United States Environmental Protection Agency

# Water Quality Model Selection

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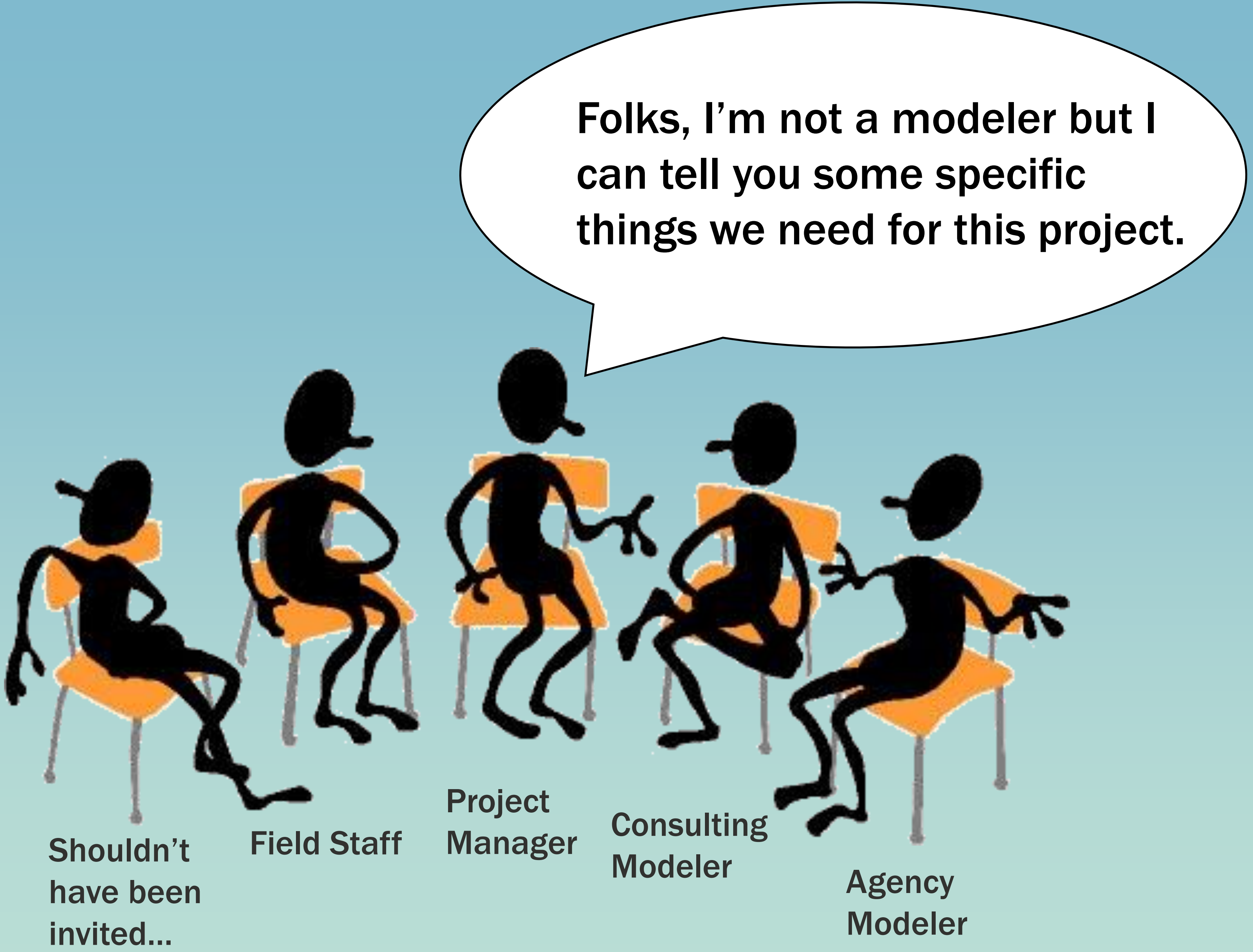
EPA National Water Modeling Workgroup

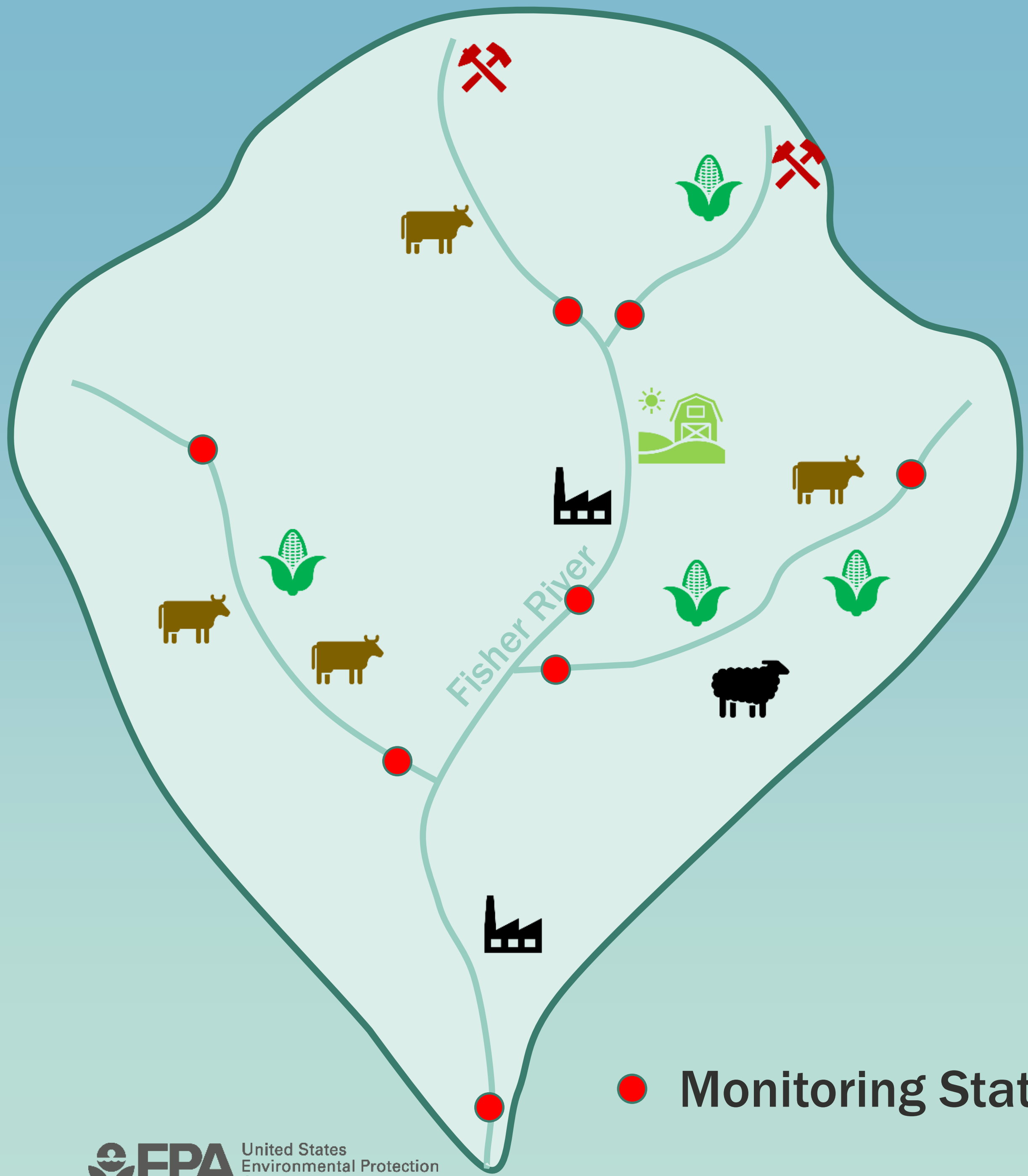
# Day 1 of your TMDL Modeling Project :

## A little fear, chaos, and nothing but questions

- Why do we need a model?
- What specifically do we need to predict?
- Who is going to build the model – in house or contractor?
- What's the budget and schedule?

You need a project team and a plan


Folks, I'm not a modeler but I can tell you some specific things we need for this project.
Shouldn't have been invited…
Field Staff
Project Manager
Consulting Modeler
Agency Modeler




# Architecture of the problem and the information base

● Monitoring Stations

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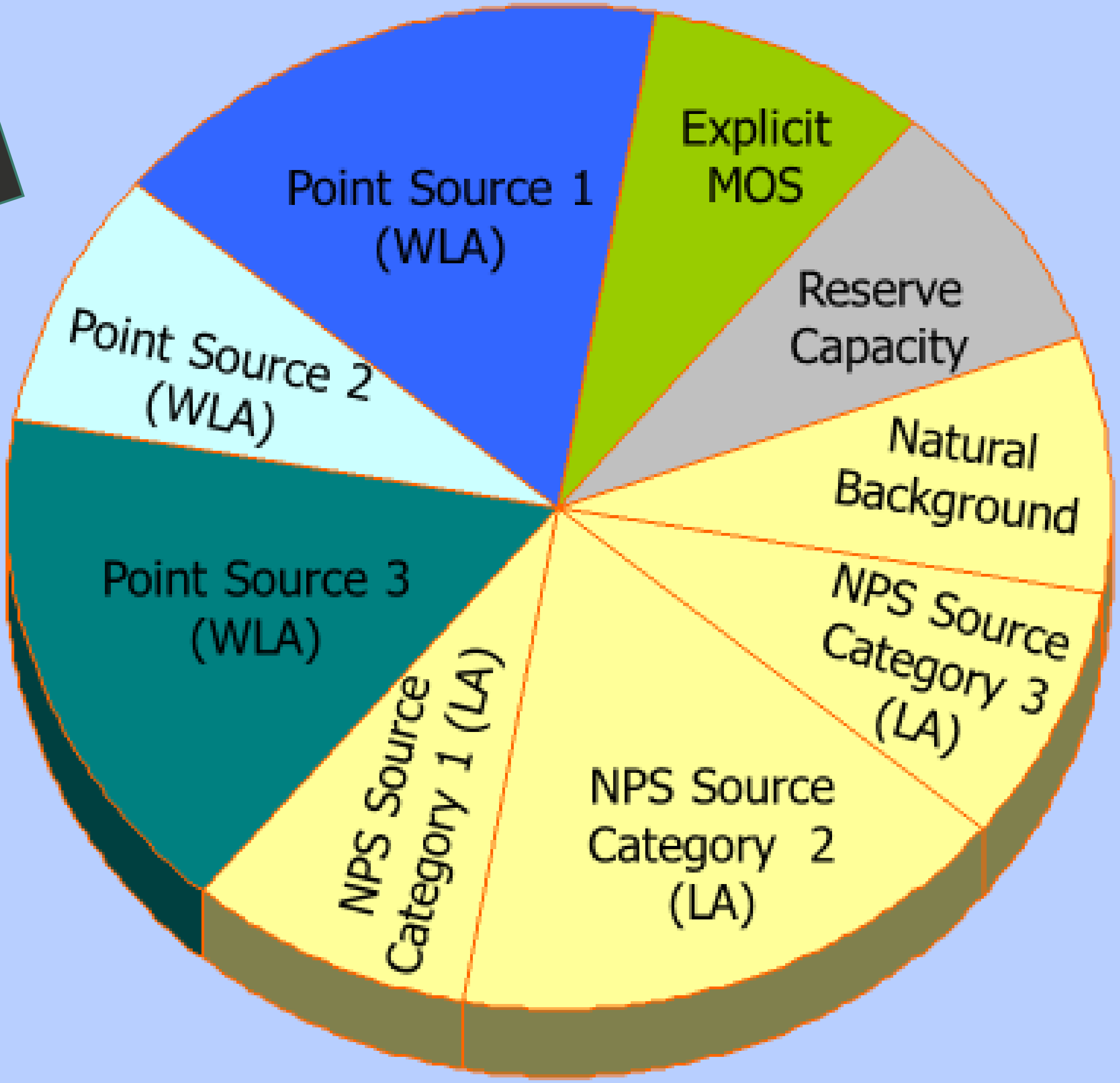
Ultimate Goal :
TMDL Budget and Allocations

But how do combine WQ standards, WQ data, and system understanding to reach a reasonable budget?

We need a technical approach that links them all together

## TMDL Allocation

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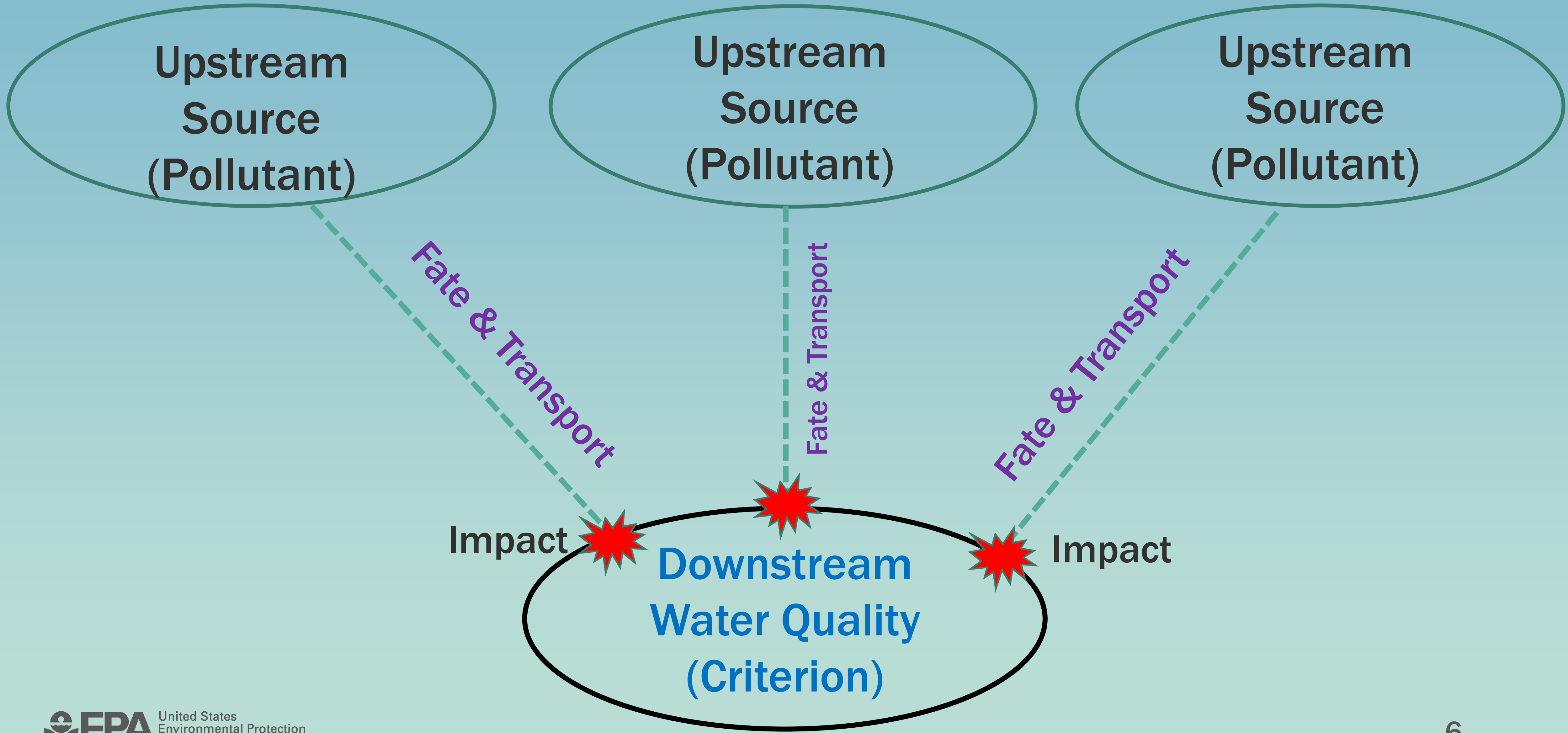
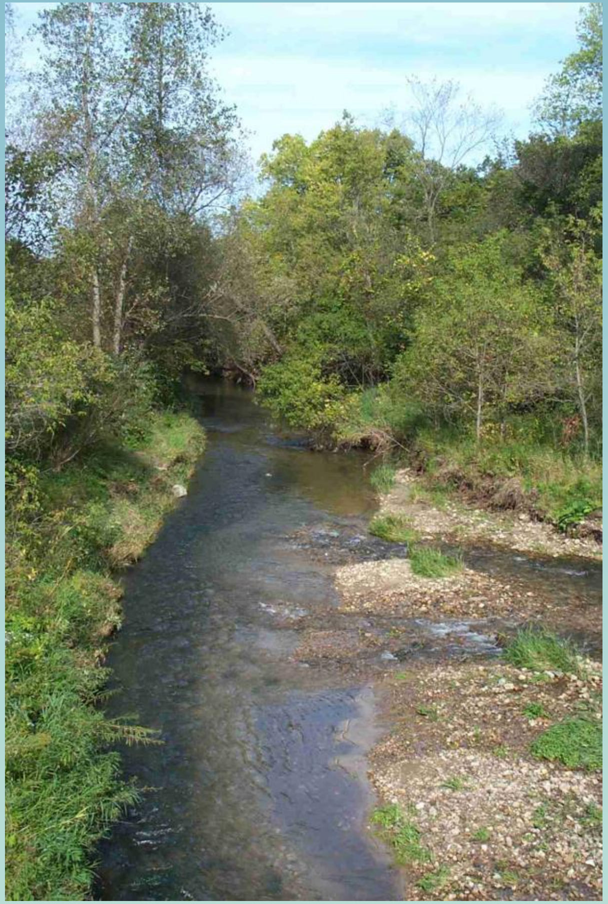
# Linkage


Upstream Source (Pollutant)
Upstream Source (Pollutant)
Upstream Source (Pollutant)
Fate & Transport
Fate & Transport
Fate & Transport
Impact
Impact
Downstream Water Quality (Criterion)

# Linkage Analysis Process

**Select an analytical/modeling approach based on:**

- Expression of the water quality criterion
- Nature and complexity of the receiving water
- Nature of pollutant – mass is conserved or not?
- Sources of pollutants
- Quantity and quality of data and information
- Budget and available resources



- Always look for the simplest approach
  - But not too simple!



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# Water Quality Impairments

- Top 10 TMDL Pollutants

1. Mercury (state-wide TMDLs)
2. Bacteria*
3. Metals (other than Mercury)
4. Nutrients**
5. Sediment
6. Temperature
7. Dissolved Oxygen***
8. pH
9. Salinity/Total Dissolved Solids
10. Turbidity

* Examples

# Model Development Process

Phase I
*SCIENCE & POLICY*

Quality Assurance Project Plan (QAPP)

Phase II
*SCIENCE*

Model Development

- Data gathering (historic, field monitoring)
- Model input preparation and configuration

Phase III
*SCIENCE*

Model Calibration and Evaluation

- Calibration (modeled vs. measured)
- Peer review

Phase IV
*SCIENCE & POLICY*

Model Acceptance and Application

- Analysis of Model Alternatives – Compliance Scenarios

1D, 2D, or 3D?

Size of Model Domain?

Parameters of Interest?

Steady State or Dynamic?

Available Data?

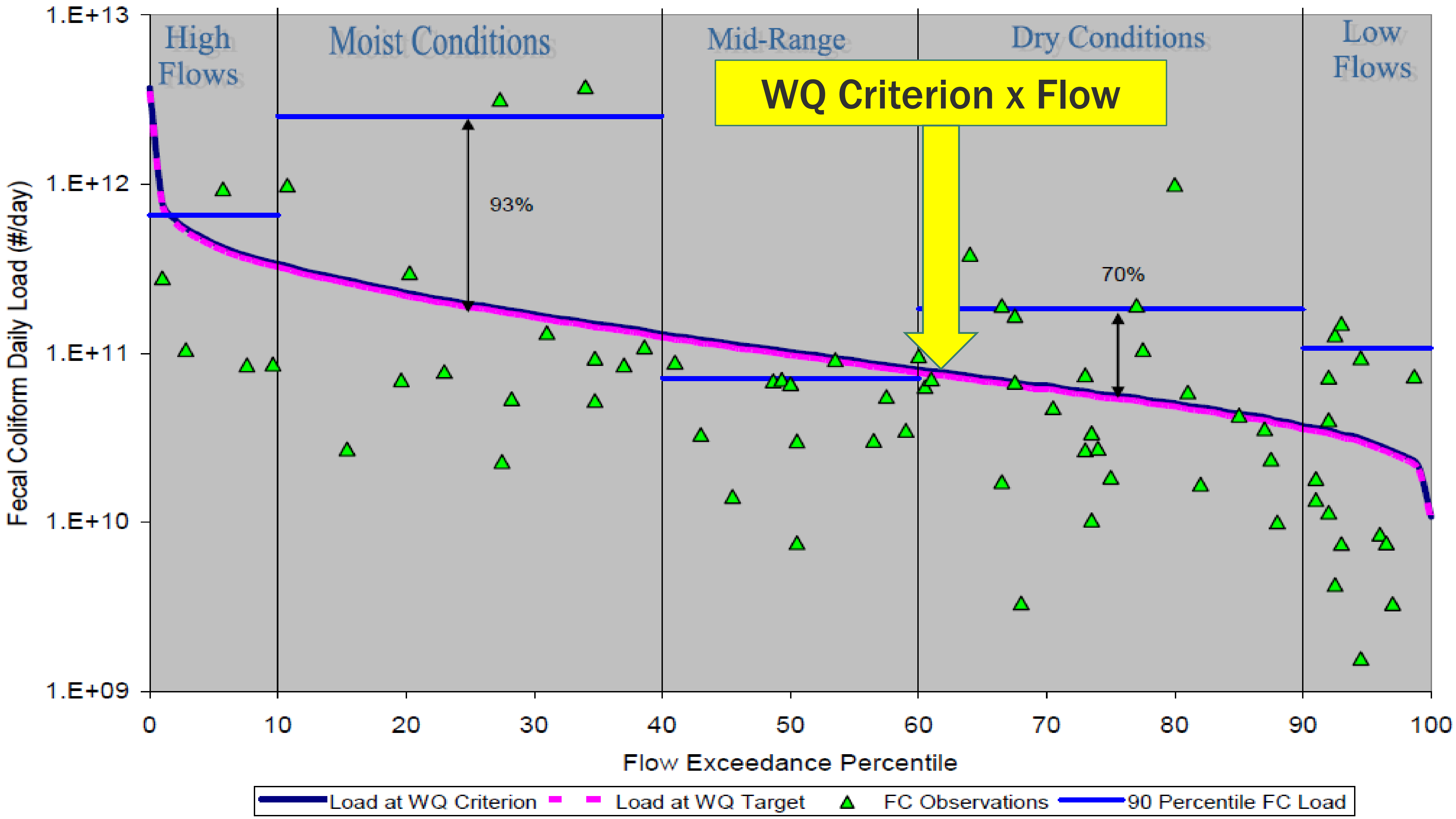
Candidate Models?

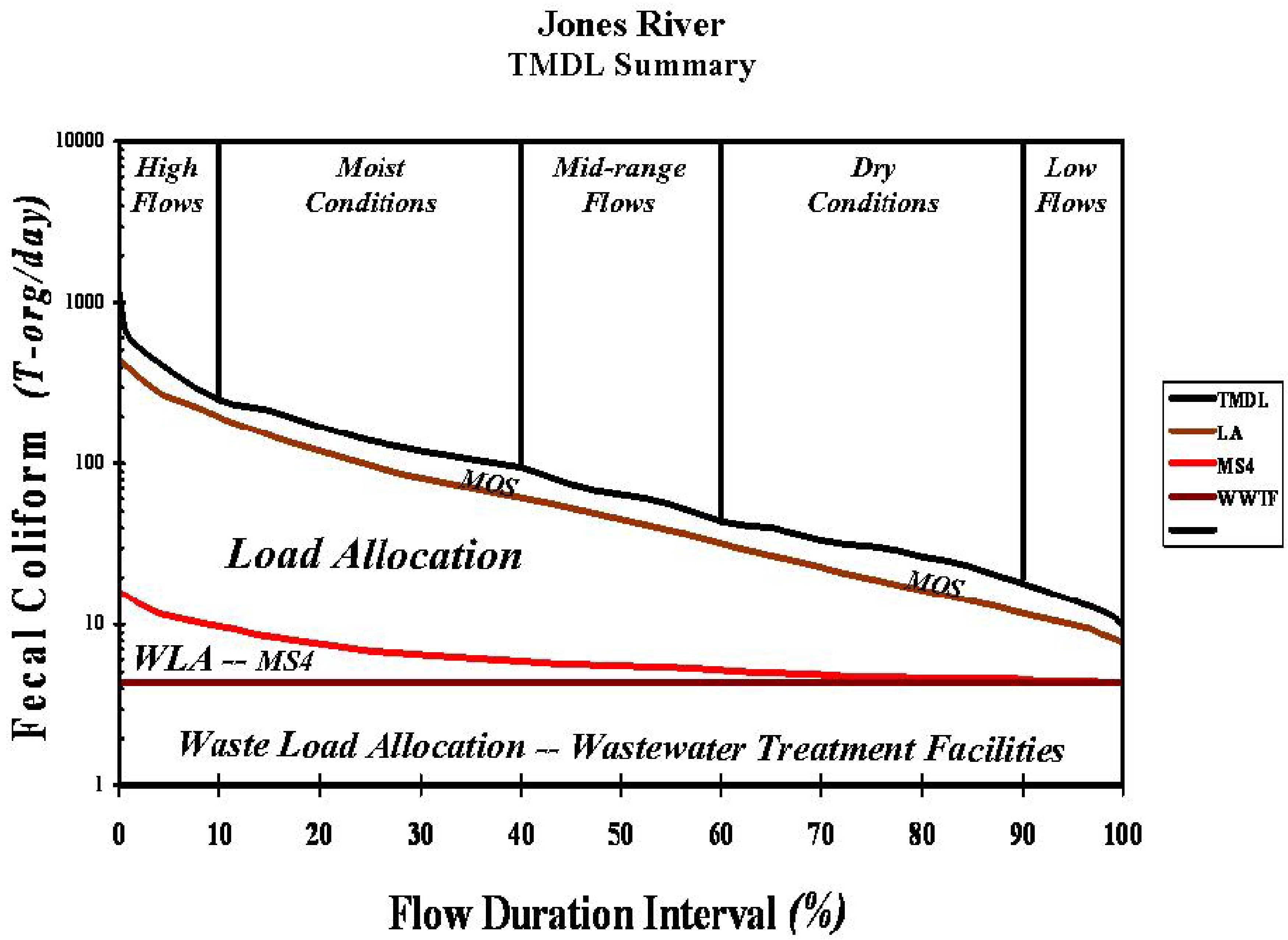
# QAPP

AKA “Who, what, how, and when we’re going to build a model”

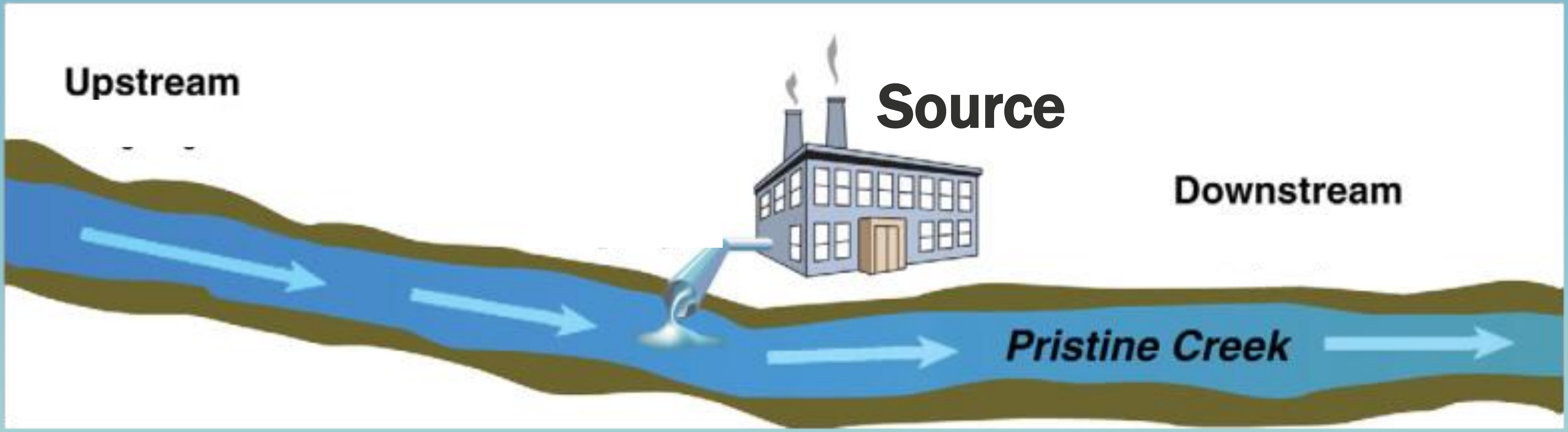
# Simple vs. Complex

# Easier than a model…Load Duration Curve




Jones River
TMDL Summary
10000
1000
100
10
1
Fecal Coliform (T-org/day)
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
MOS
Load Allocation
MOS
WLA -- MS4
Waste Load Allocation -- Wastewater Treatment Facilities
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
TMDL
LA
MS4
WWTF

# Simple Mass Balance Model

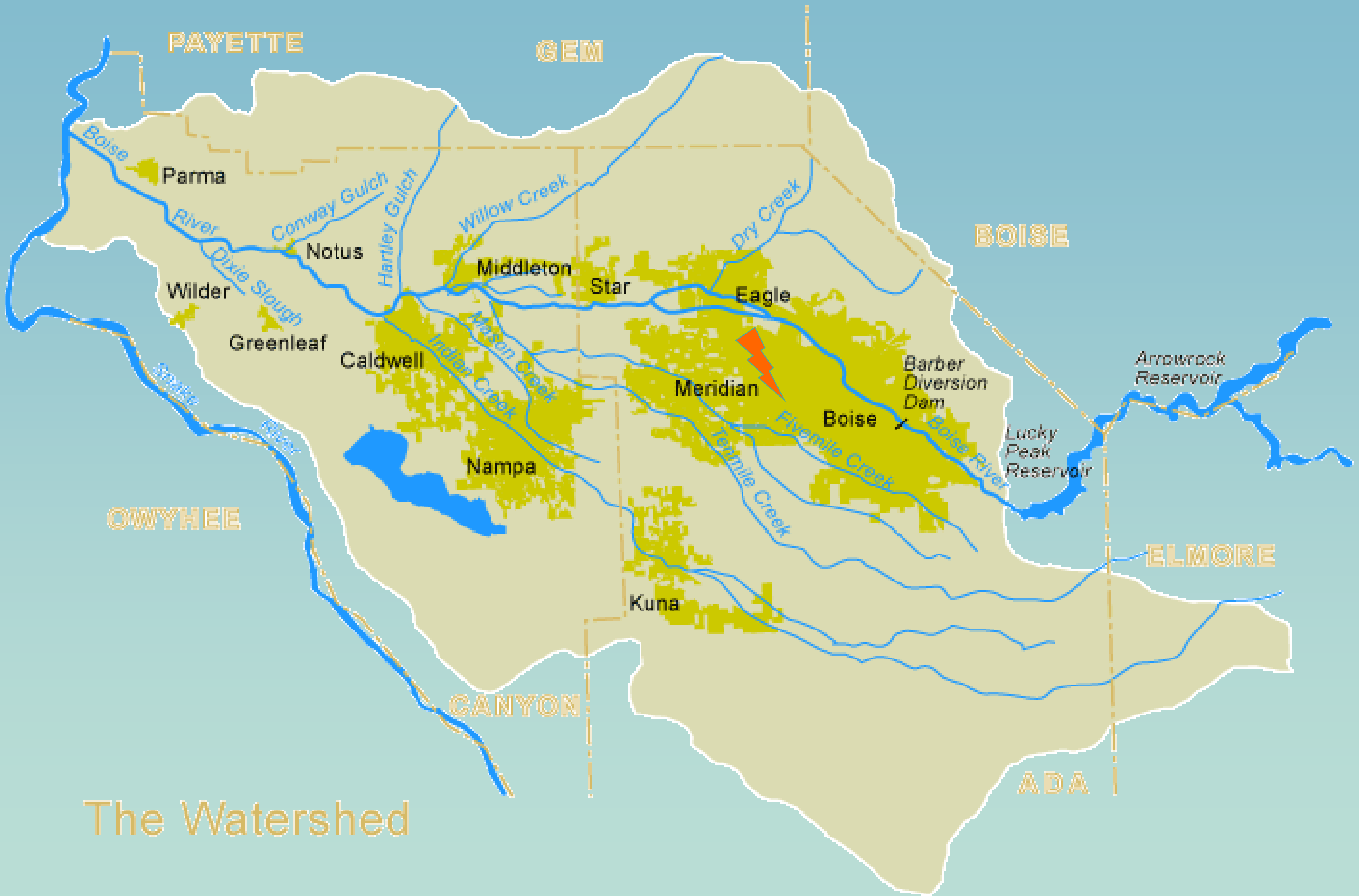



Upstream Source Downstream

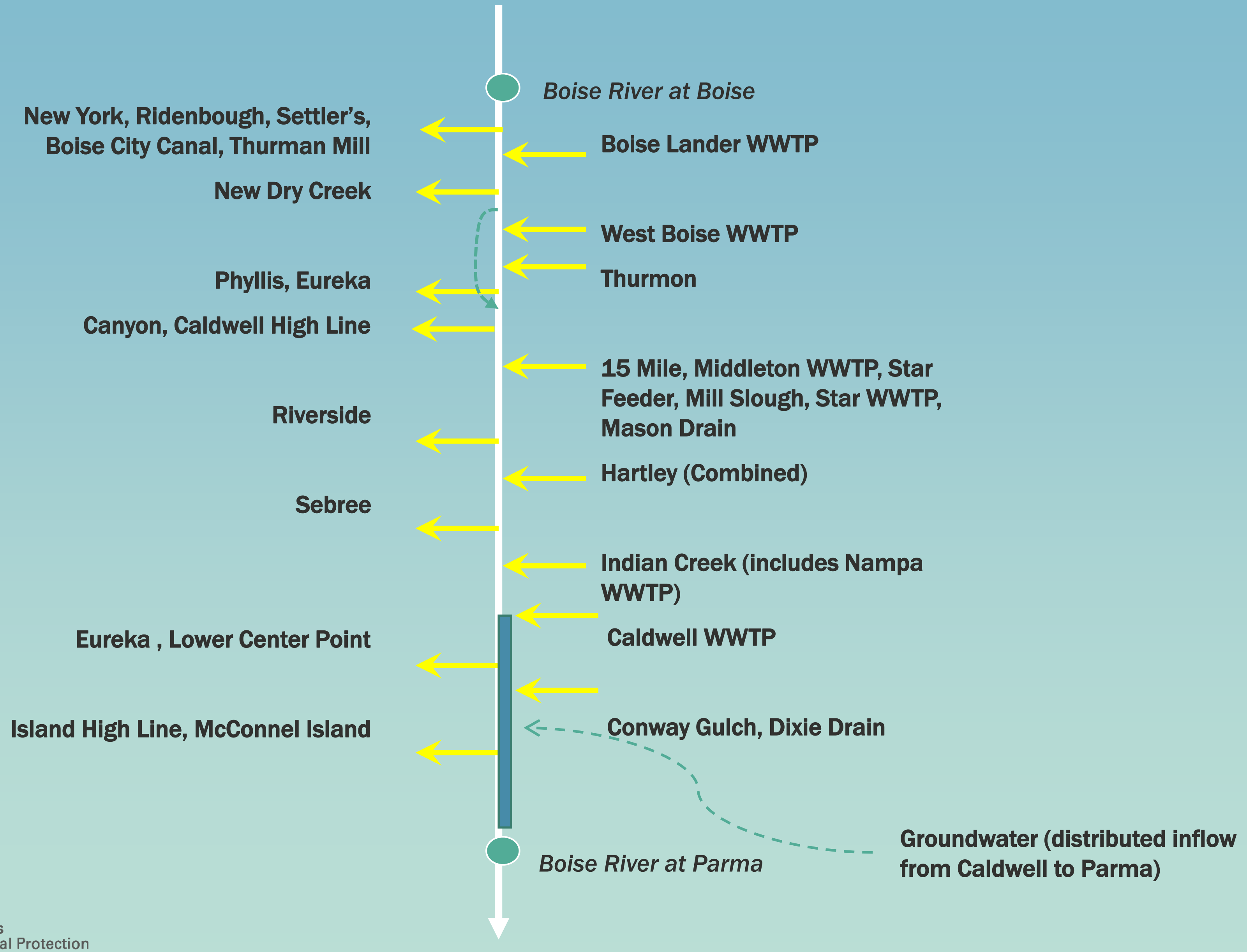
$$Q_u \cdot Cu + Qs \cdot Cs = Qd \cdot C_d$$

Assumptions: Complex mix, pollutant conserved

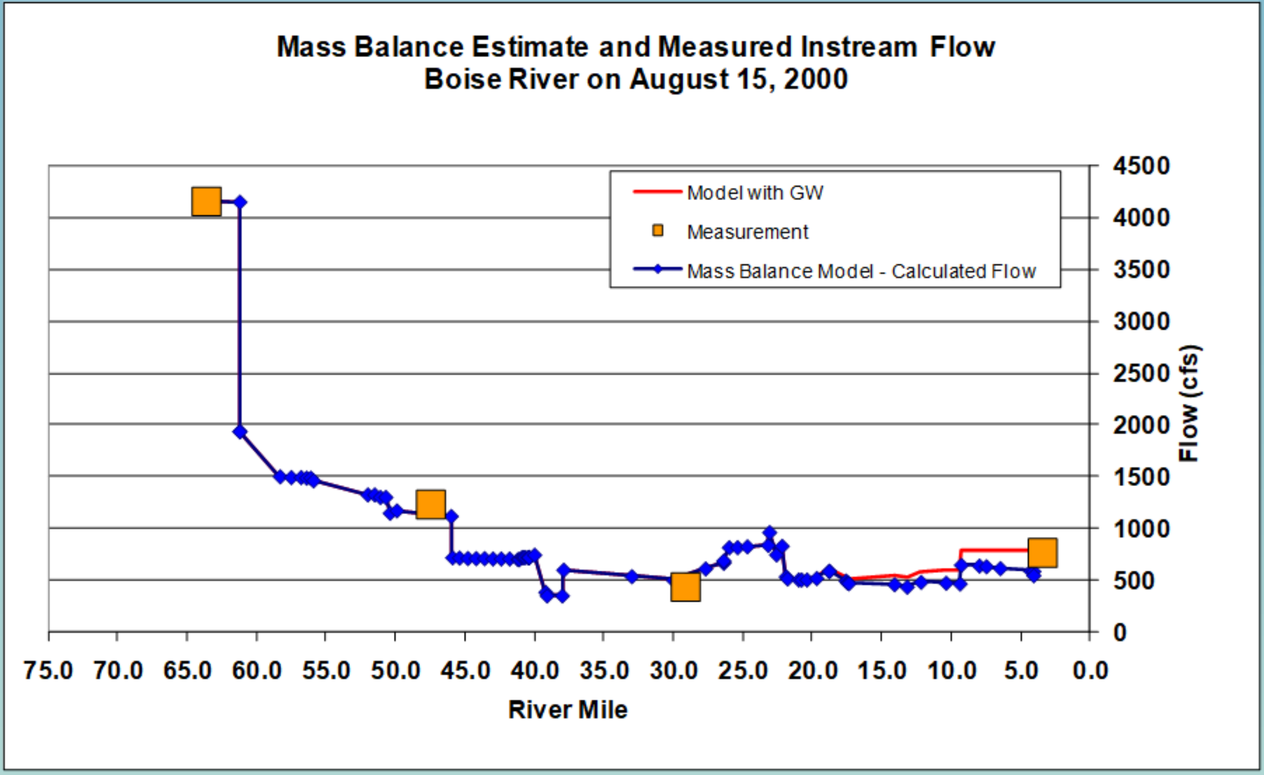
# Lower Boise River Watershed



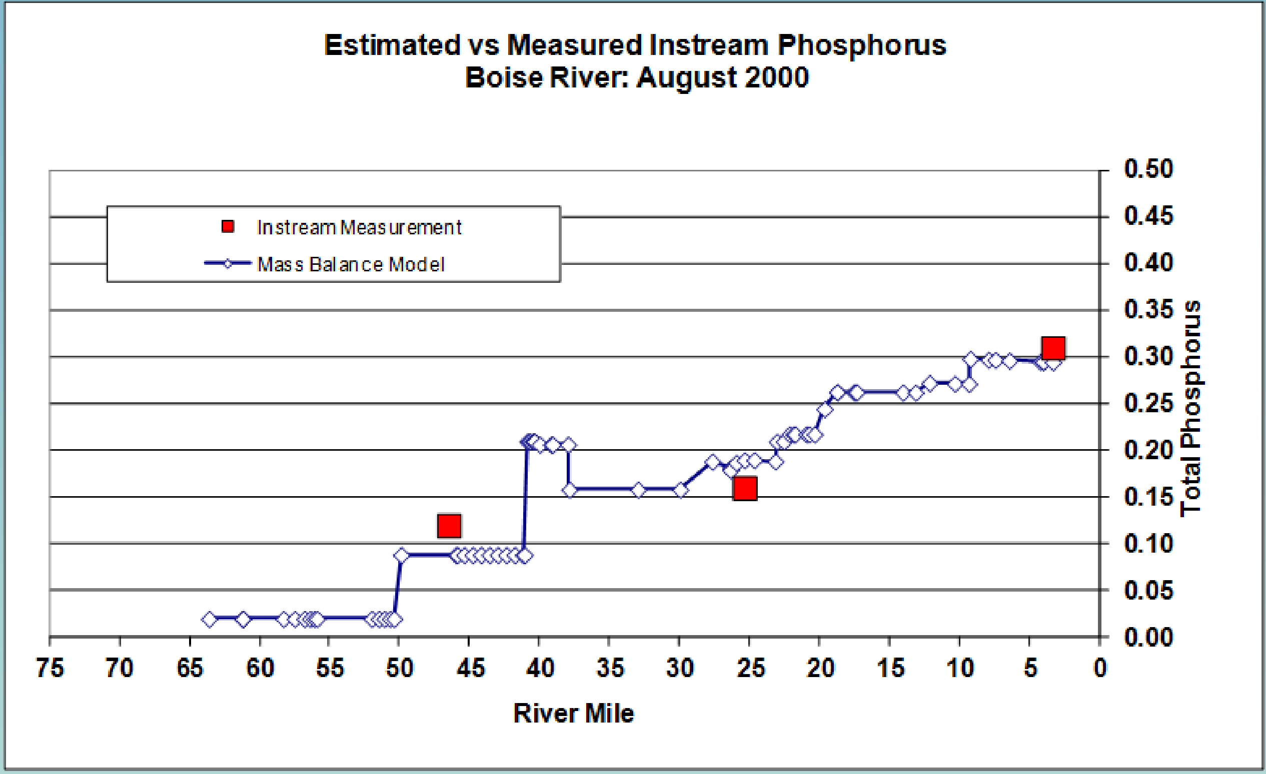
# Boise River:  Major Inflows and Diversions



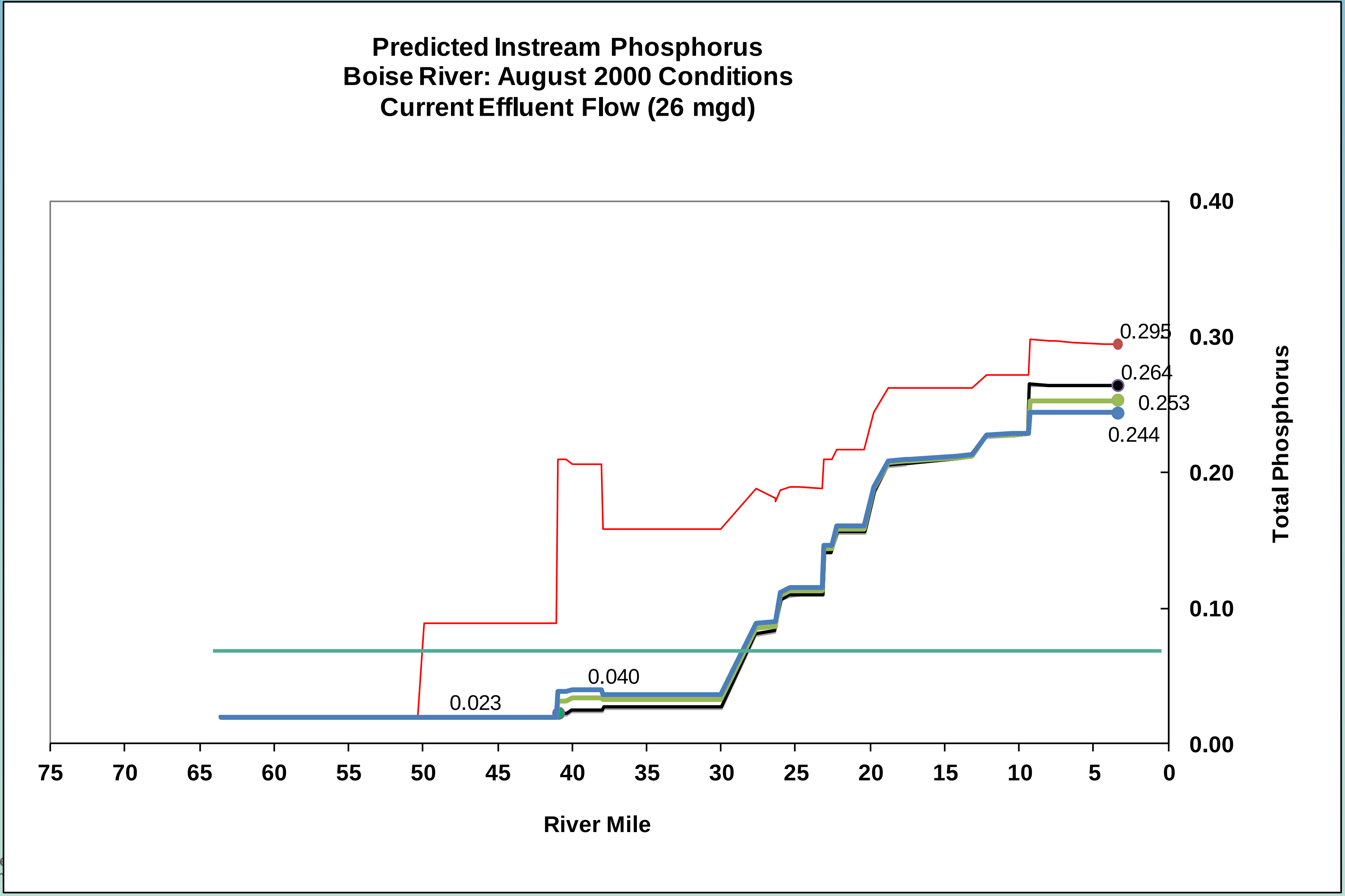
## Flow




## Phosphorus



# Predict effect of reducing sources

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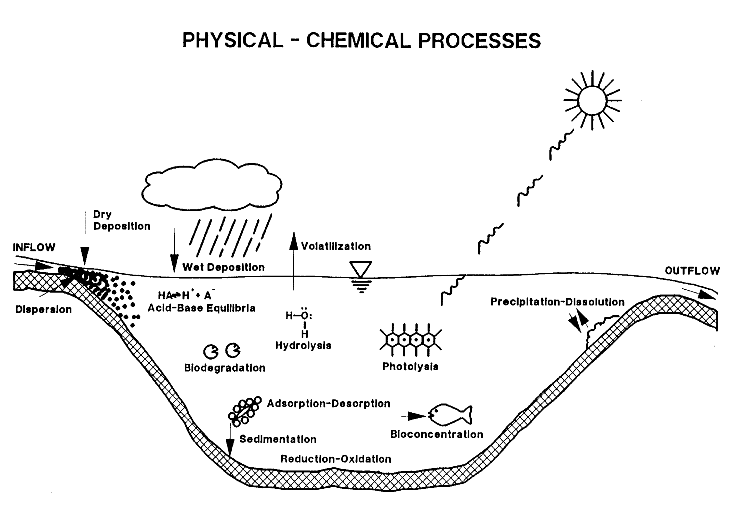
# Process models versus simpler methods

## Use a process model for:

- Non-conservative or complex pollutants
- Complex source types  (e.g., mix of point & nonpoint)
- Lakes and reservoirs that have complex hydrology
- Remedies that are expensive or controversial
- Running scenarios and predicting future conditions




Speciation, Transport and Transformation Processes in the Aquatic Environment

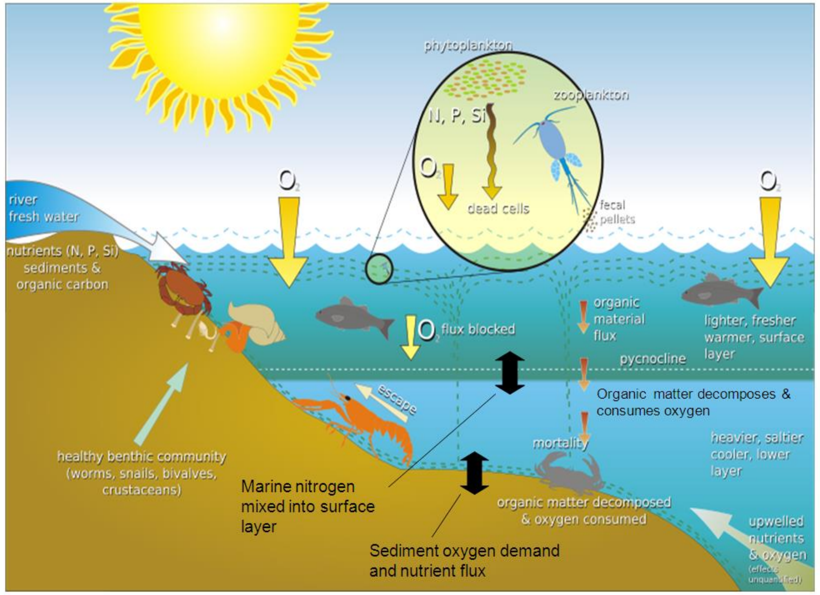
# Lots of models and tools...(examples)

| | | |
|---|---|---|
| QUAL2K | AQUATOX | BASINS |
| FVCOM | CE-QUAL-ICM | CE-QUAL-W2 |
| HEC-RAS | EFDC | CORMIX |
| HSPF | LSPC | RBM10 |
| SPARROW | SWAT | SWMM |
| SWTOOLBOX | HEAT SOURCE | WASP |
| AGNPS | LOAD DURATION | BATHTUB |

# Workhorse Models

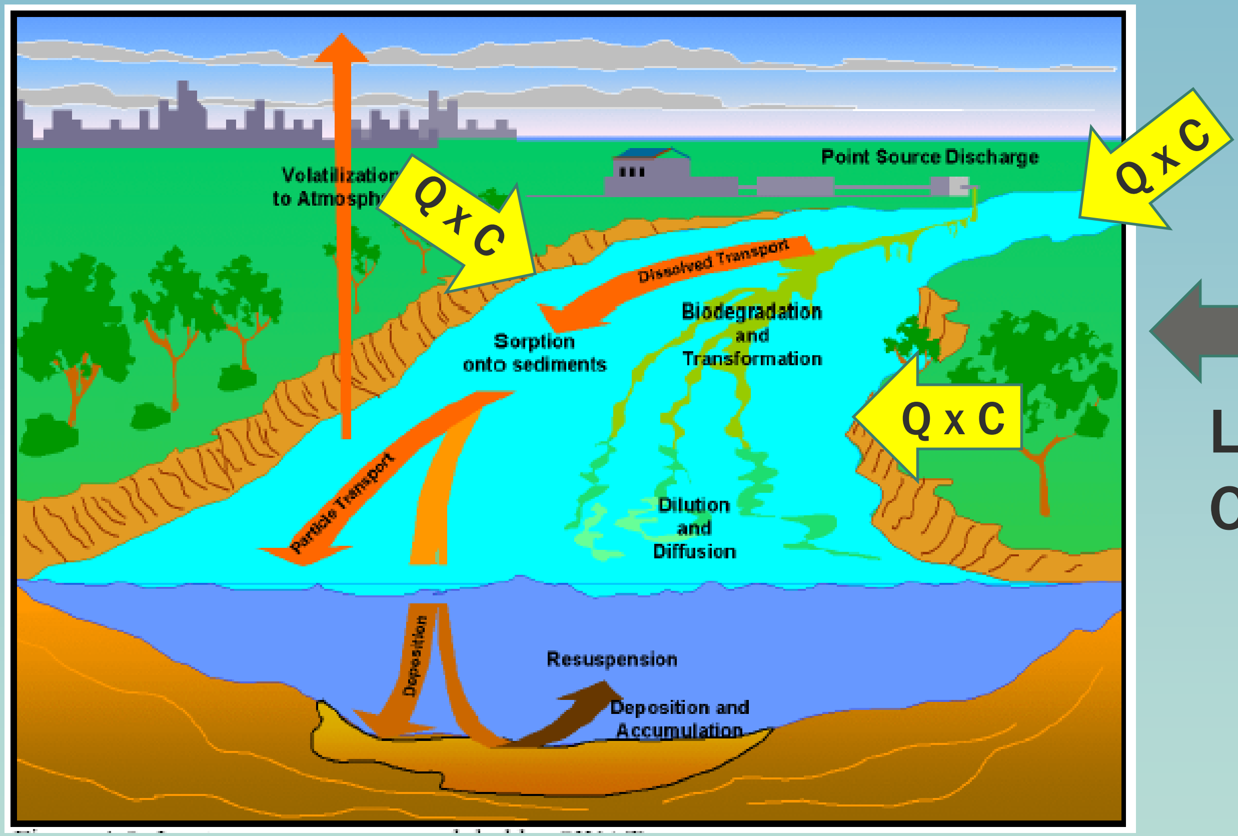
- Open source, non-proprietary
- Widely-used and well-documented
- Versatility – e.g., multiple parameters, ease of use
- User community

- Workhorses in Northwest:
  - QUAL2Kw, Heat Source, CE-QUAL-W2, HSPF



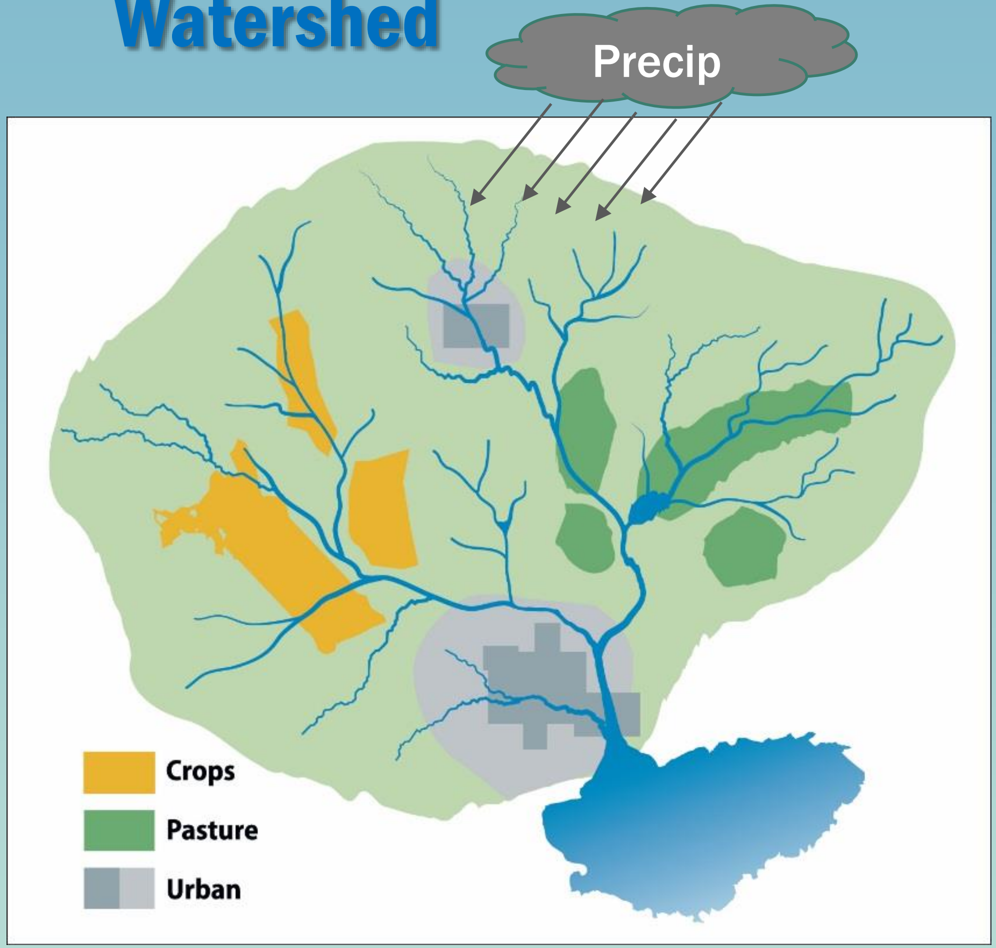
# Is runoff a primary driver of impairment?

## Waterbody or Receiving Water

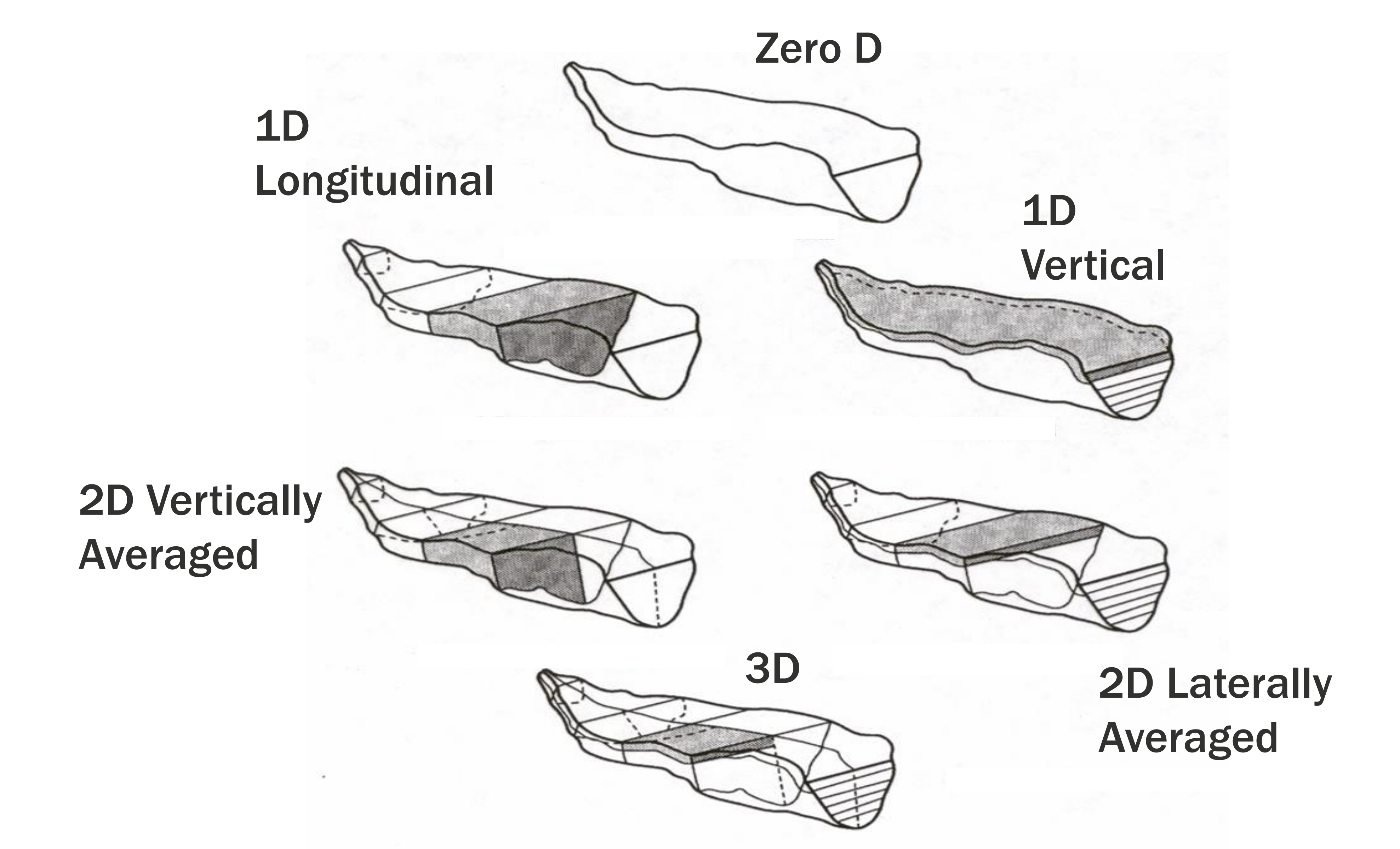



Linkage Option

## Watershed



# Waterbody Model Types – Spatial Dimensions



# Different models offer different dimensions

- QUAL2K → 1D longitudinal – rivers
- HSPF → 1D runoff, 1D longitudinal – rivers
- CE-QUAL-W2 → 2D long/vertical – reservoirs
- EFDC/WASP → 3D - estuaries

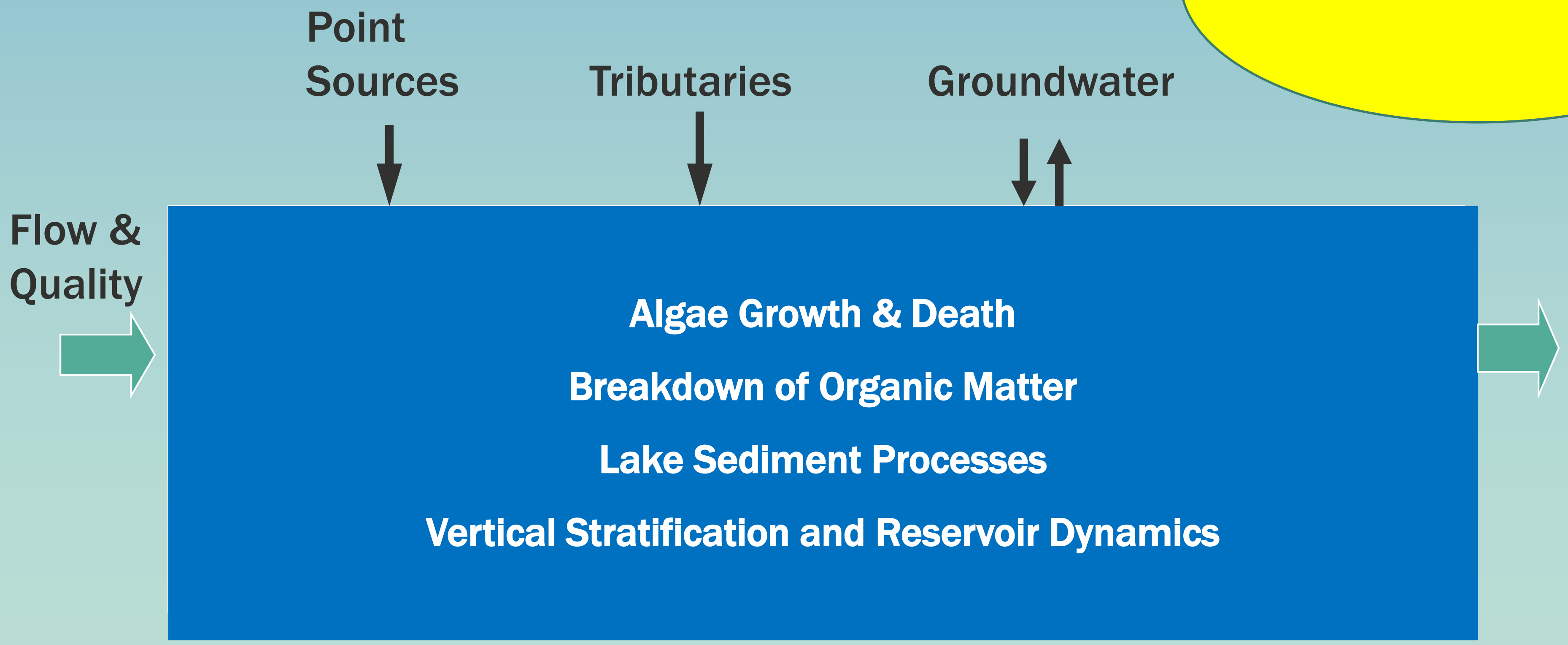
# Spokane River dissolved oxygen TMDL

- Spokane River dissolved oxygen TMDL
- Low dissolved oxygen in hypolimnion of a reservoir (Long Lake)
  - Ancillary issue:  Harmful algal blooms
- Reservoir is downstream of the city of Spokane, Washington and other smaller cities
- Water quality standard:  Dissolved oxygen
- Pollutants of concern:  Phosphorus, BOD, ammonia

# Factors that affect oxygen levels

- Flow, nutrients, and organic matter entering the river
- Processes within the river and reservoir that drive

Selection: CE-QUAL-W2



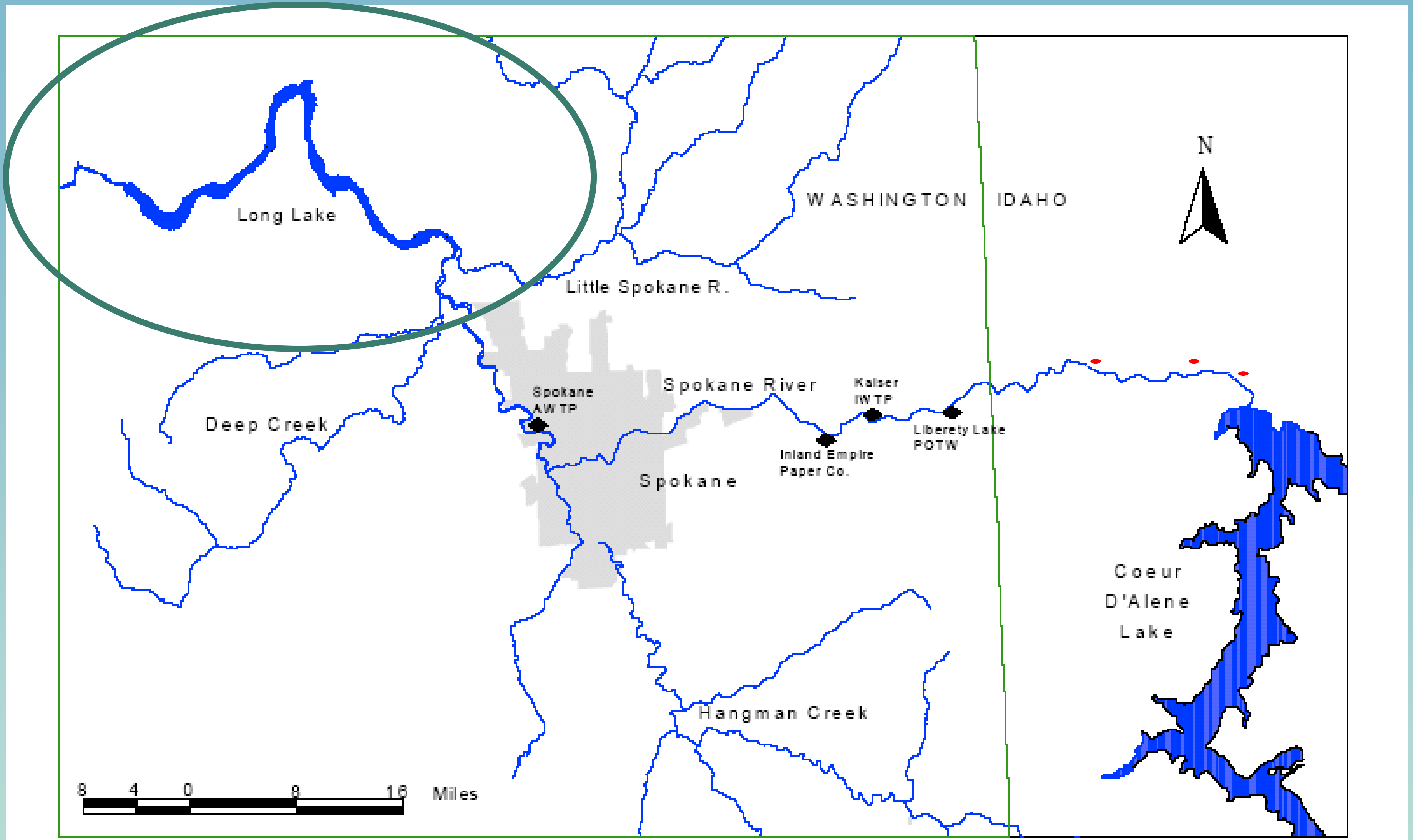



Figure 4. Current TMDL study area for the Spokane River.

- CE-QUAL-W2 (2D model, laterally averaged)
- The model divides the river into 250 segments

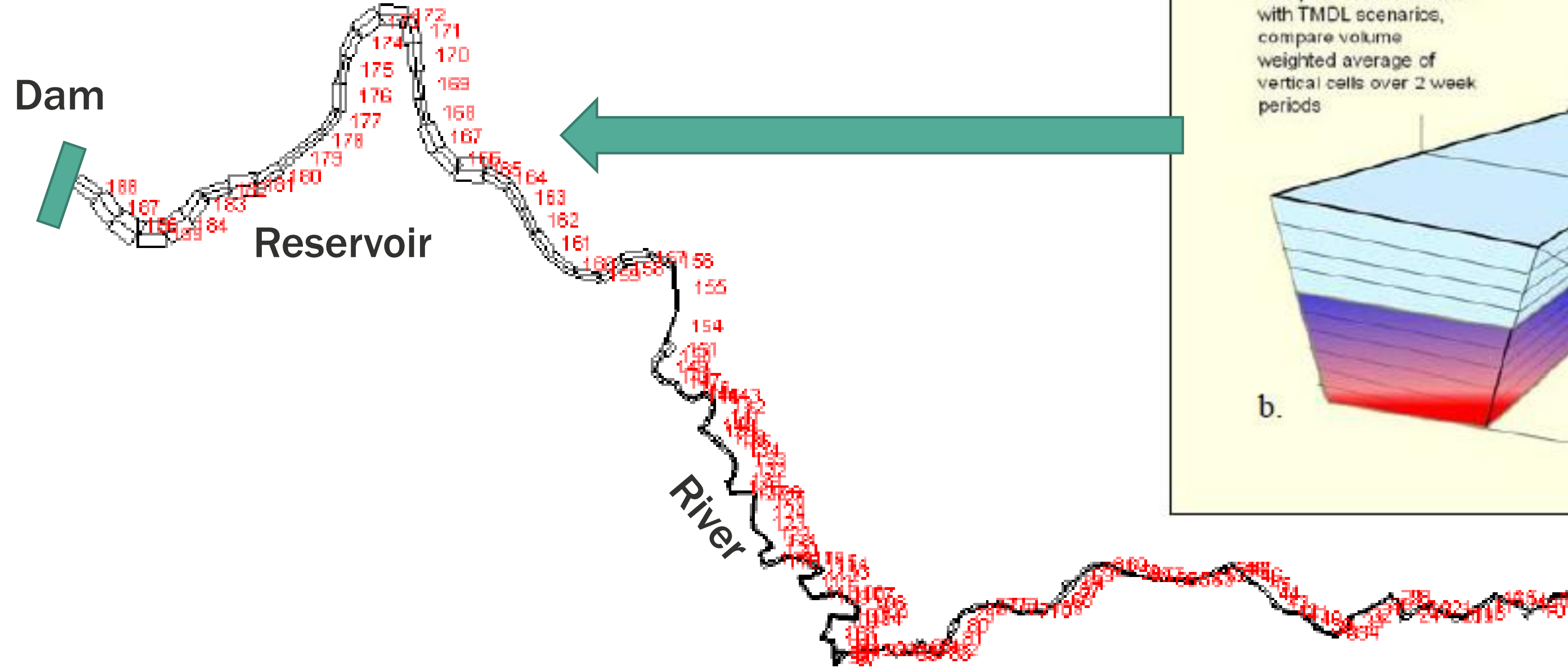
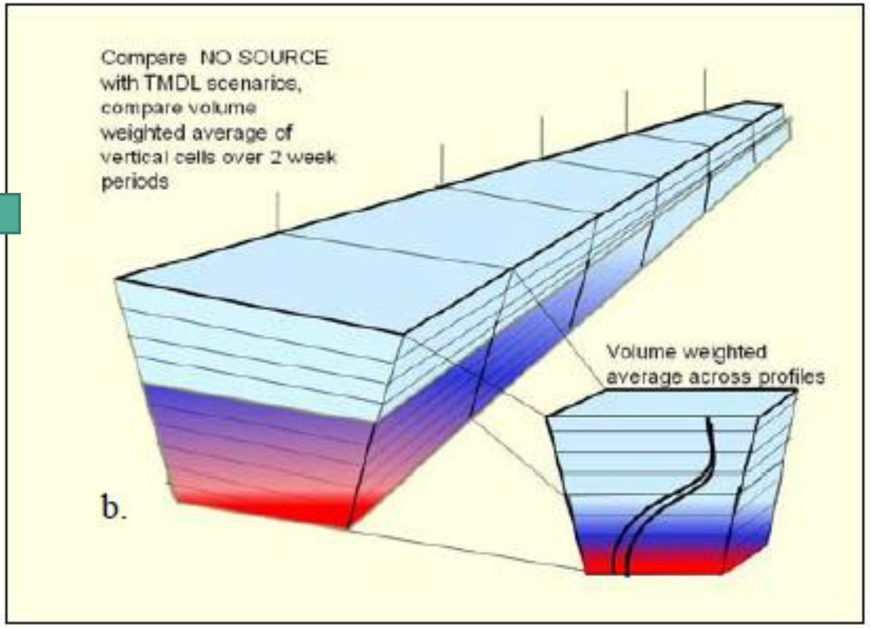
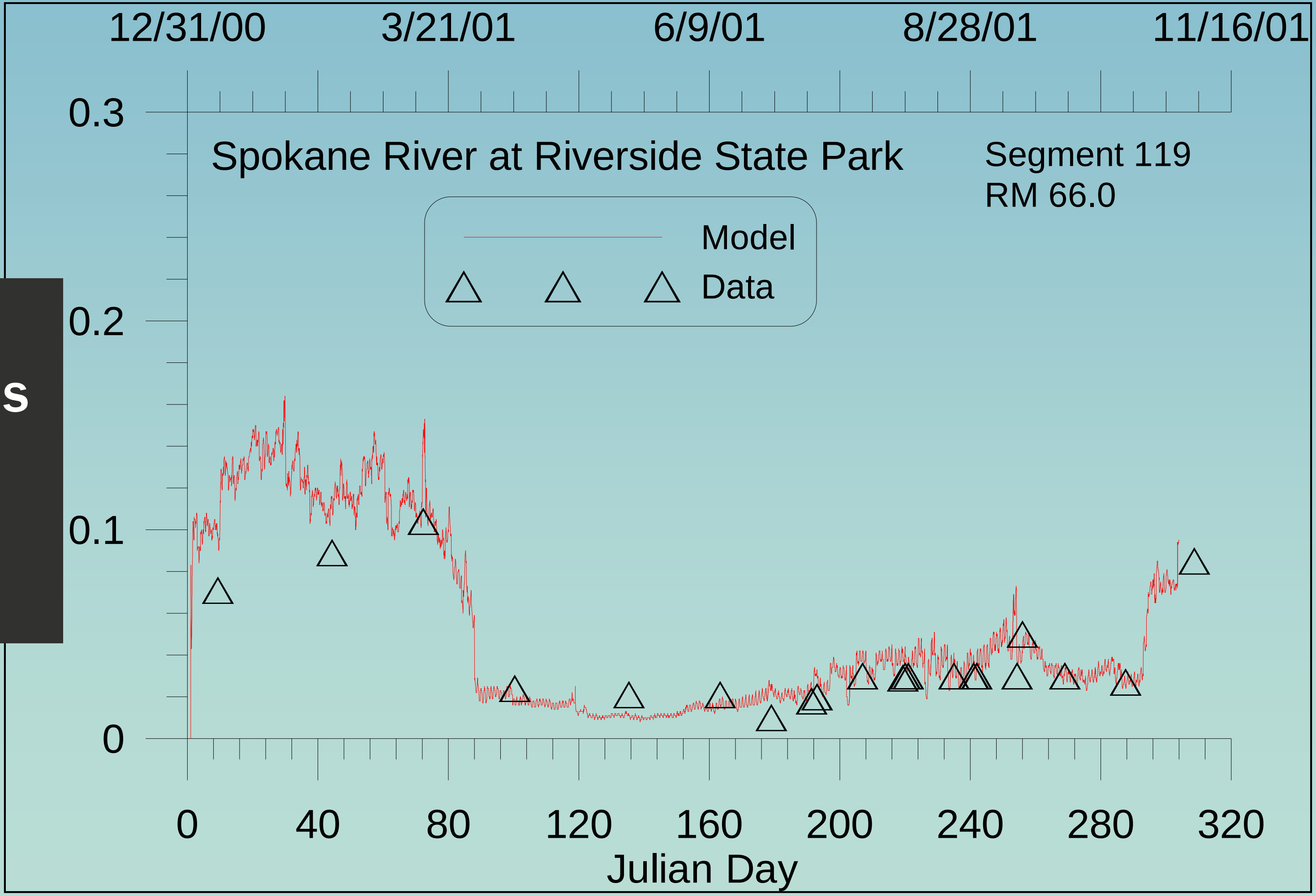



Figure 30. Plan view grid layout including Long Lake



# Calibrating Model to Existing River Conditions

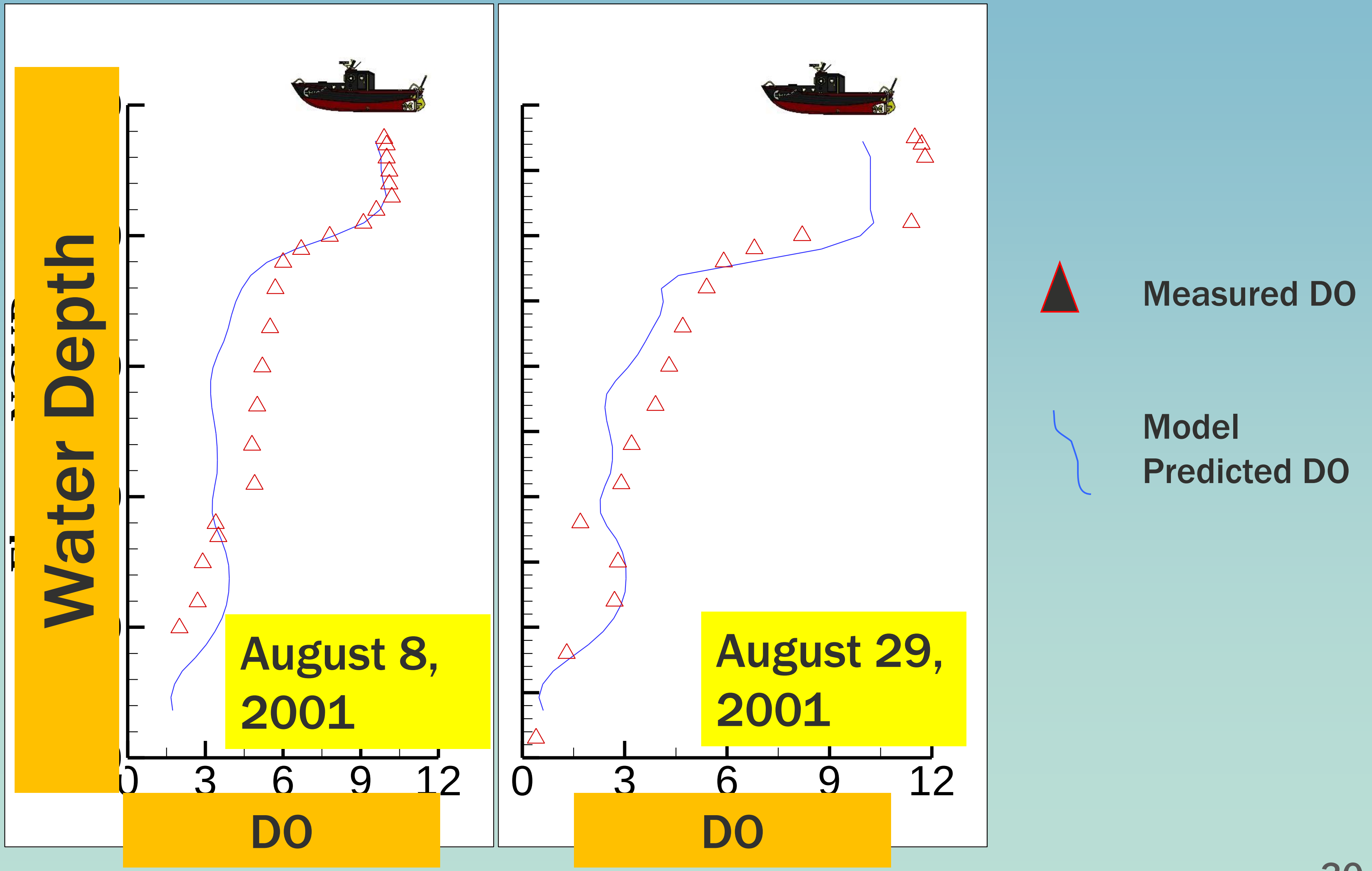
**Total Phosphorus (mg/l)**



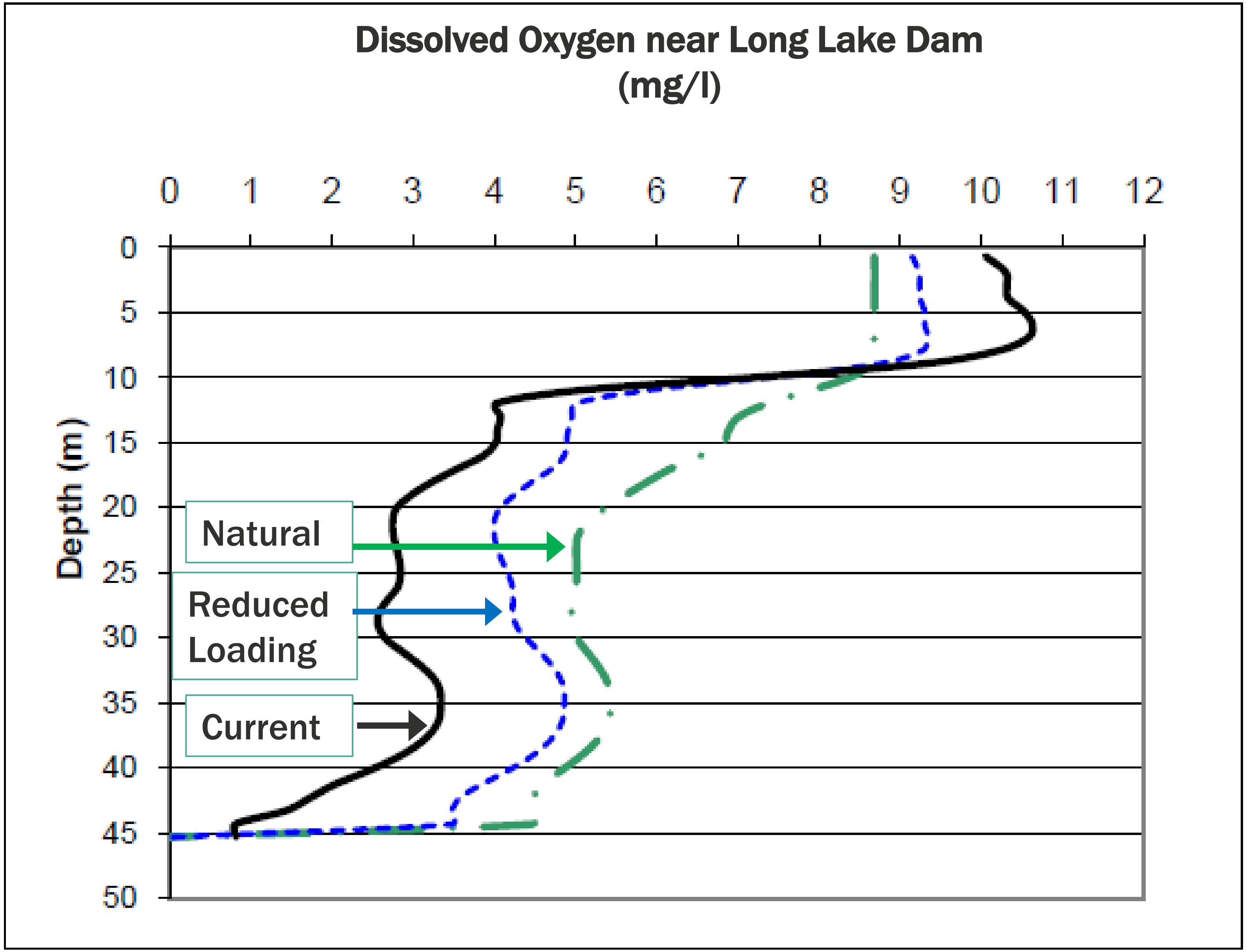
# Dynamic 2D Reservoir Model

CE-QUAL-W2

Nutrients and Dissolved Oxygen



# TMDL Scenario Prediction

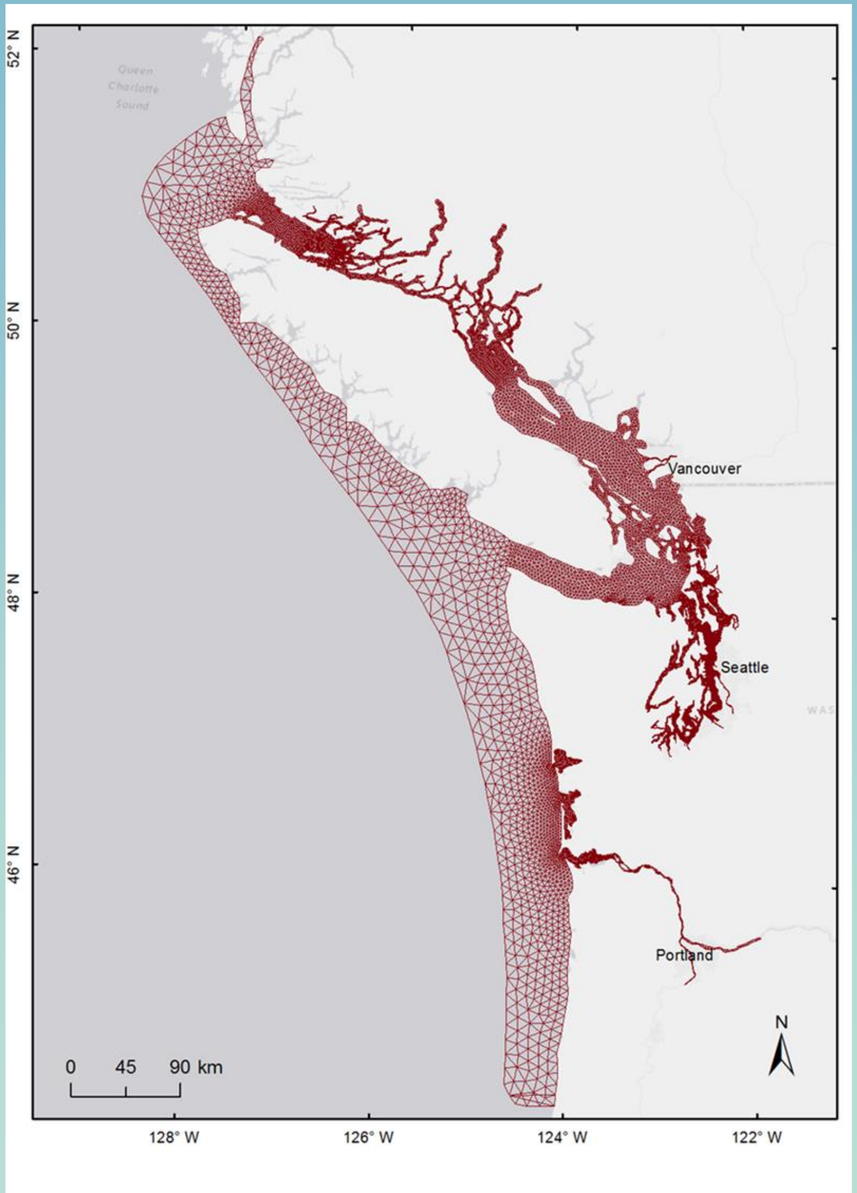


# Complex:  3D Estuary Models

## Salish Sea Model (FVCOM/CE-QUAL-ICM)

### Temperature, suspended solids,  nutrients, algae, DO, pH, toxics

### Many point sources and tributaries



# Questions?

Contact: cope.ben@epa.gov

Resources

- Model status document for widely-used models
  - https://www.epa.gov/waterdata/surface-water-quality-modeling
- Webinar series – covers many specific models and tools
  - https://www.epa.gov/waterdata/surface-water-quality-modeling-training