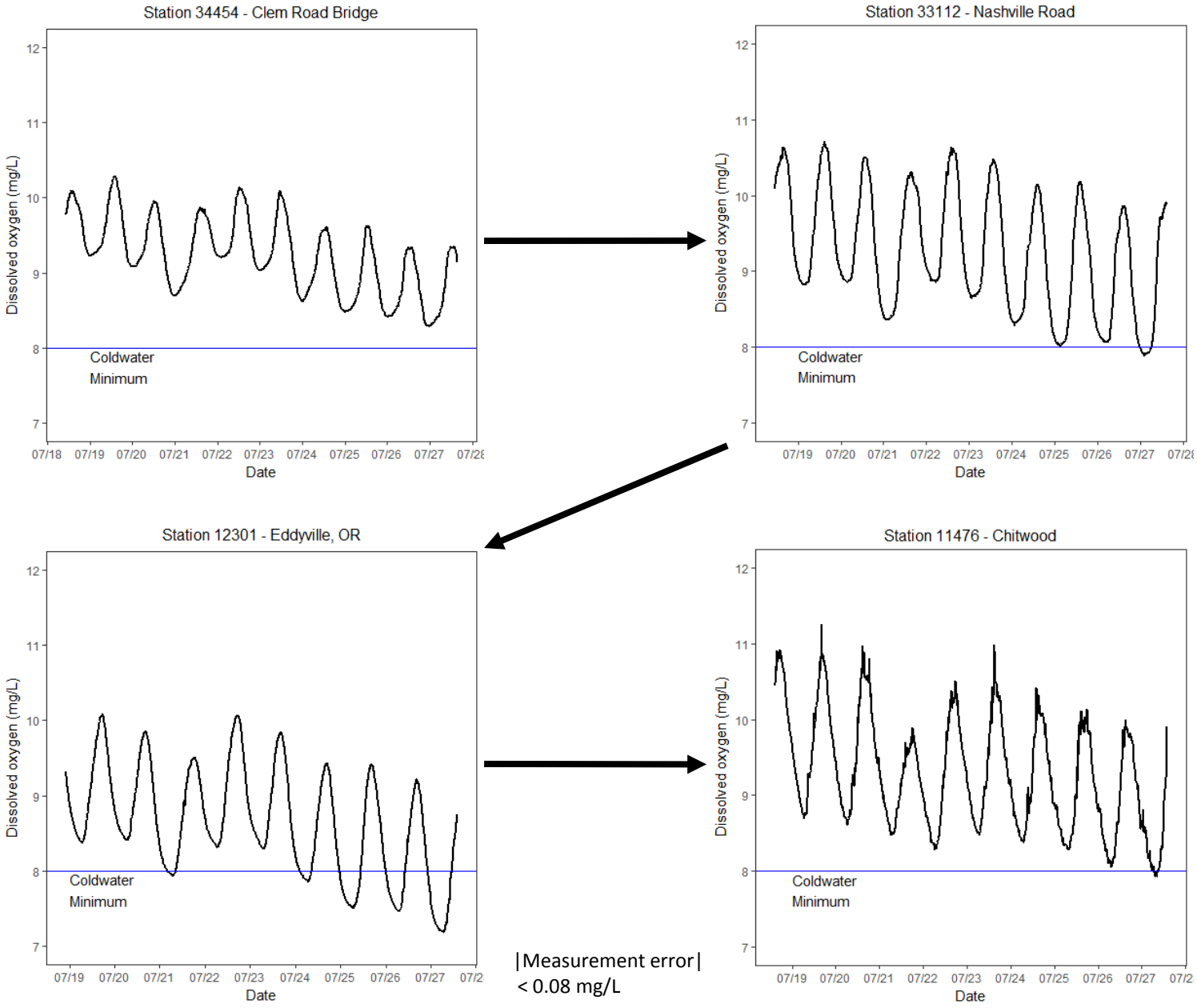
8 segments based on HSPF subbasins

4 tributaries with direct outlet to reach



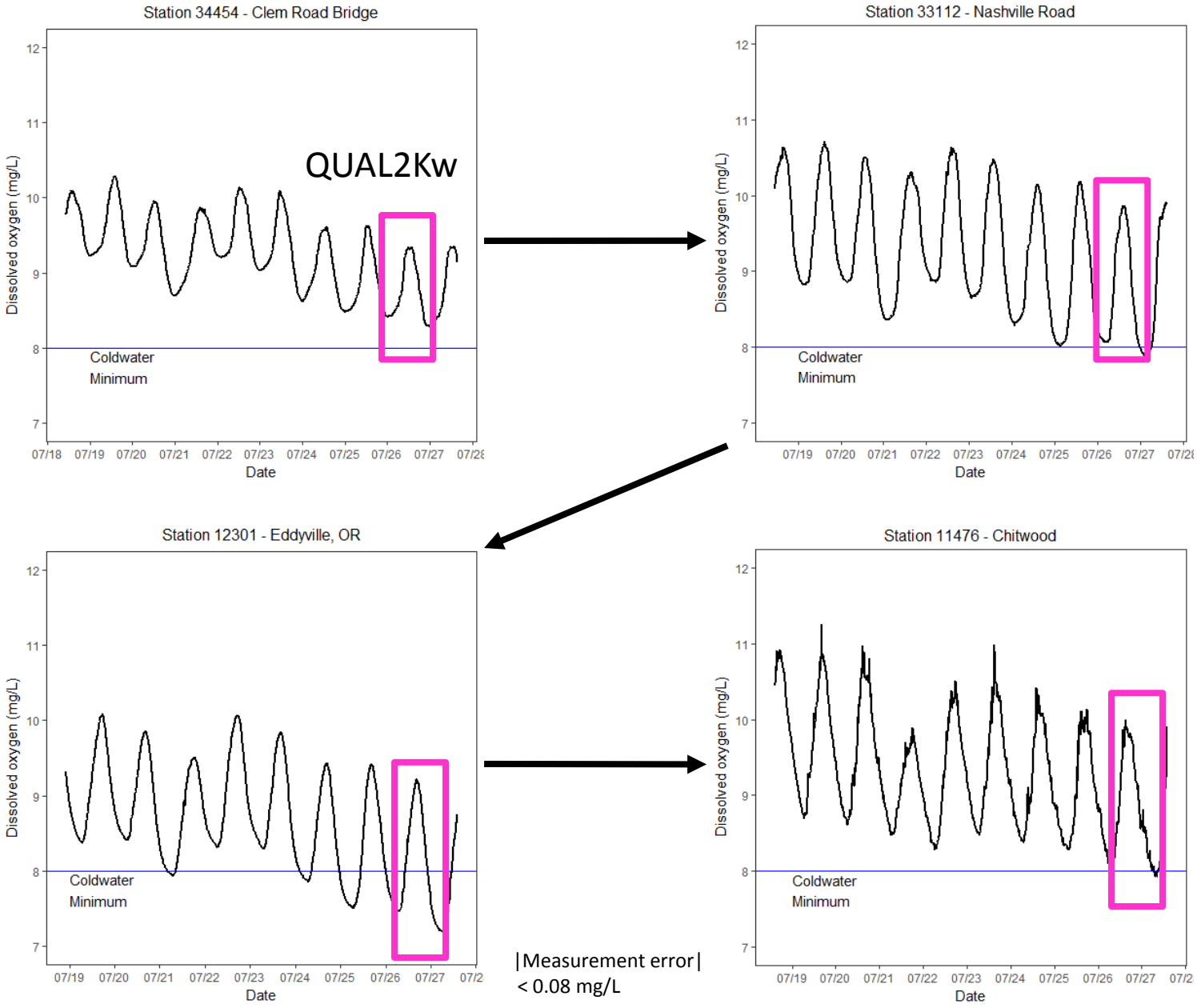
July 2016

Dissolved oxygen, July 2016



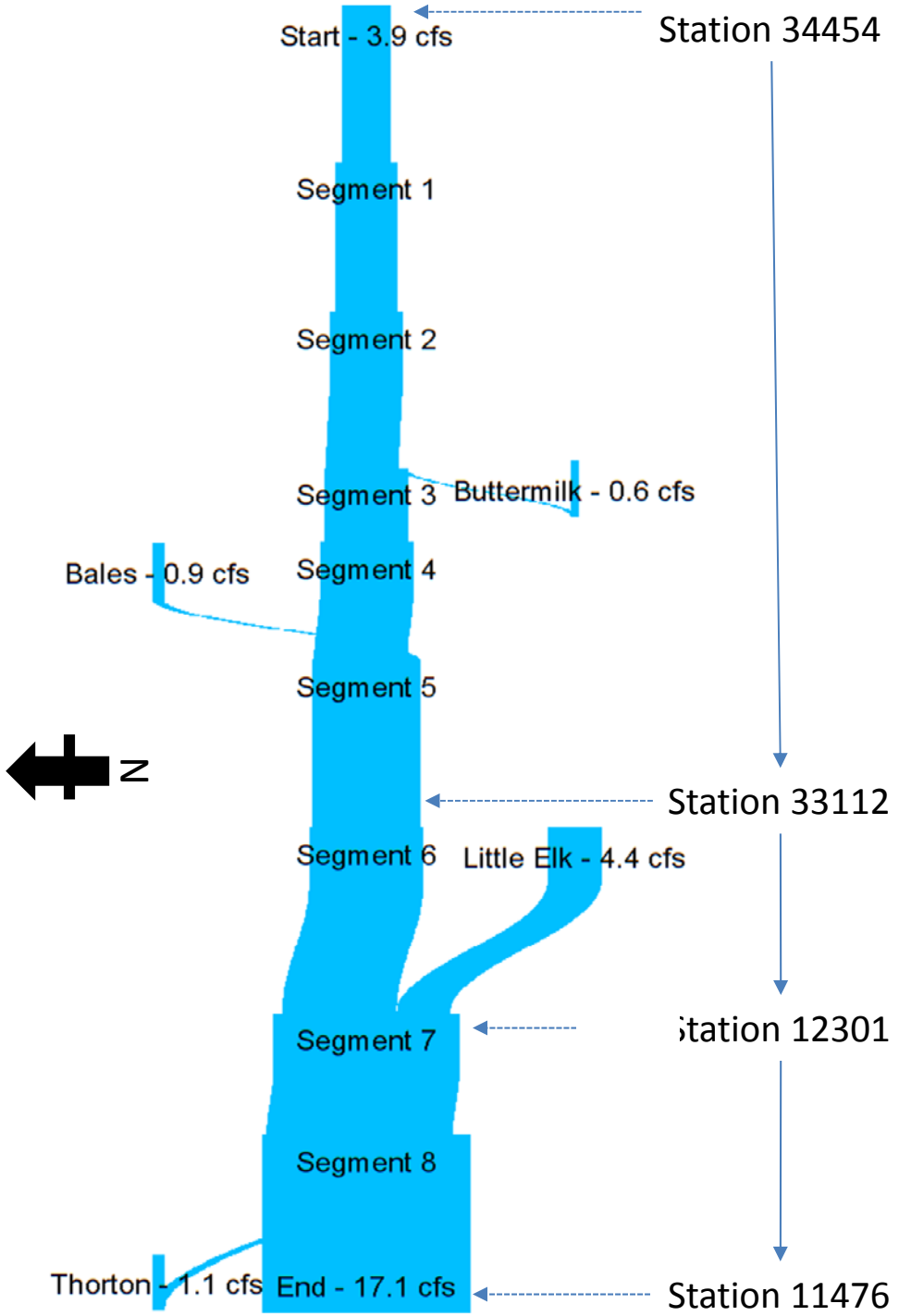
|Measurement error|
< 0.08 mg/L

Dissolved oxygen, July 2016

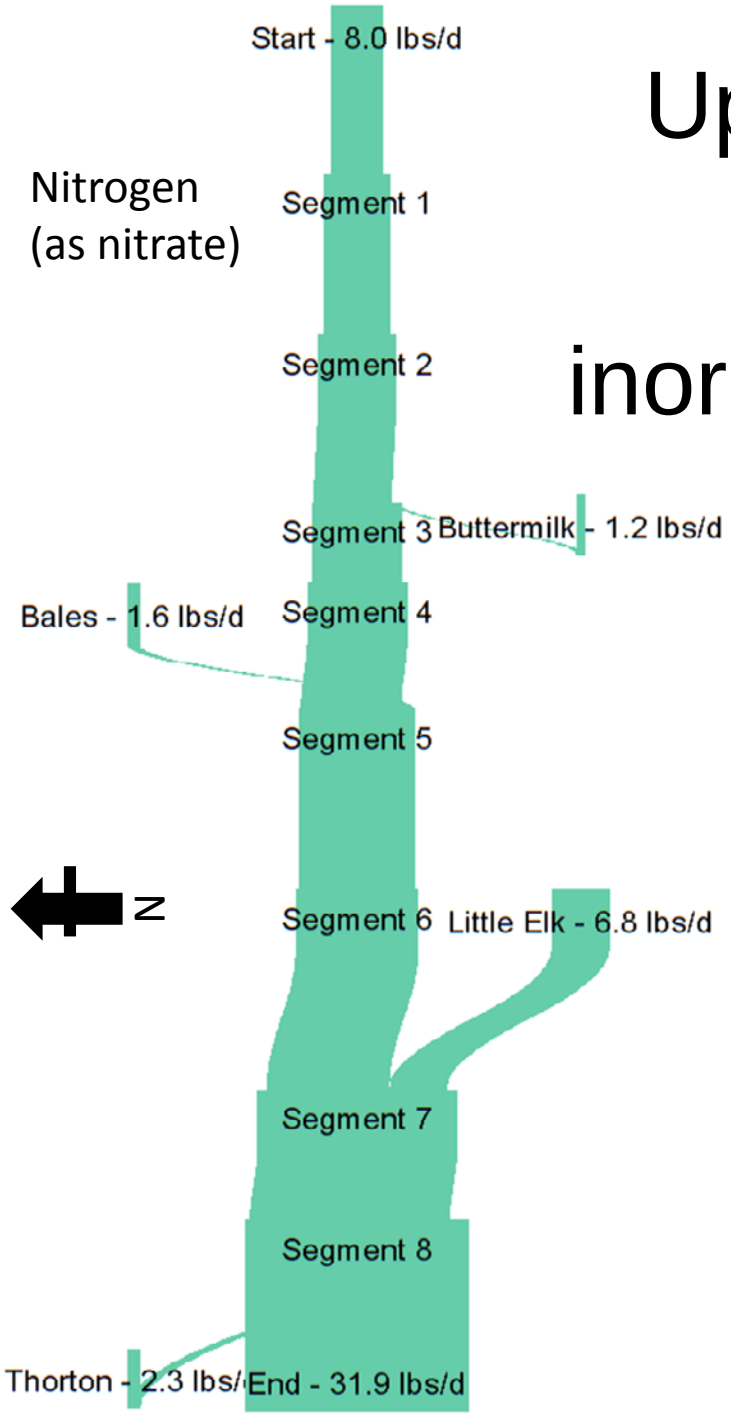


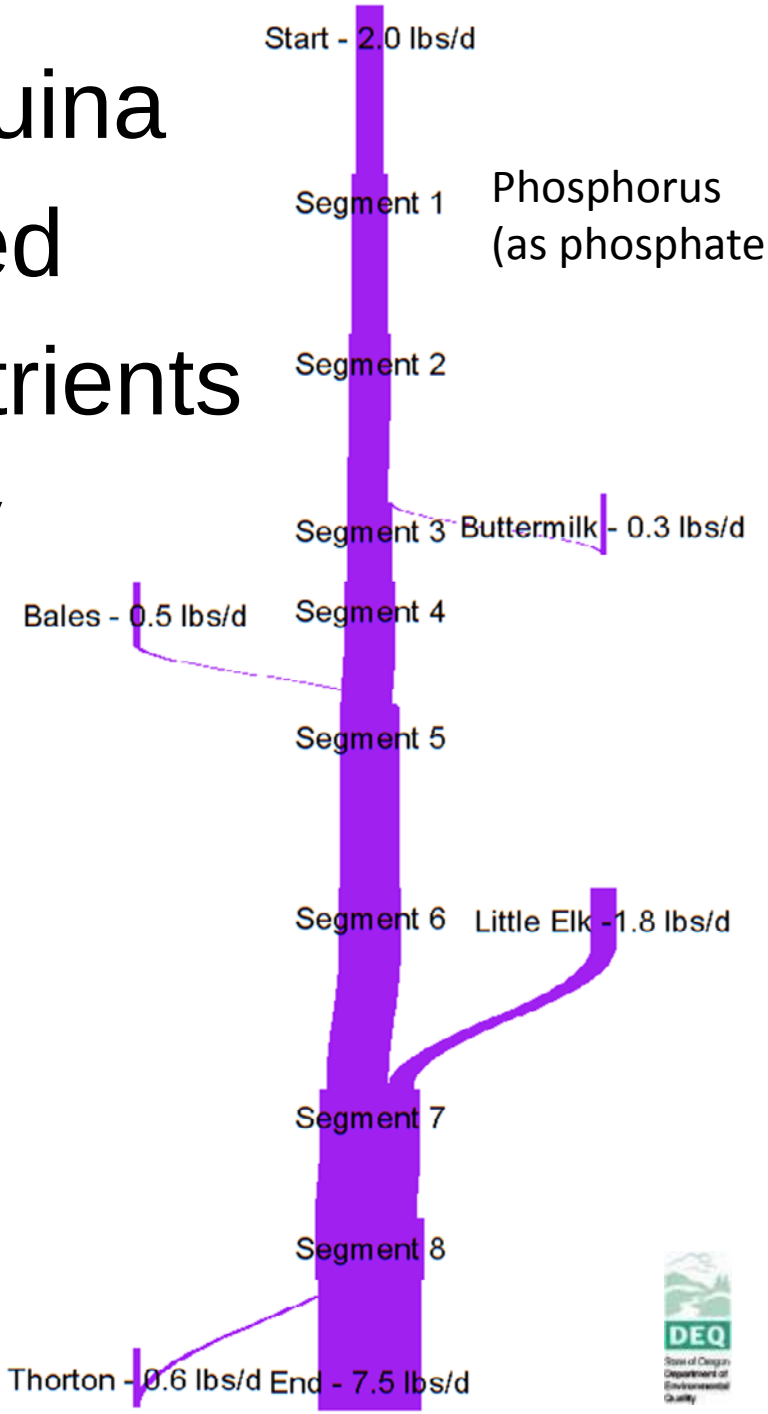
|Measurement error|
< 0.08 mg/L

Upper Yaquina Estimated flows 26 July 2016

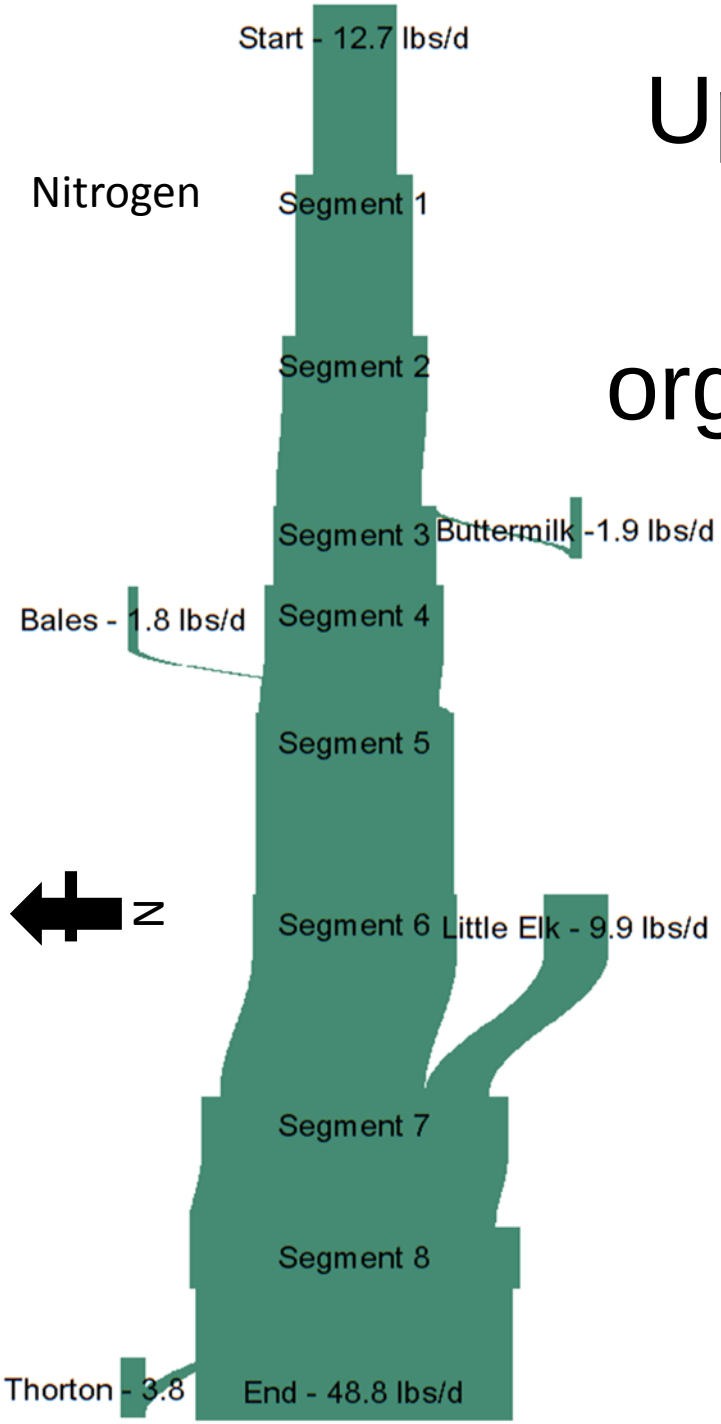


Upper Yaquina Estimated inorganic nutrients 26 July 2016

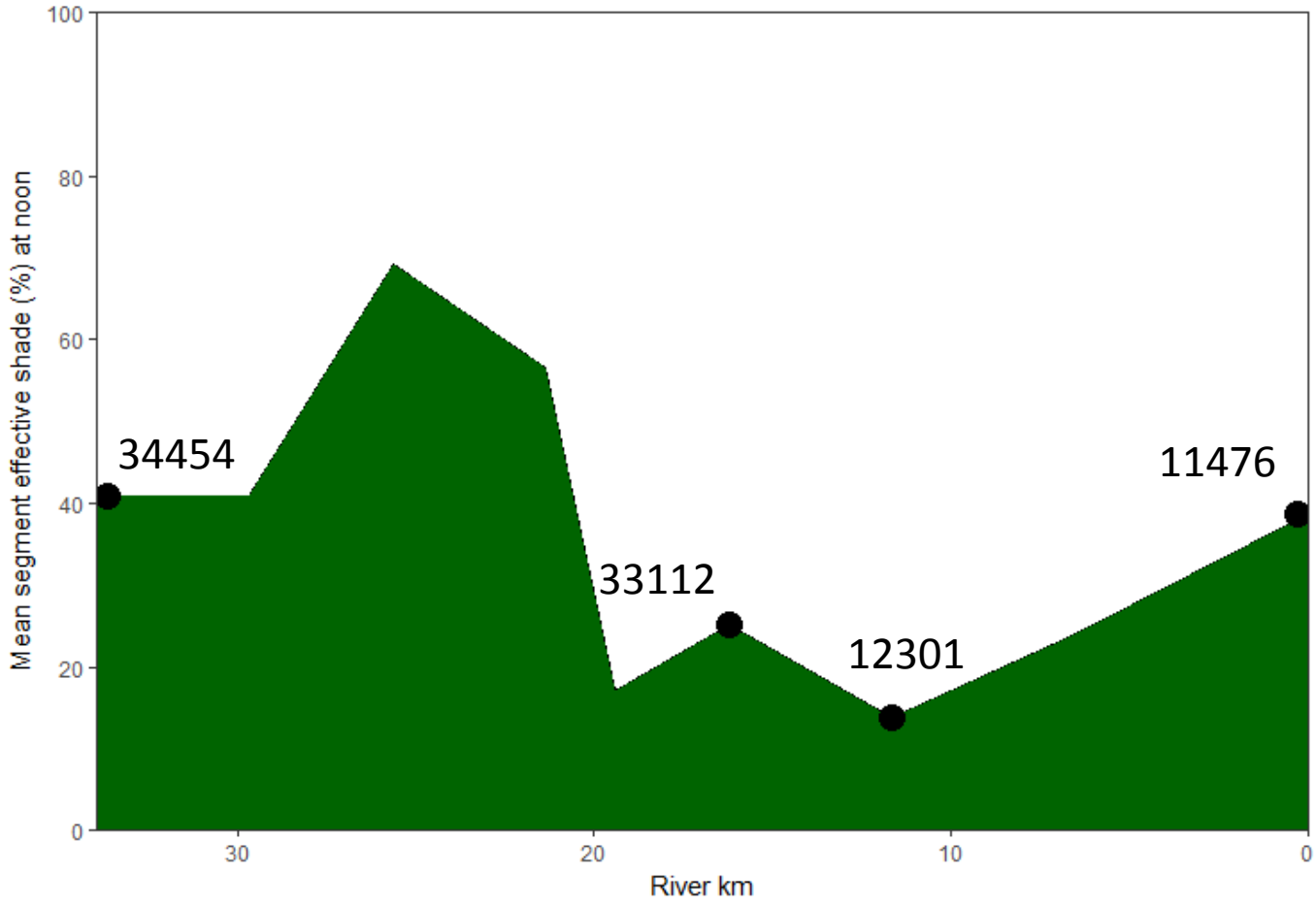




Upper Yaquina Estimated organic nutrients 26 July 2016



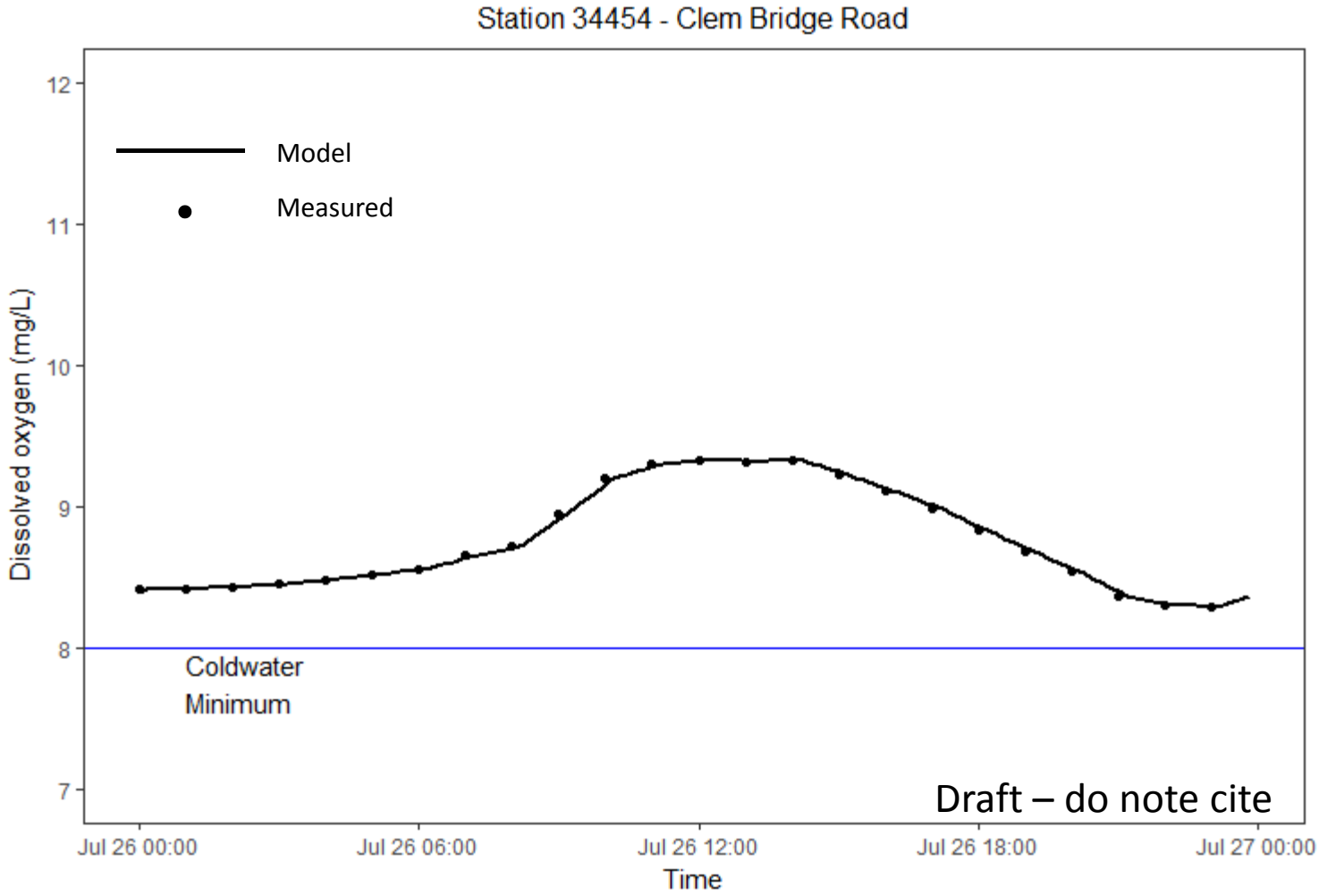
Upper Yaquina – noon effective shade 26 July 2016



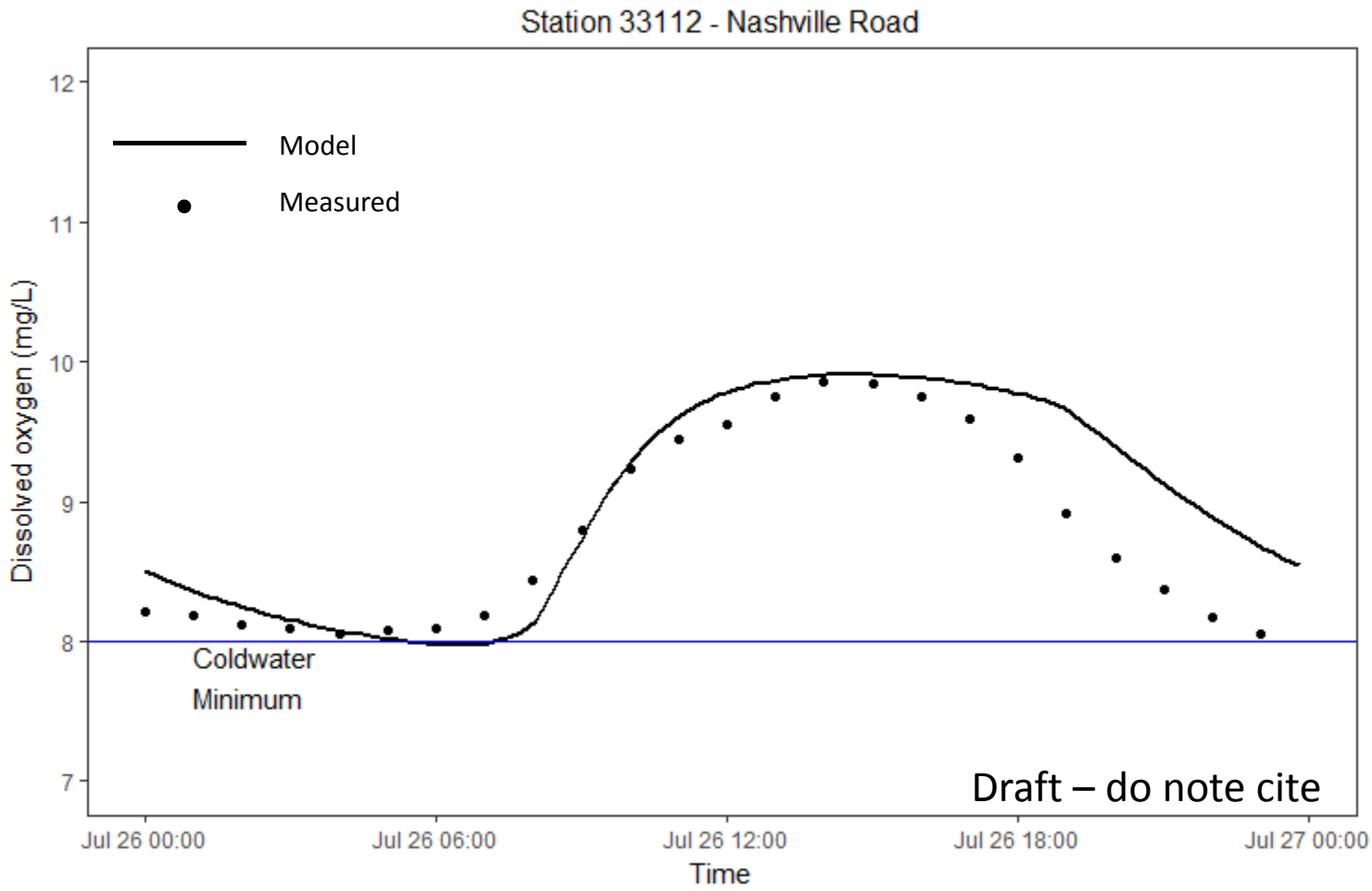
Calculated from 2011 LiDAR via ttools and shade-a-lator tool from ODEQ

July 2016 Model results

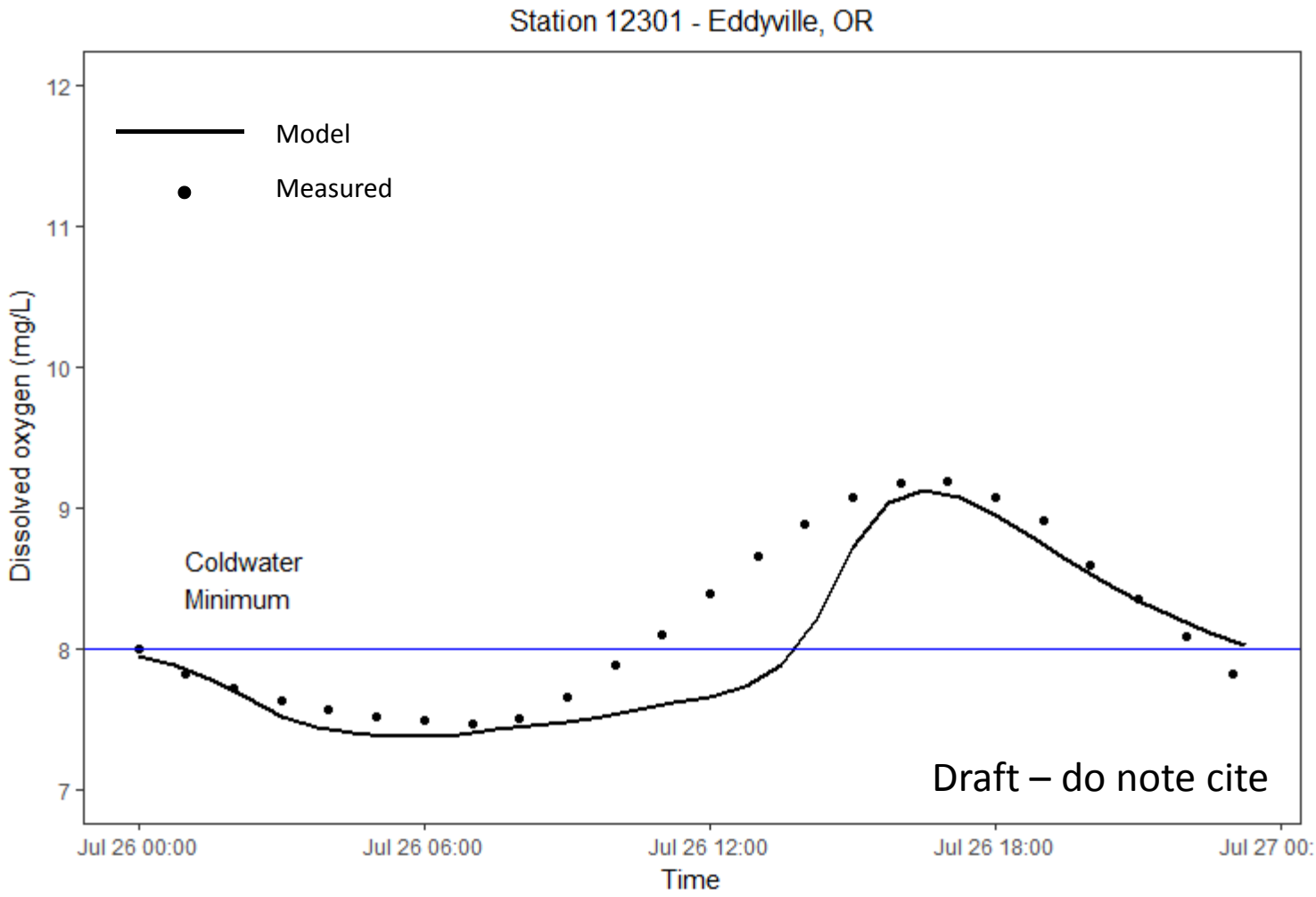
Diel dissolved oxygen – July 2016: Station 34454



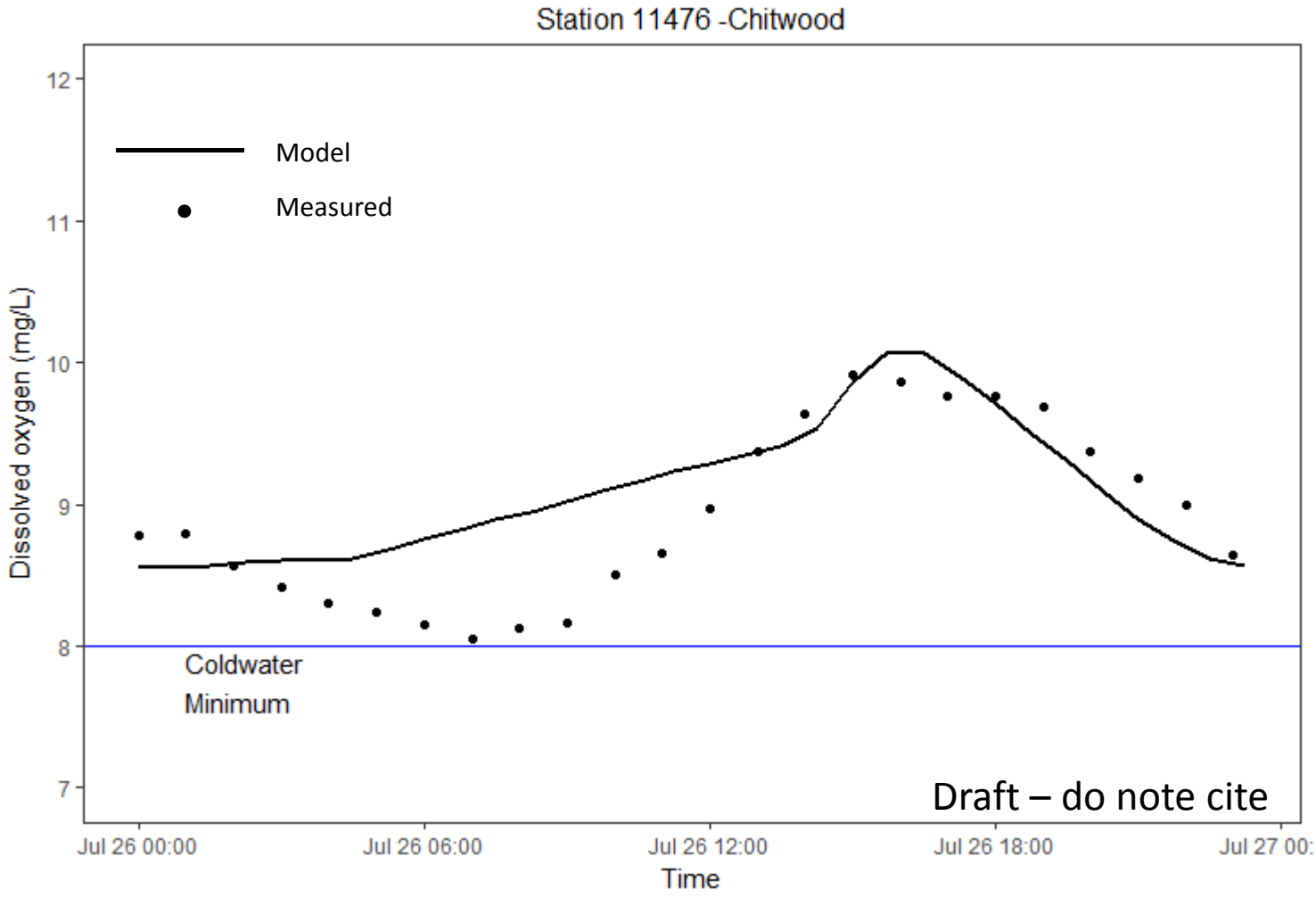
Diel dissolved oxygen – July 2016: Station 33112



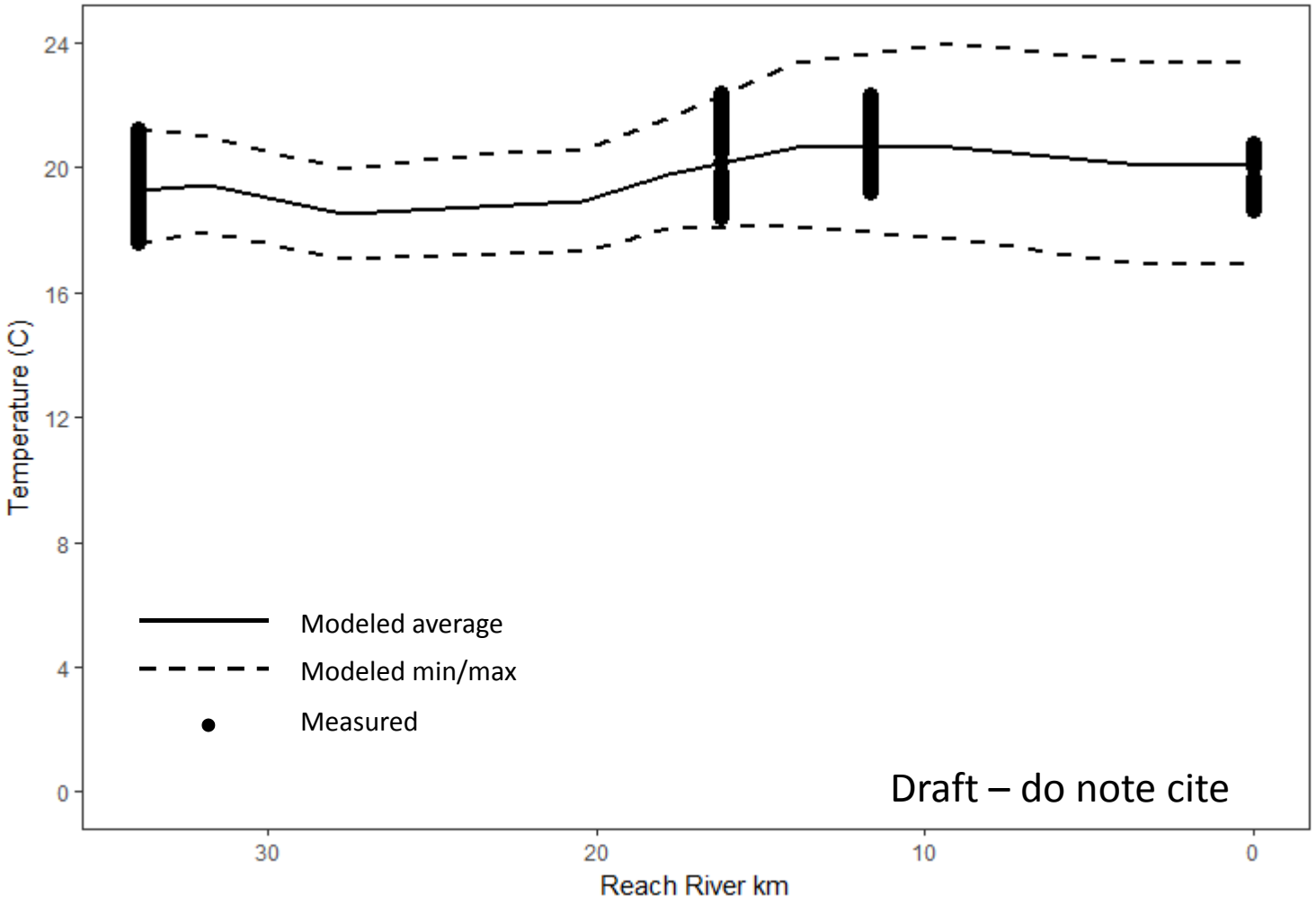
Diel dissolved oxygen – July 2016: Station 12301



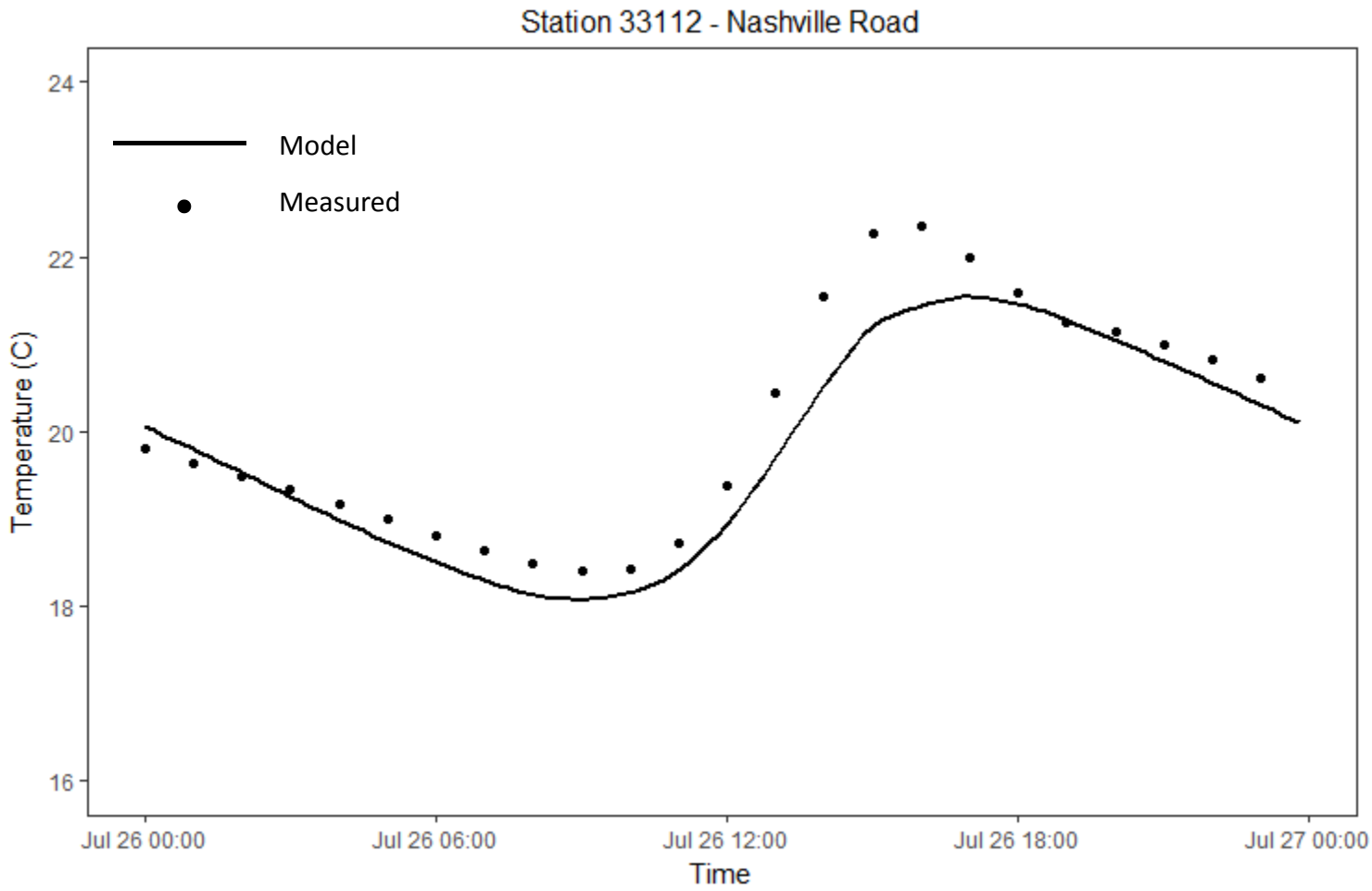
Diel dissolved oxygen – July 2016: Station 11476



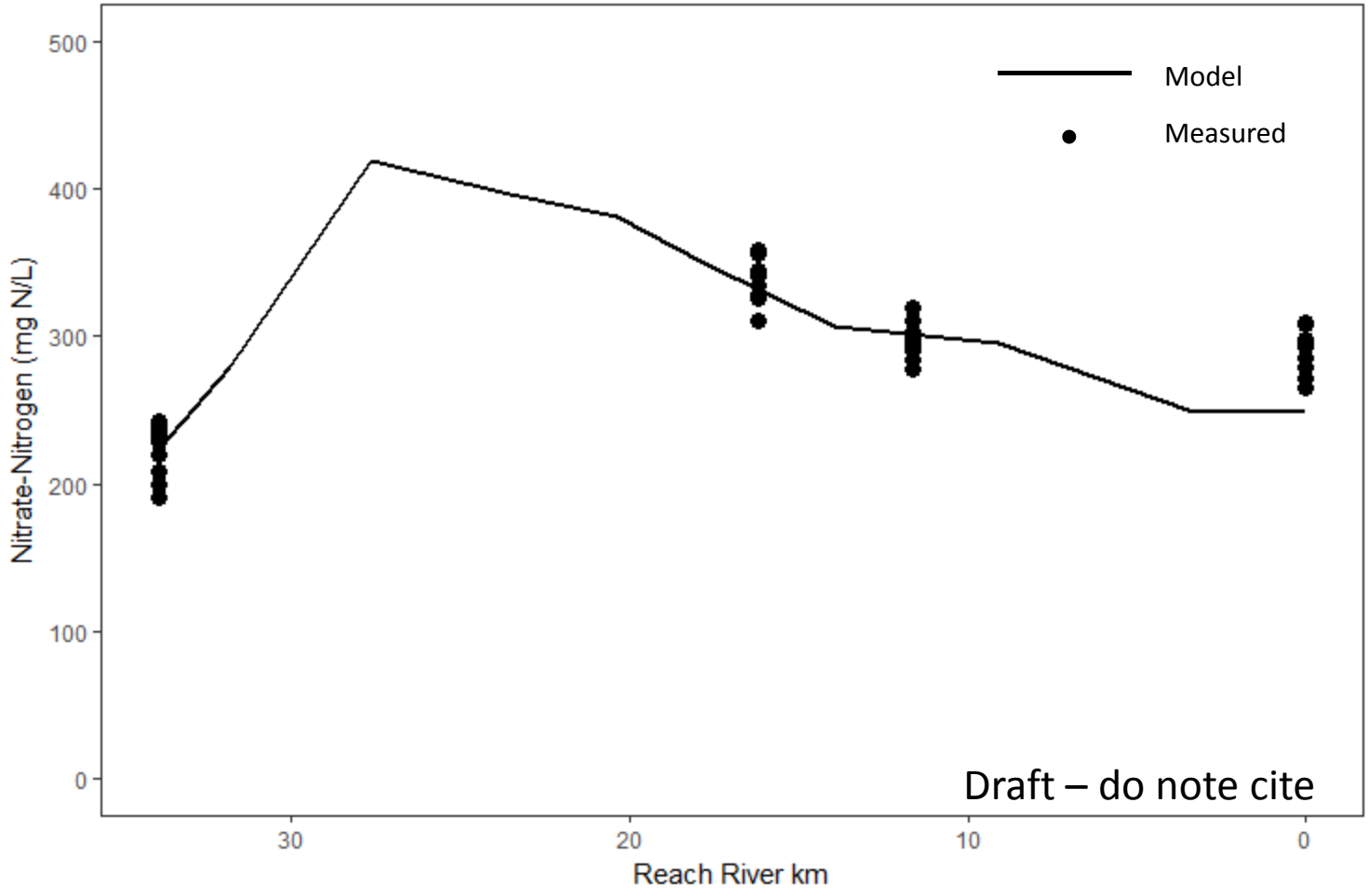
Longitudinal temperature – July 2016: Station 11476



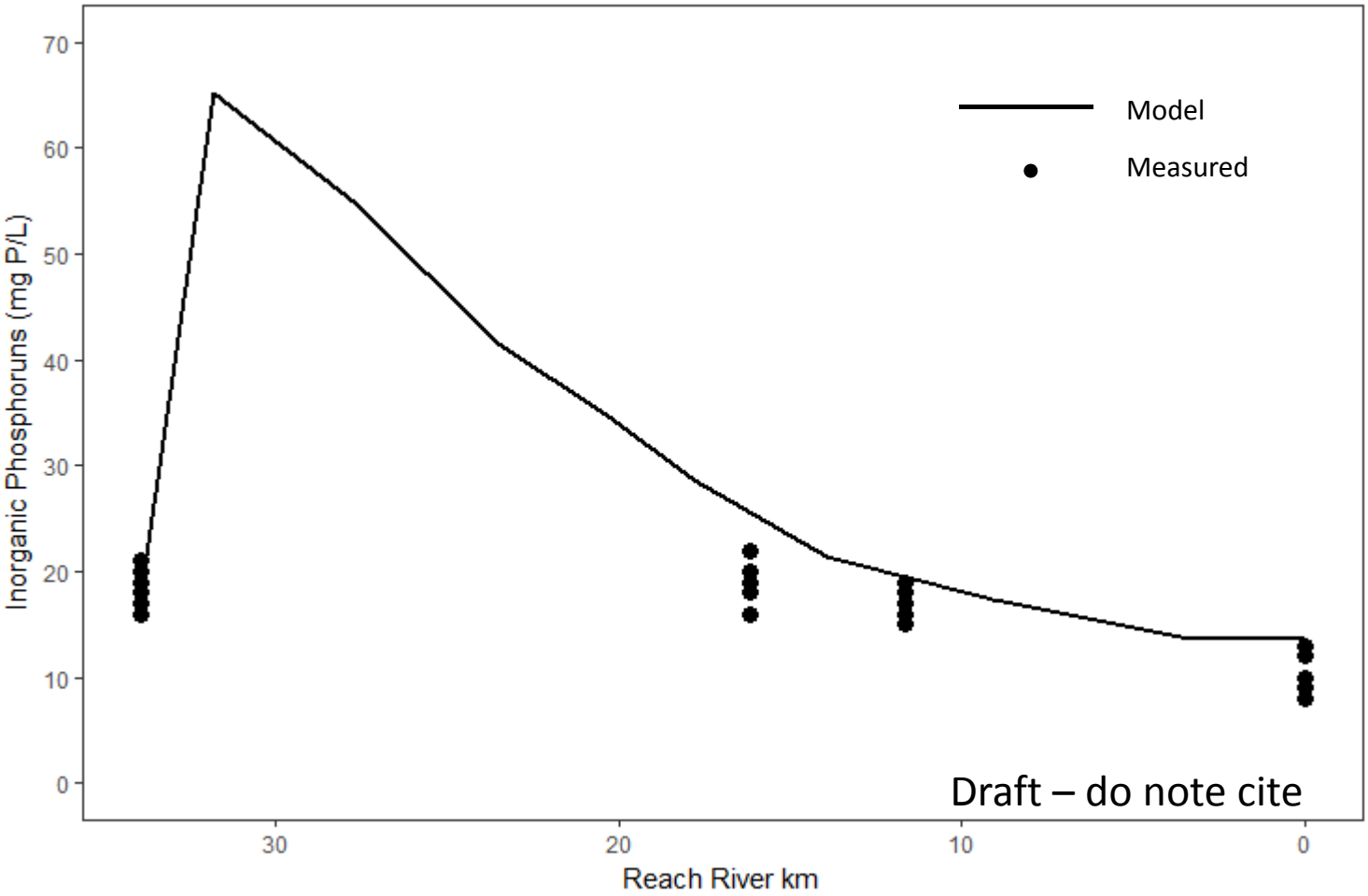
Diel temperature – July 2016: Station 33112



Longitudinal nitrate – July 2016:



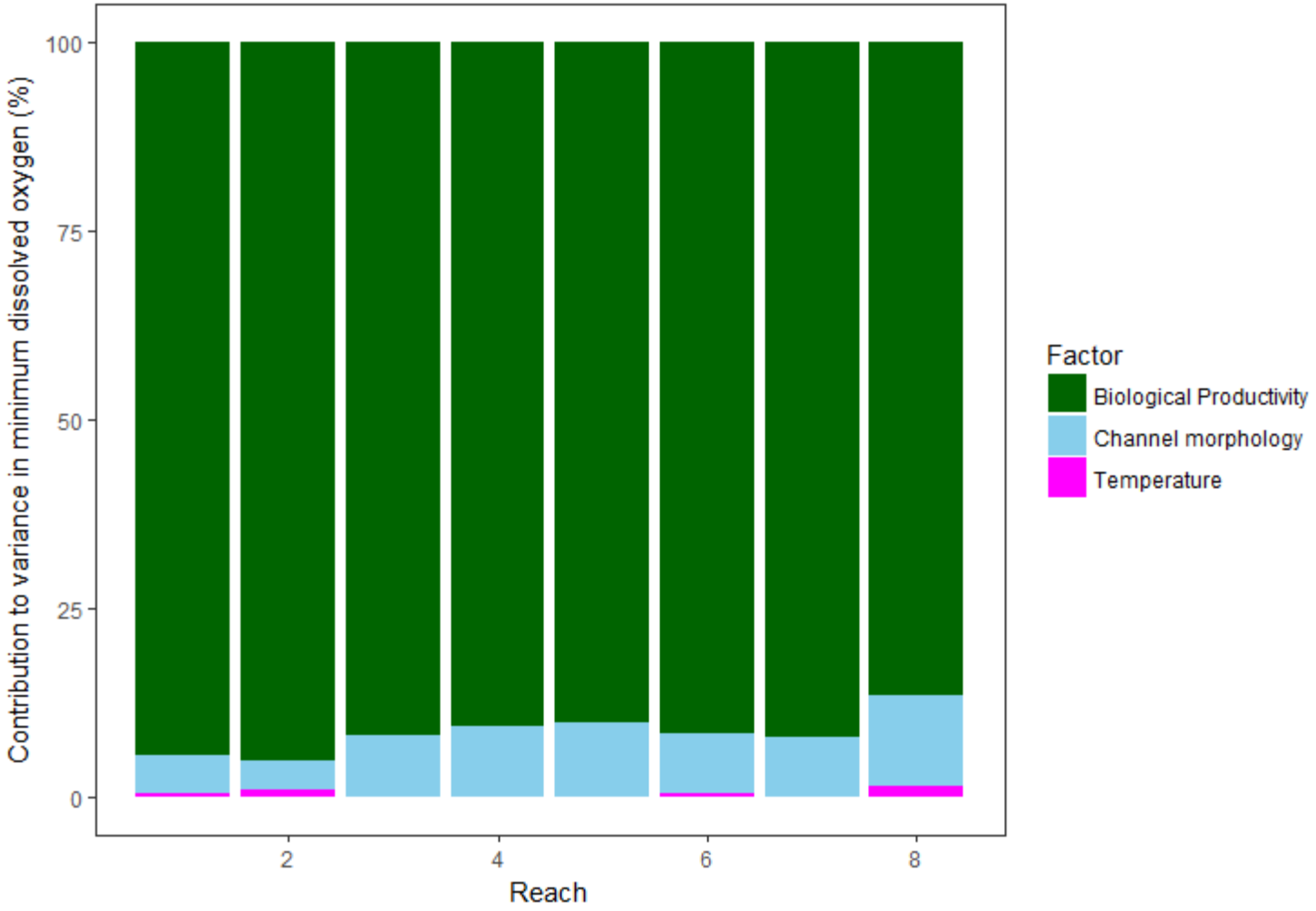
Longitudinal inorganic P – July 2016:



Which are factors affect dissolved oxygen the most?

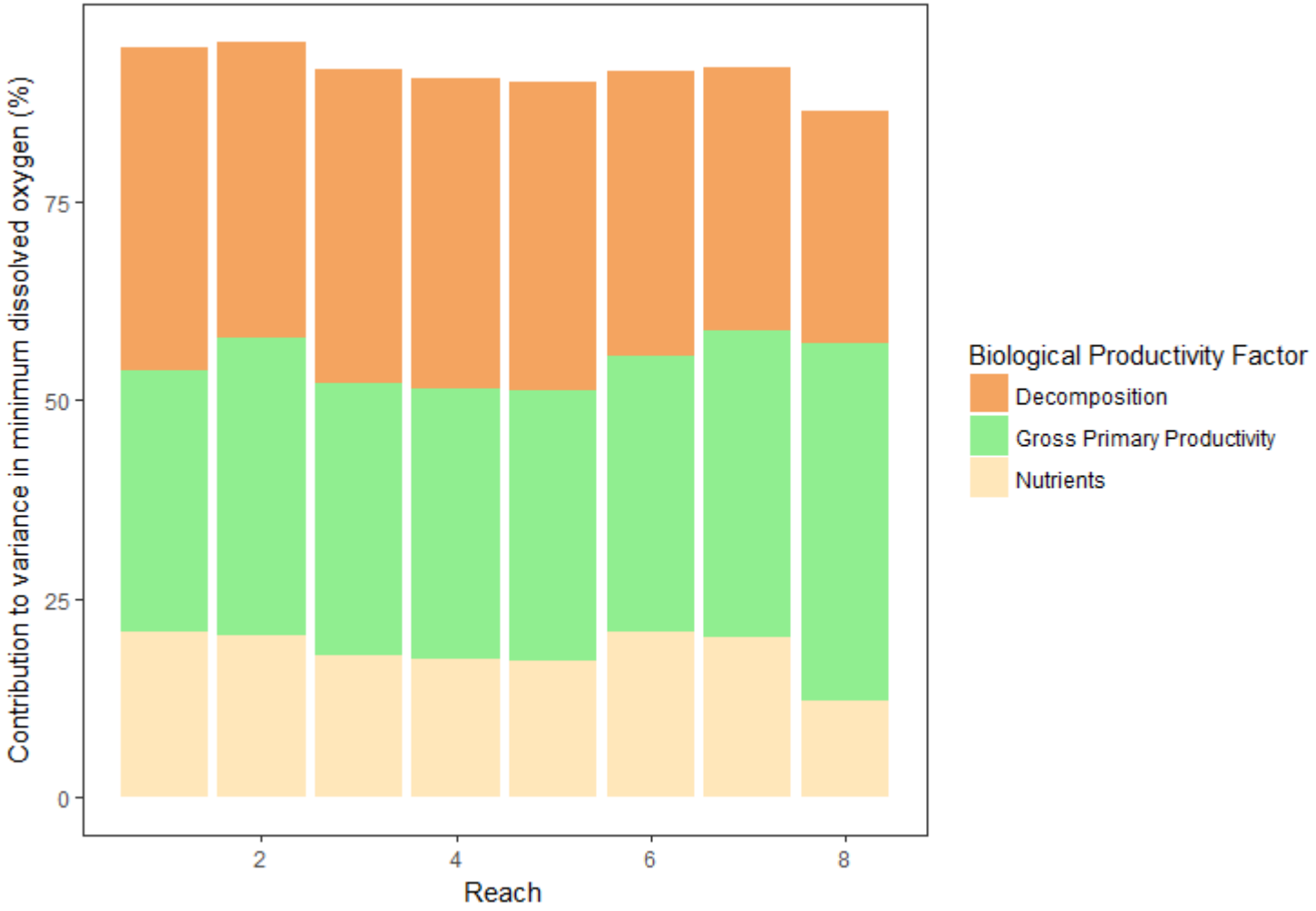
- Used Monte Carlo simulation procedure provided with QUAL2Kw model
- Varied calibrated parameters ± 5%
- Done for individual reach segments and key factor groups that influence dissolved:
  - Temperature
  - Channel morphology
  - Biological productivity

Sensitivity analysis – July 2016



Draft – do note cite

Biological Productivity – July 2016



Draft – do note cite

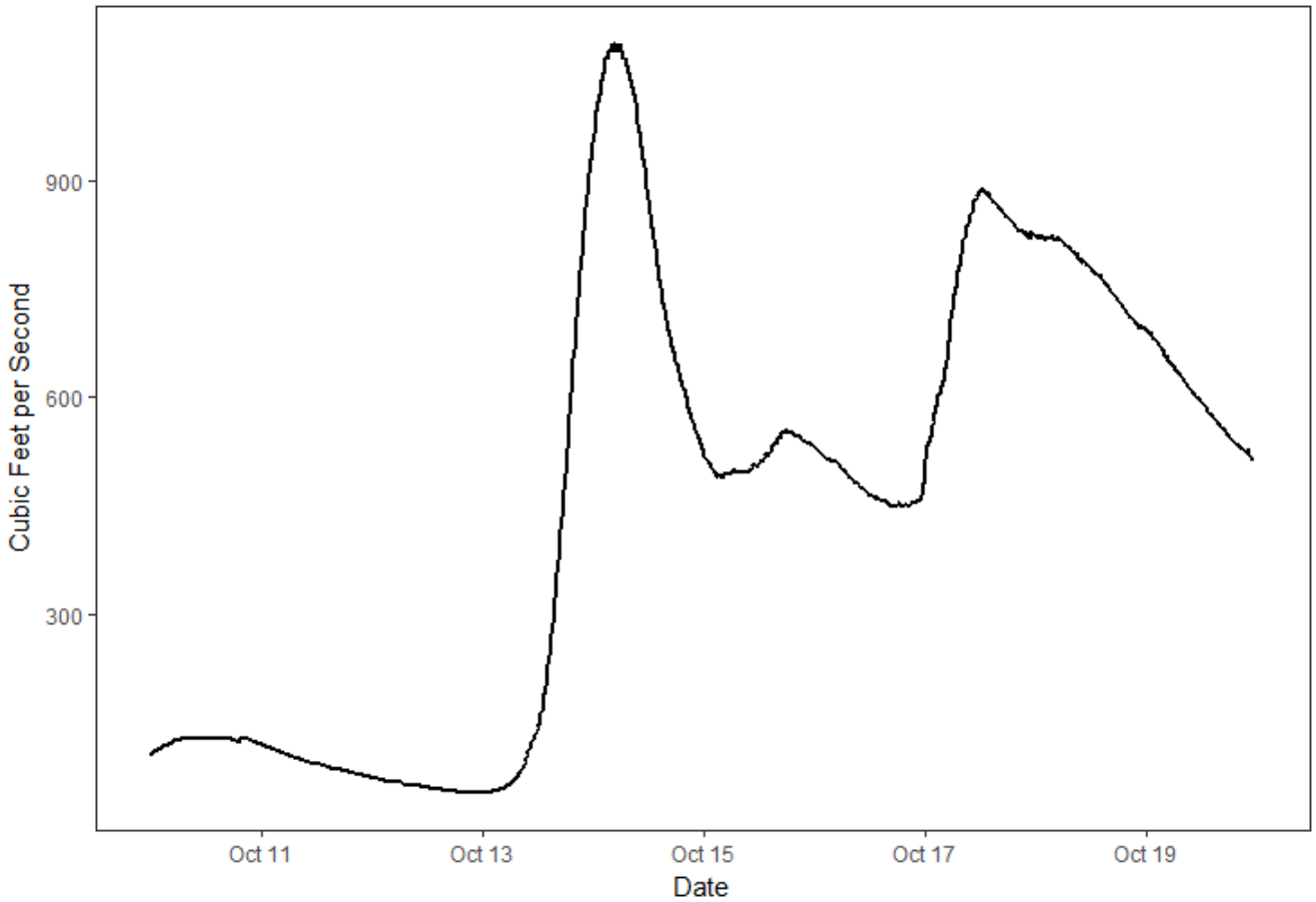
QUAL2Kw calibration – July 2016

- Relative difference between measured and modeled average, minimum, and maximum DO < 5% across all monitoring locations

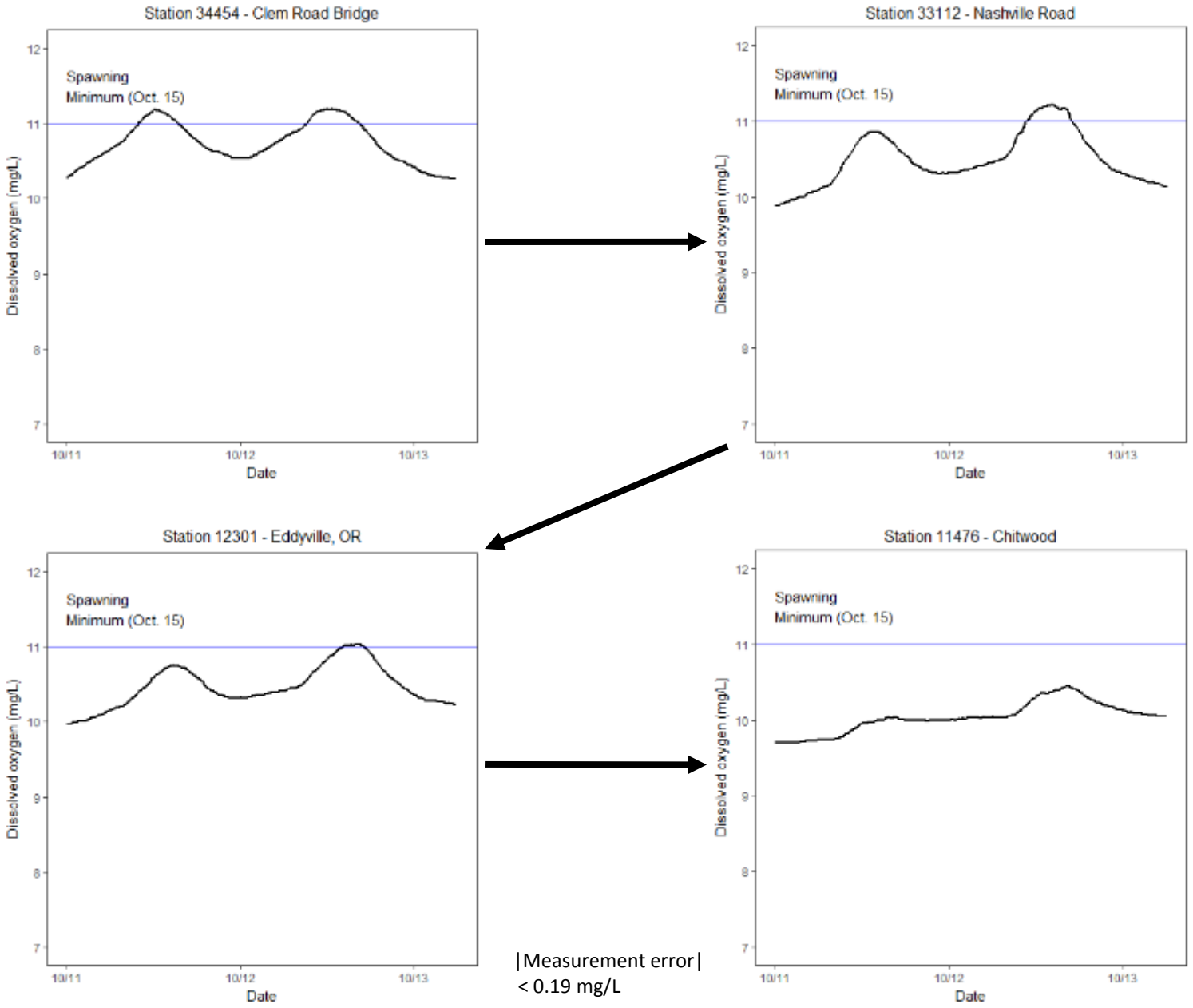
- Focus on factors affecting rates of organic matter decomposition, primary production, and nutrient loading

- Decomposition rates more important upstream and primary production more important downstream

October 2016

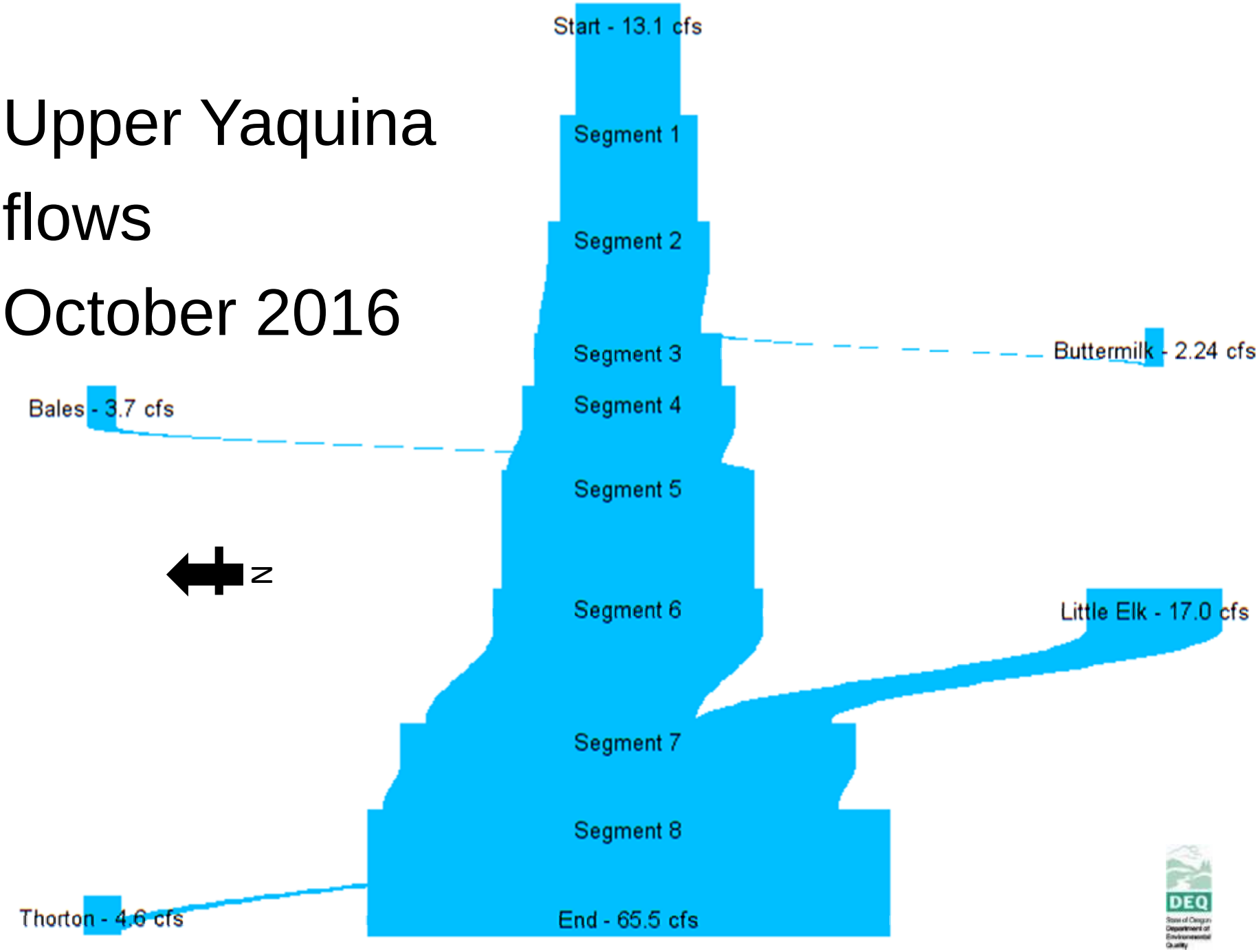


Dissolved oxygen, October 2016



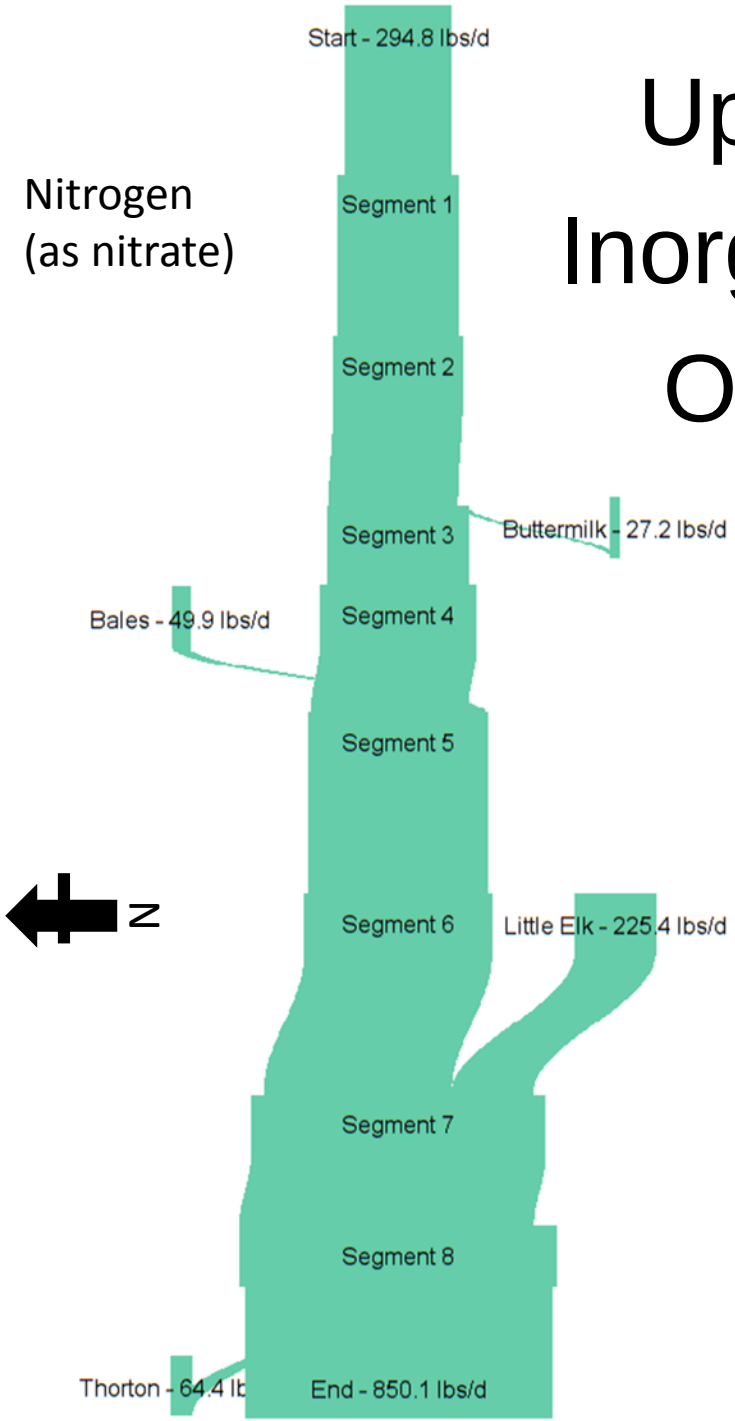
|Measurement error|
< 0.19 mg/L

Upper Yaquina flows October 2016

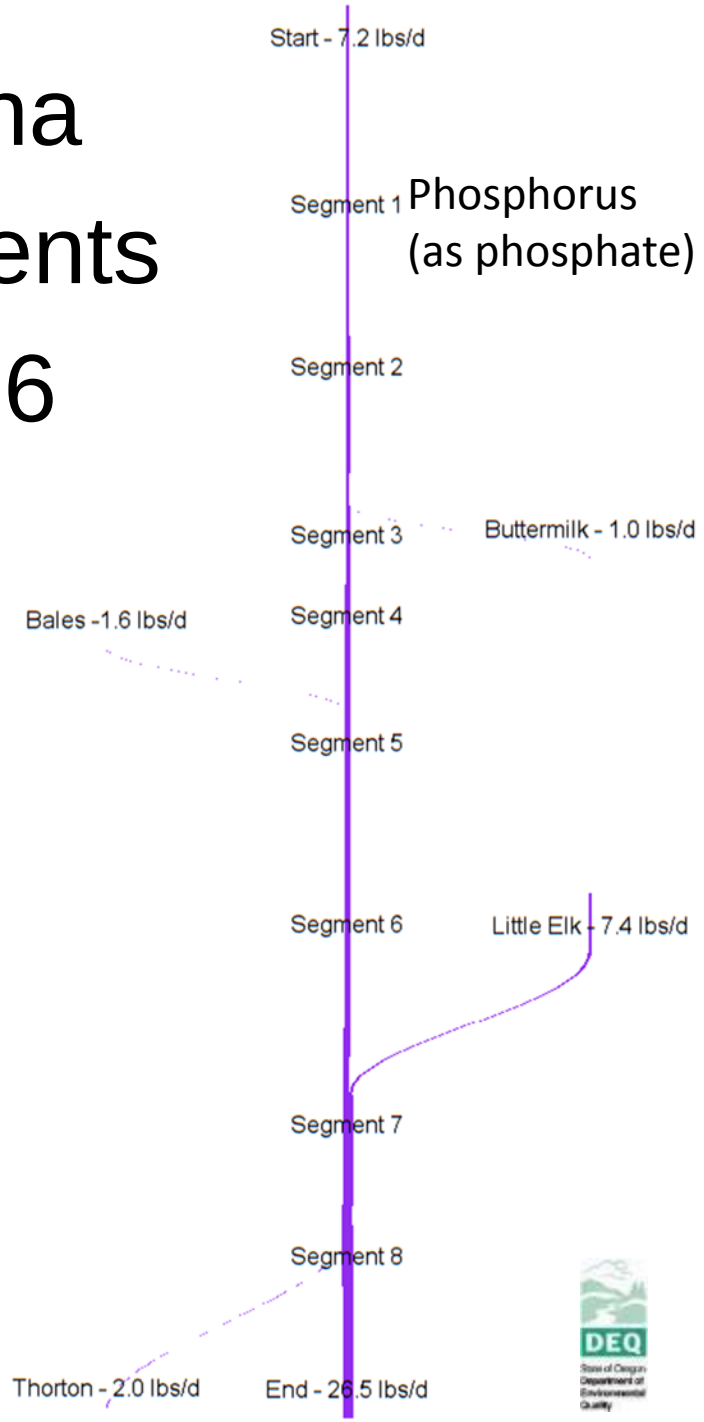


Upper Yaquina Inorganic nutrients October 2016

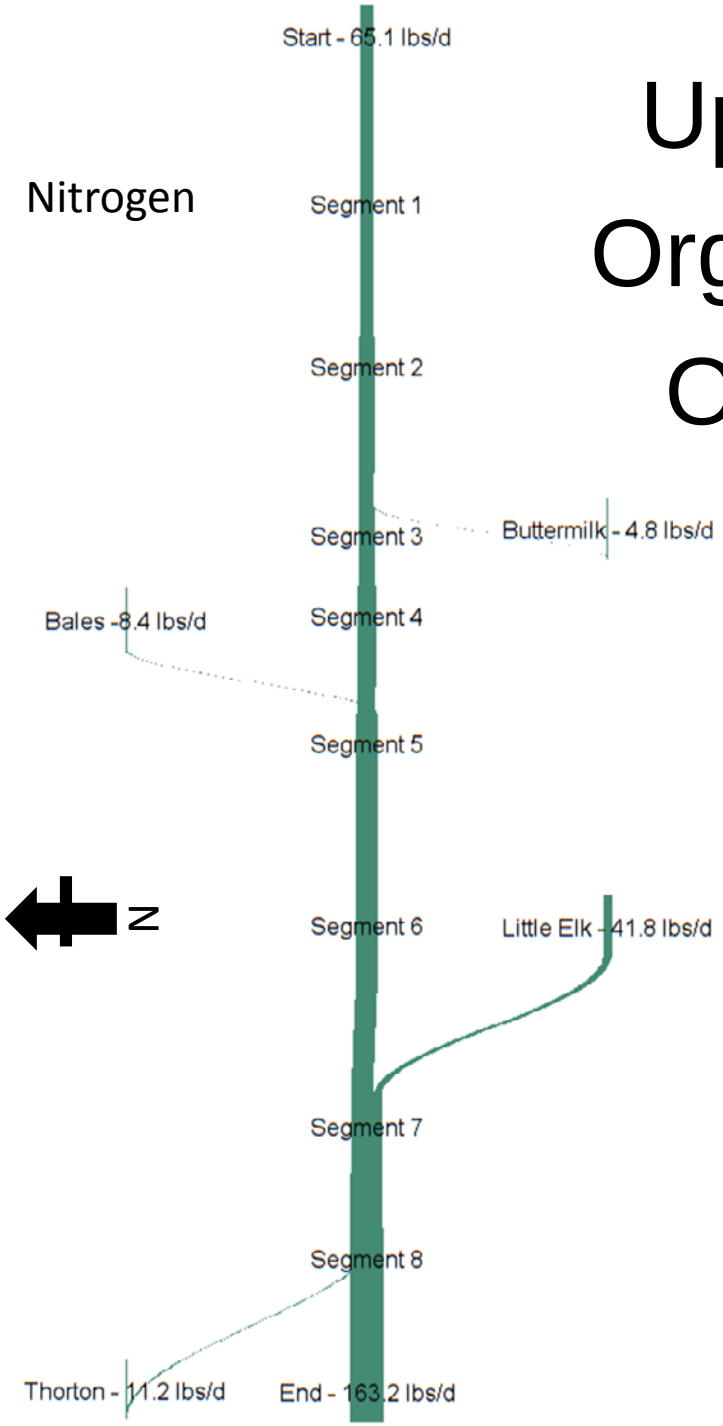
Nitrogen (as nitrate)

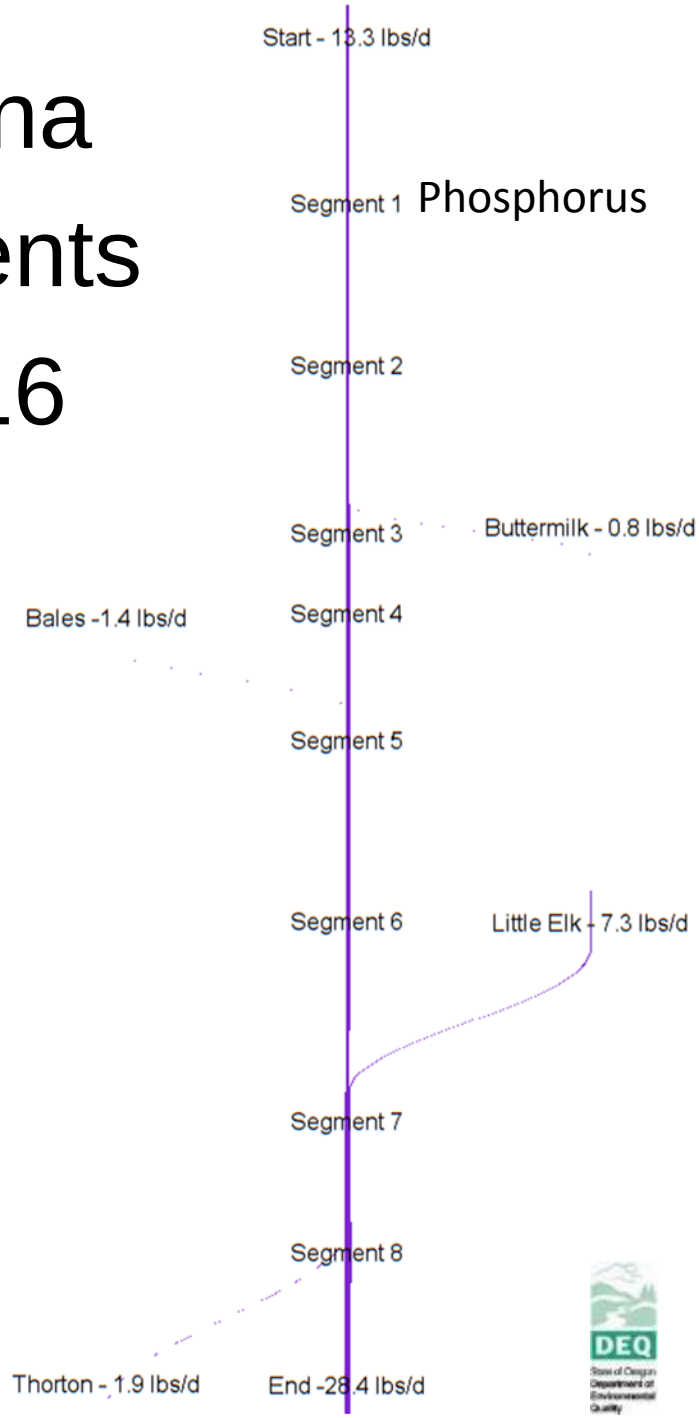


Phosphorus (as phosphate)

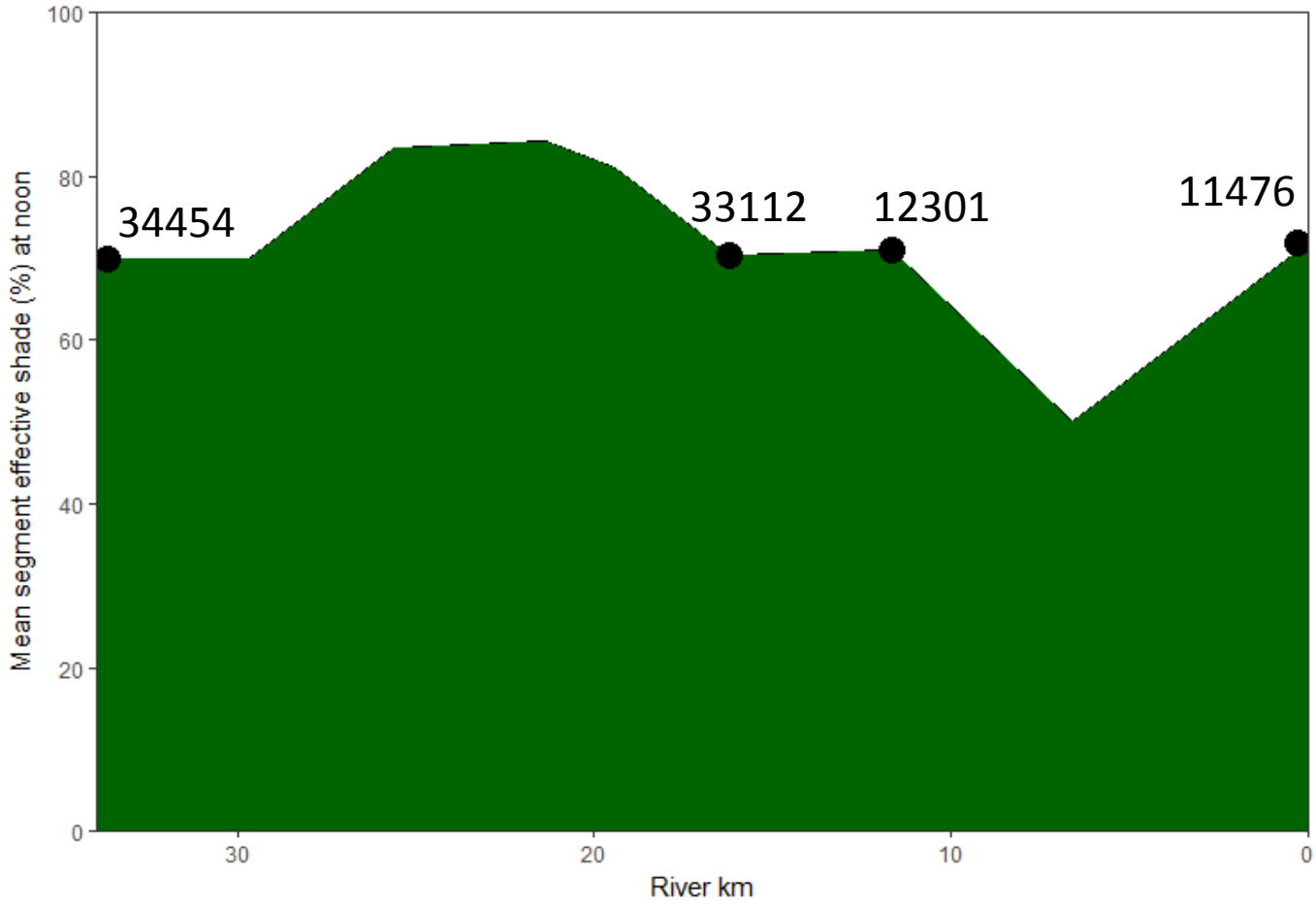


Upper Yaquina Organic nutrients October 2016





Upper Yaquina – noon effective shade October 2016



Calculated from 2011 LiDAR via ttools and shade-a-lator tools from ODEQ

QUAL2Kw calibration – October 2016

- Storms before and in the middle of the monitoring period may be complicating model calibration

- Continuing to work on calibration and sensitivity analyses; should be complete this fall

Takeaways from linked HSPF - QUAL2Kw model

- Linked models producing results consistent with known watershed and stream processes
  - HSPF allows us to examine influences of upland watershed processes on DO
  - QUAL2Kw allows us to examine riparian and in-stream processes on DO
- Storm flows in fall may be complicating calibration process for October 2016 model

Next Tasks

- Provide TWG with July 2016 calibration report for Upper Yaquina dissolved oxygen modeling at the end of October 2017

- Complete analysis and calibration of October 2016 model

- Look at 7Q10 flow scenario to assess extreme low flow conditions for summer conditions

- Talk with DMAs about specific land management practices and scenarios in the Upper Yaquina


Questions?

Documents can be provided upon request in an alternate format for individuals with disabilities or in a language other than English for people with limited English skills. To request a document in another format or language, call DEQ in Portland at 503-229-5696, or toll-free in Oregon at 1-800-452-4011, ext. 5696; or email deqinfo@deq.state.or.us.