Summary of AQUATOX Modeling for the Lower Boise River

LBWC TAC Meeting
May 23, 2013
Presented by HDR
(Some slides courtesy of Dr. Richard Park)

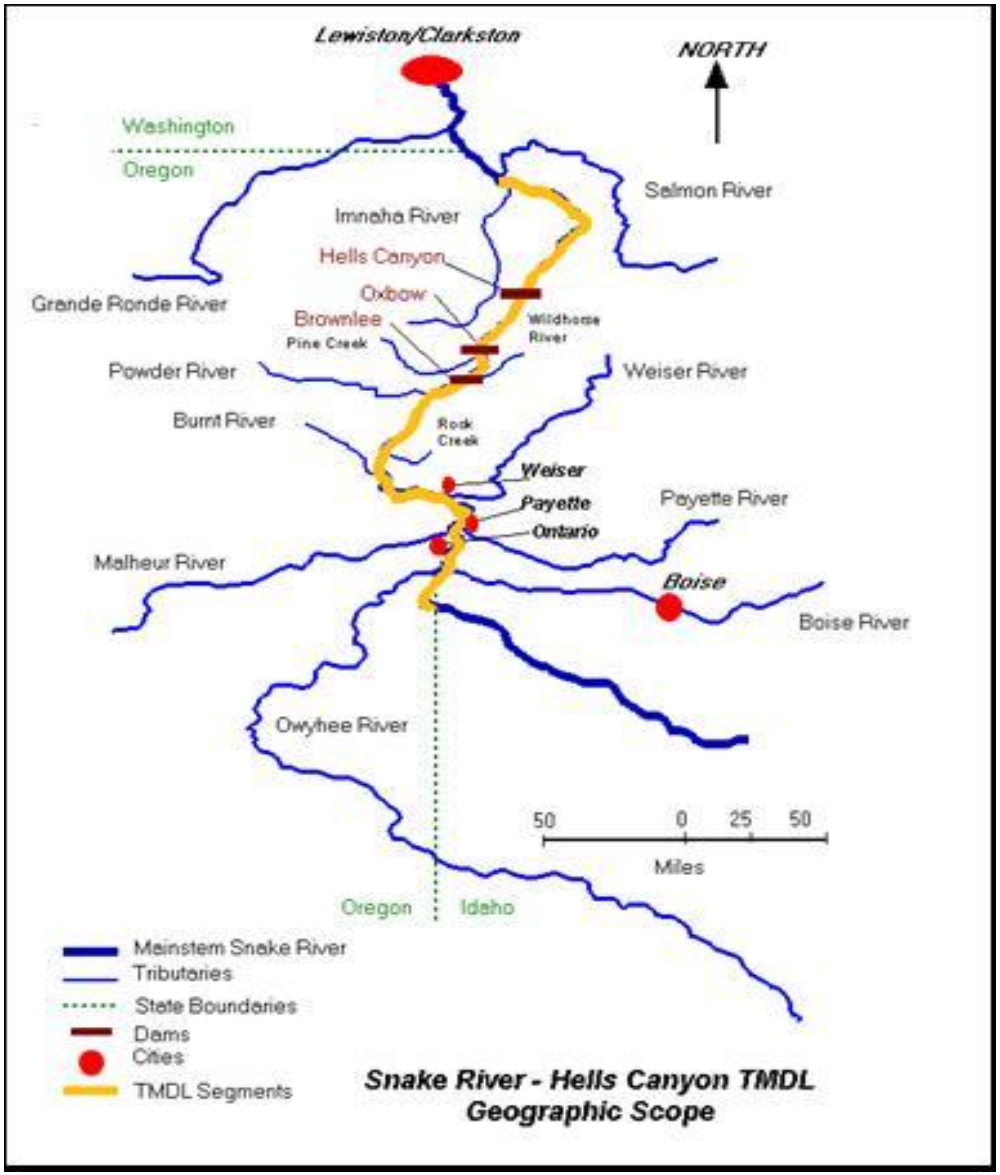
AQUATOX Topics

- Background
- Description of AQUATOX
- Application of AQUATOX to LBR
  - Model Setup and Calibration
  - Scenario Runs and Example Results
- Potential Application for Nutrient Criteria for the LBR (2008 report)
- Update of the model for the ongoing TP TMDL

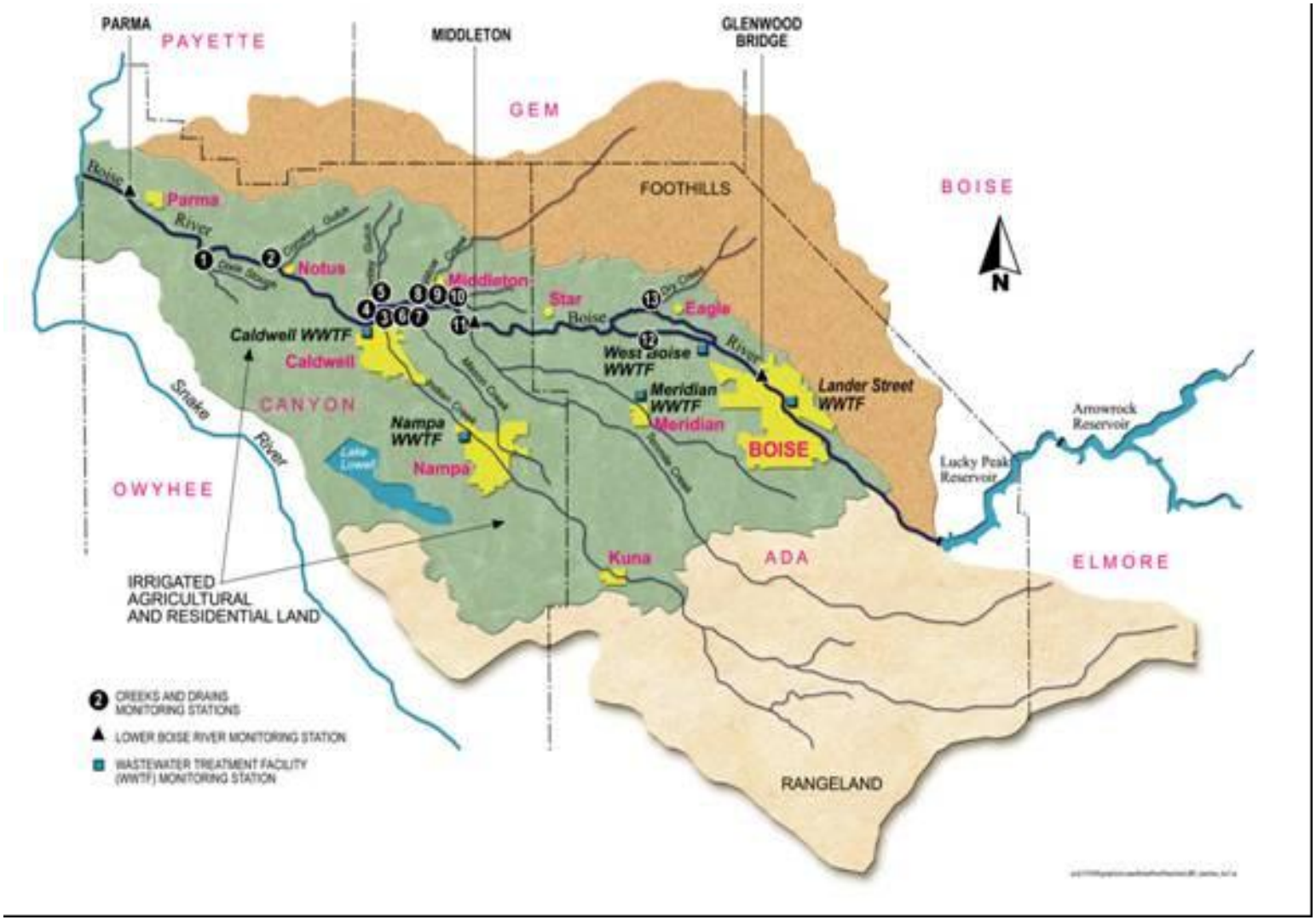
Background

- EPA HQ looking for applications of AQUATOX model for derivation of numeric nutrient criteria
- Provide insights on how SR-HC TP allocations will affect LBR
- Provide insights on how LBR sediment allocations will affect algae at Parma
- Use to reevaluate BOD allocations for point sources to the LBR

SR-HC TMDL Area



Lower Boise Watershed



Algae Issues in SR vs. LBR

- Snake River:
  - Primary driver in final TMDL was phytoplankton in river upstream of Brownlee (seasonal target of 14 ug/L of phytoplankton chlorophyll)

- Lower Boise River:
  - DO and pH meet standards, part of basis for DEQ delisting
  - Lingering concern has been periphyton at Middleton (low flow location)
  - Additional concern has been phytoplankton at Parma when sediment TMDL increases light availability

Description of AQUATOX

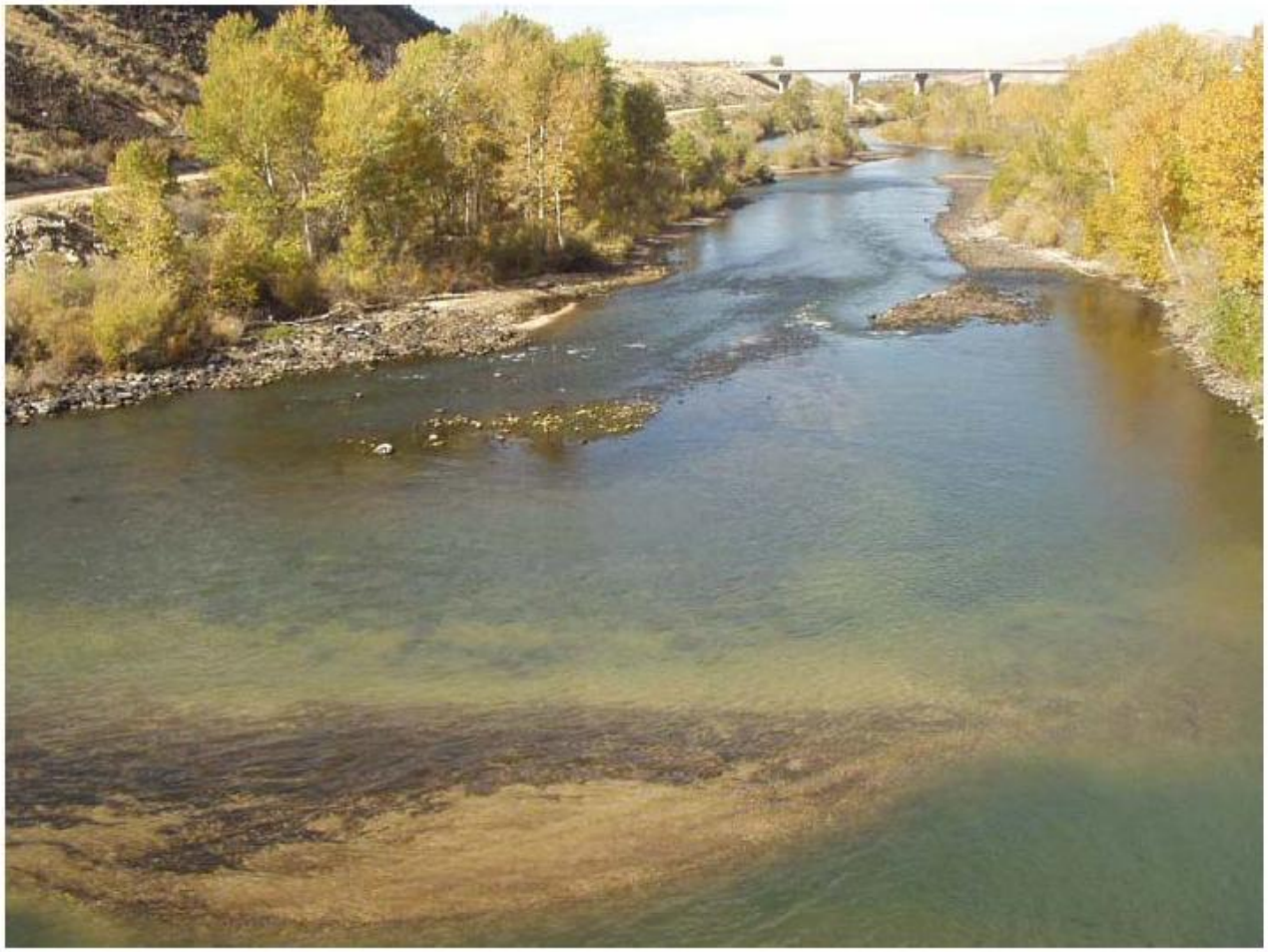
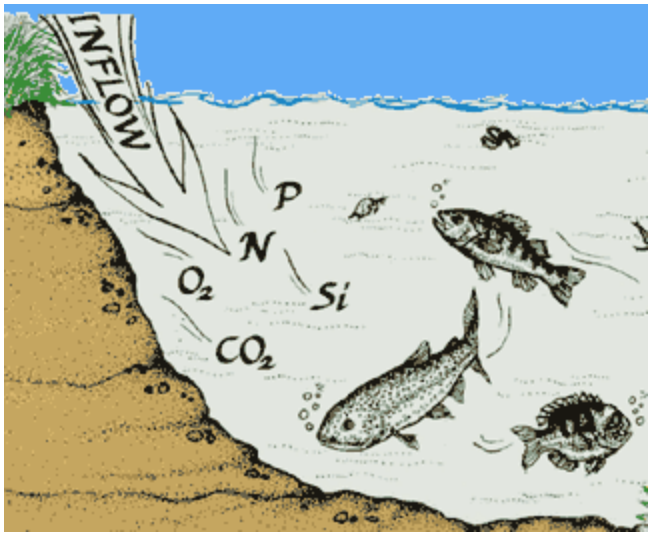


Figure 3. Below Diversion Dam at head of Lower Boise River.

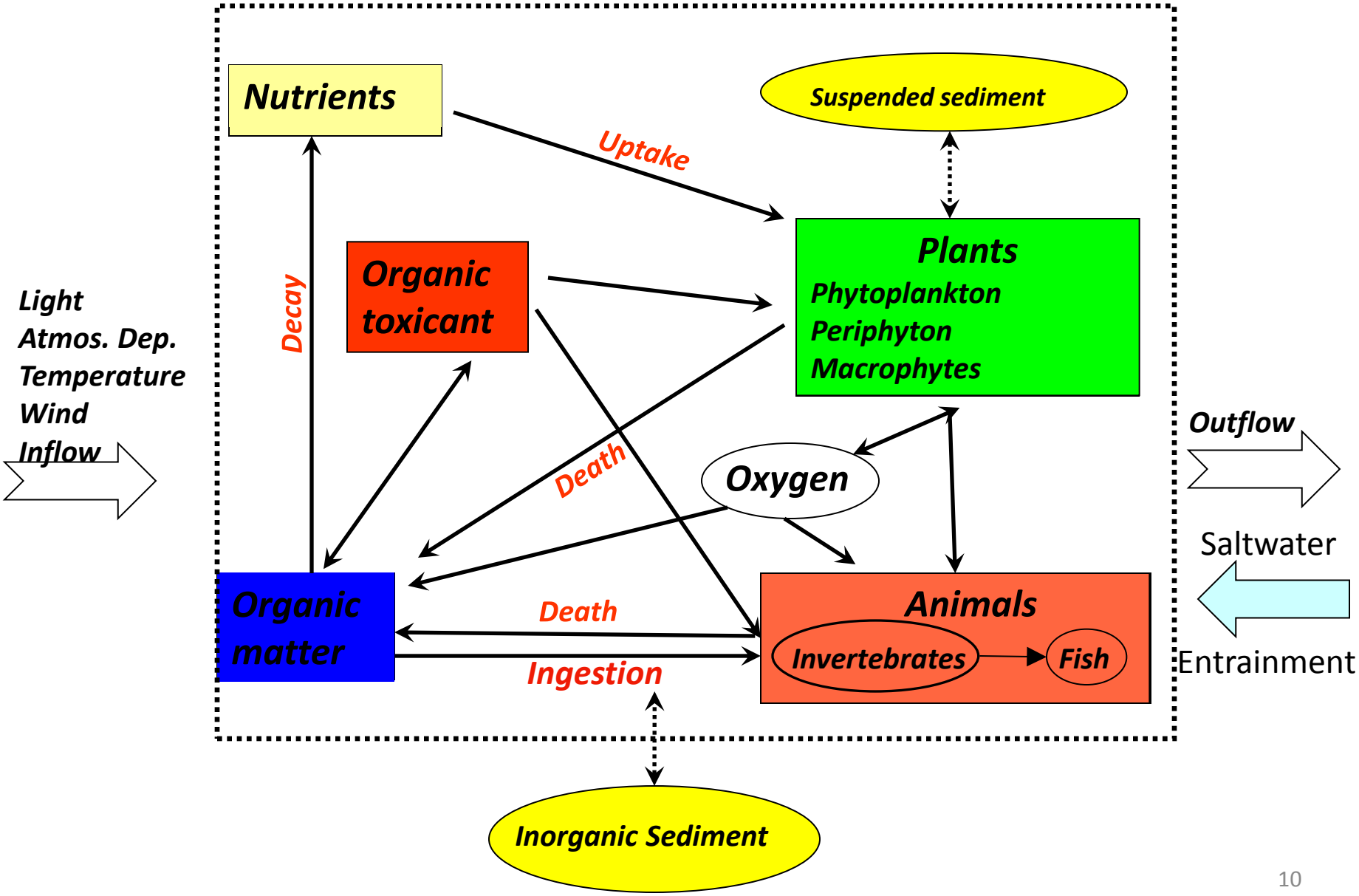
What is AQUATOX?

- Simulation model that links pollutants to aquatic life
- Integrates fate & ecological effects
  - Fate & bioaccumulation of organics
  - Food web & ecotoxicological effects
  - Nutrient & eutrophication effects
- Predicts effects of multiple stressors
  - Nutrients, organic toxicants, temperature, suspended sediment, flow, salinity
- Peer reviewed by independent panel and in published model reviews
- EPA distributed and supported



http://water.epa.gov/scitech/datait/models/aquatox/index.cfm

AQUATOX Ecosystem Representation



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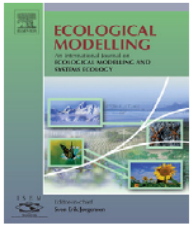

Review

AQUATOX: Modeling environmental fate and ecological effects in aquatic ecosystems☆

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ABSTRACT

AQUATOX combines aquatic ecosystem, chemical fate, and ecotoxicological constructs to obtain a truly integrative fate and effects model. It is a general, mechanistic ecological risk assessment model intended to be used to evaluate past, present, and future direct and indirect effects from various stressors including nutrients, organic wastes, sediments, toxic organic chemicals, flow, and temperature in aquatic ecosystems. The model has a very flexible structure and provides multiple analytical tools useful for evaluating ecological effects, including uncertainty analysis, nominal range sensitivity analysis, comparison of perturbed and control simulations, and graphing and tabulation of predicted concentrations, rates, and photosynthetic limitations. It can represent a full aquatic food web, including multiple genera and guilds of periphyton, phytoplankton, submersed aquatic vegetation, invertebrates, and fish and associated organic toxicants. It can model up to 20 organic chemicals simultaneously. (It does not model metals.) Modeled processes for organic toxicants include chemodynamics of neutral and ionized organic chemicals, bioaccumulation as a function of sorption and bioenergetics, biotransformation to daughter products, and sublethal and lethal toxicity. It has an extensive library of default biotic, chemical, and toxicological parameters and incorporates the ICE regression equations for estimating toxicity in numerous organisms. The model has been implemented for streams, small rivers, ponds, lakes, reservoirs, and estuaries. It is an integral part of the BASINS system with linkage to the watershed models HSPF and SWAT.

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Why Use AQUATOX?

- When have aquatic life endpoints
  - Models hydraulic scour of periphyton
  - Most water quality models do not include animals
- When have complex ecological & biological processes
  - Feedback loops, indirect effects
  - Trophic cascades
  - Multiple factors affecting ecosystem responses
  - Non-linear relationships

Process for Application to LBR

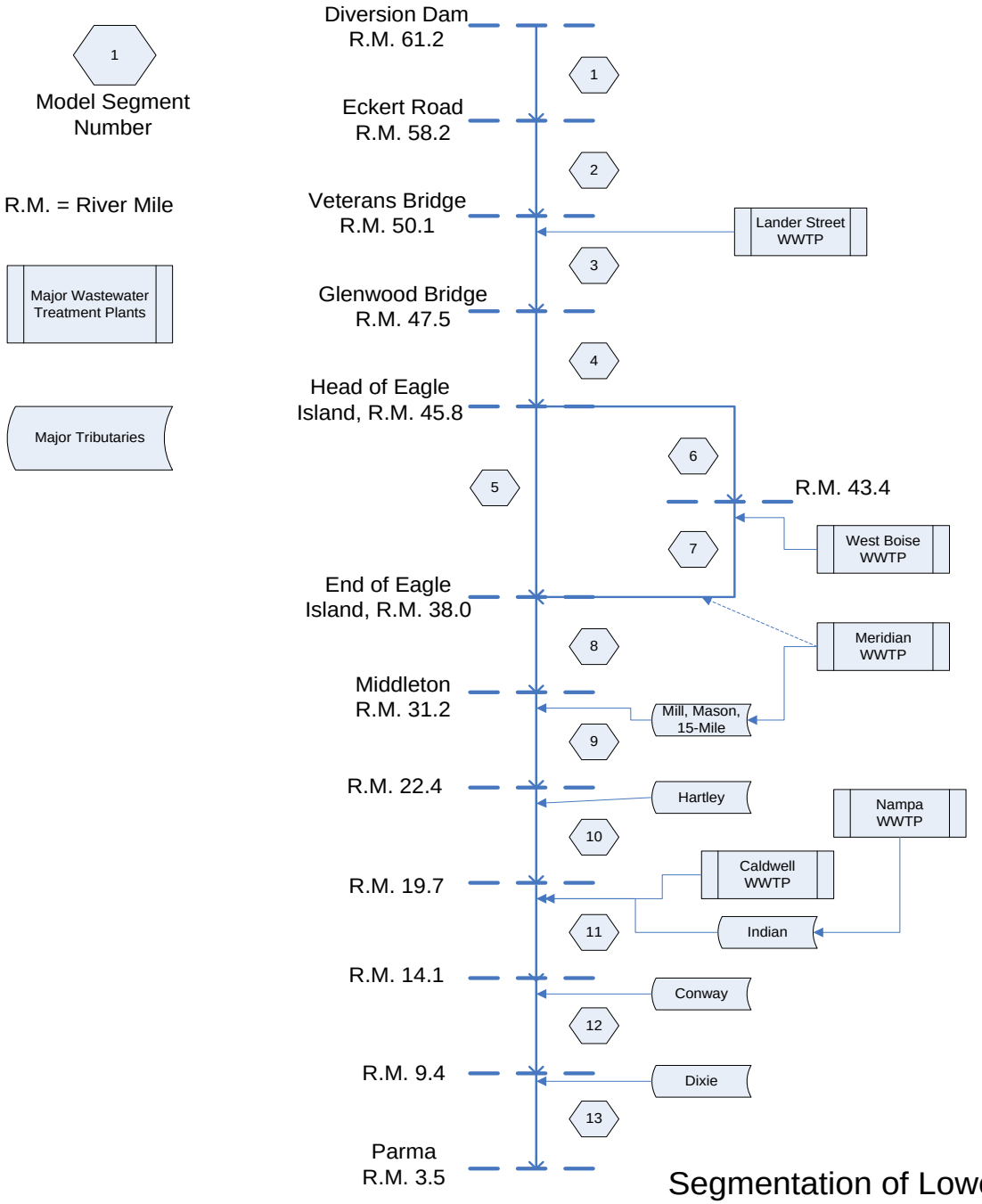
- EPA HQ contract with CH2M HILL, with Eco Modeling (Dick Park) and Warren Pinnacle (Jon Clough) (model developers) as subconsultants
- Boise City staff as technical support
- Kickoff meeting held Fall 2005 with LBWC TAC
- Boise City (Kate Harris) collected additional algae speciation data
- Model set up and calibrated for LBR by Jon and Dick
- Boise City (Ben Nydegger) ran multiple scenarios:
  - included current, LBR IP allocations, and many others above and below
- Final report submitted to EPA HQ at end of December 2008

Algae Speciation Example

Lower Boise River Periphyton Community Composition Analysis - September 2006							
Division	Species	Site					
Cyanophyta:		Eckert	Veteran's	Glenwood	Middleton	Caldwell	Parma
	Oscillatoria agardhii					R	
	Phormidium inundatum				C	R	
	Phormidium species*		A				
	Rivularia species				C	R	
Chlorophyta:							
	Cladophora glomerata	A	R	A		R	C
	Closterium ehrenbergii				R	R	
	Cosmarium species				R/C	R	
	Oedogonium species	C				R	
	Scenedesmus quadricauda					R	
	Spirogyra species					R	
	Stigeoclonium polymorphum	R/C	R		C		C
	Ulothrix aequalis	R	R				C
	Ulothrix zonata				R		
Bacillariophyta:							
	Centric diatoms				C		
	Pennate diatoms	A	A	A	A	A	A
	Fragilaria crotonensis						C
	Fragilaria virescens			R		A	
	Melosira granulata			R		R	
	Melosira varians	R	R	R	R		
	Stephanodiscus niagarae			R	R	R	

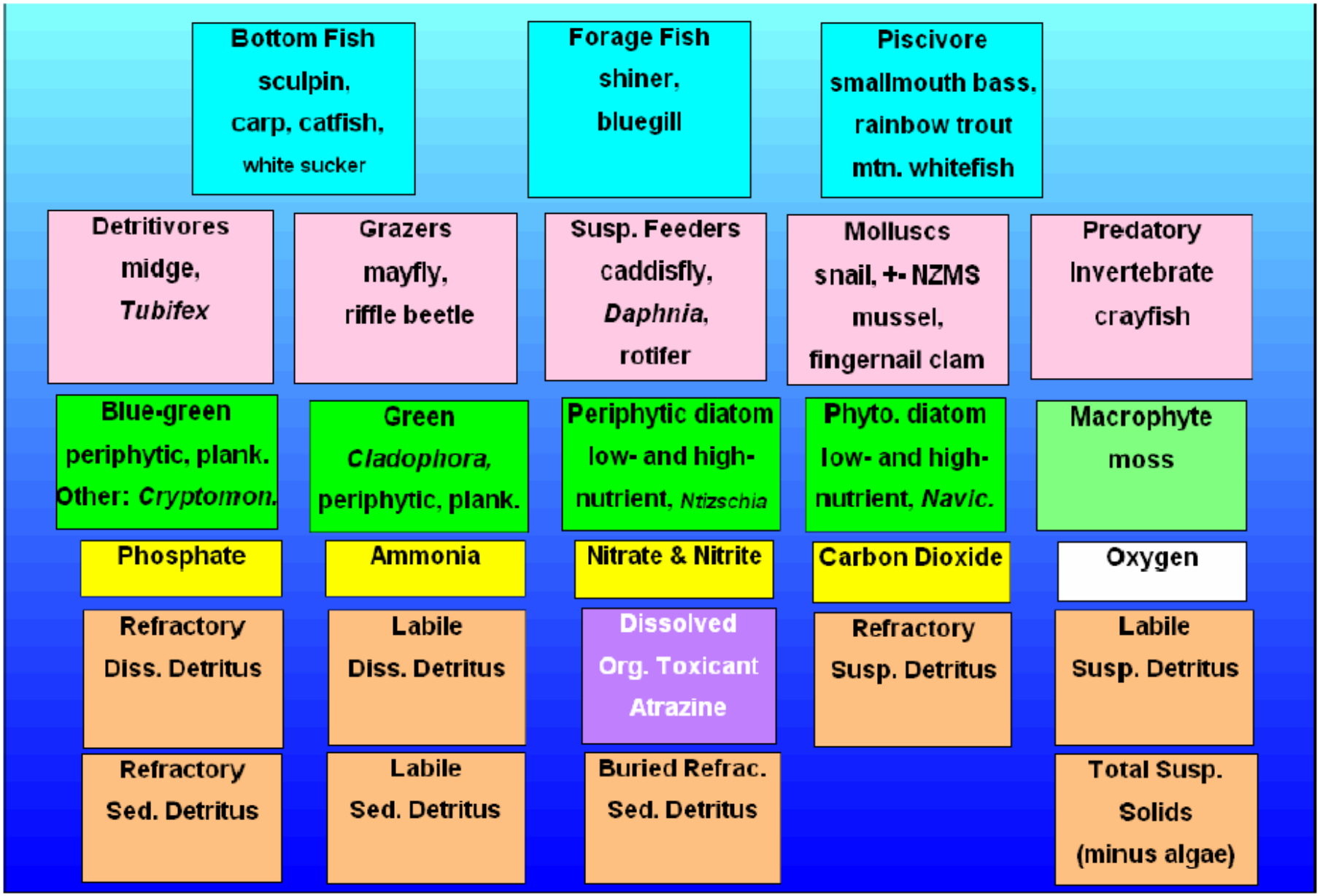
Model Setup and Calibration

Eagle Bridge over S. Channel LBR



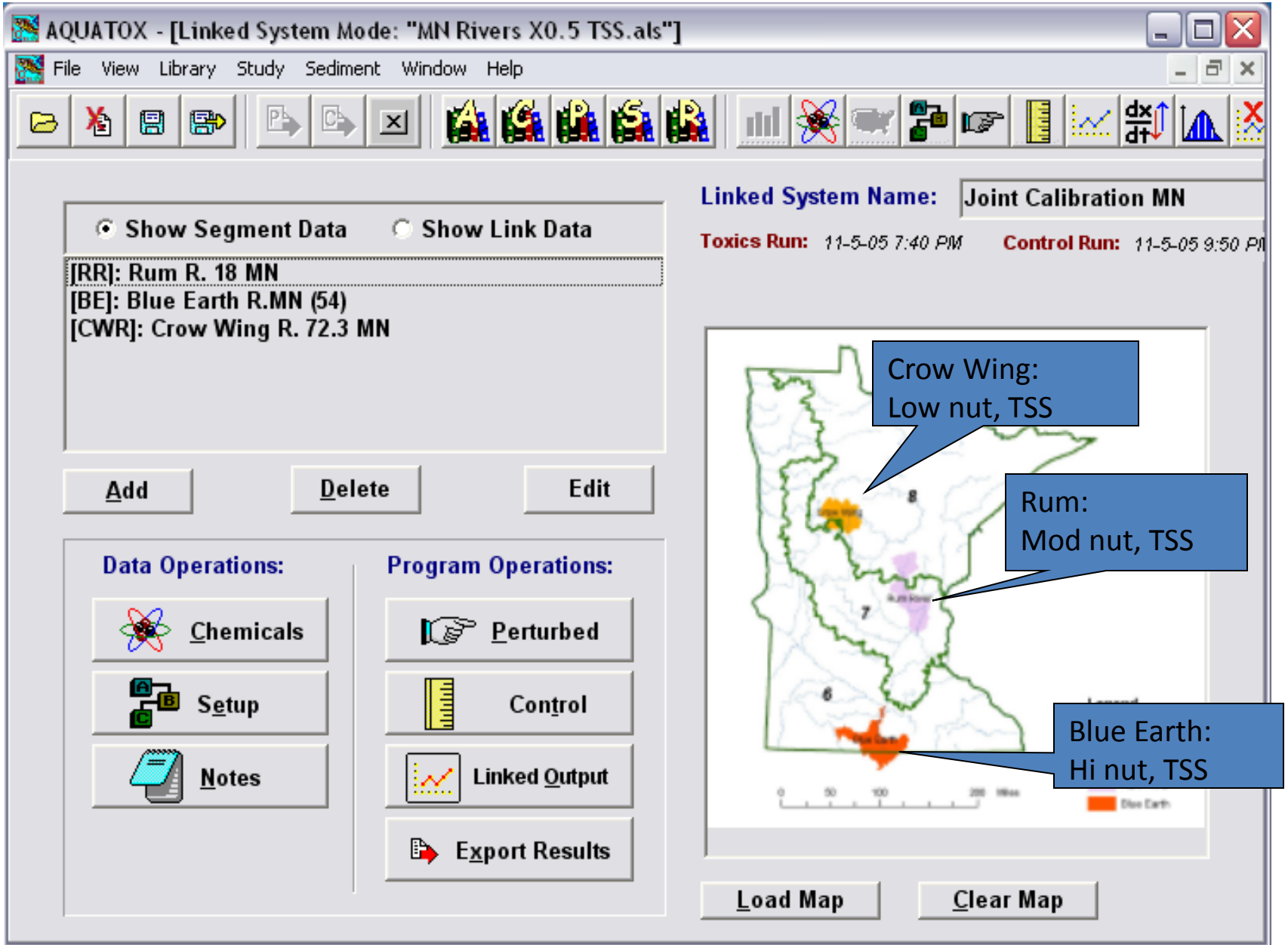
Segmentation of Lower Boise River for Aquatox Model

Ecosystem Compartments Simulated for LBR



Calibrated simultaneously for 3 sites in MN

3 ecoregions, 3 nutrient regimes

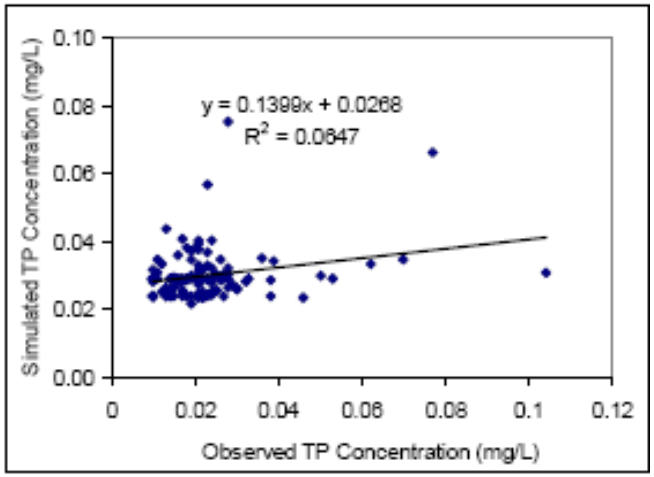


Calibration Period (1999-2001)

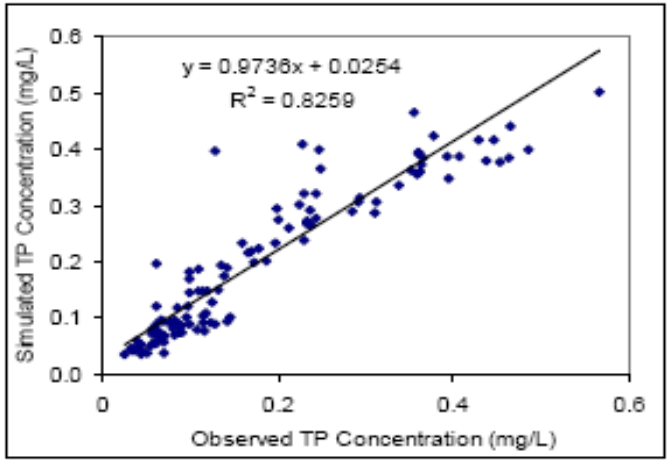
- 1999: High flow year
  - Others: 2003, 2004, 2005, 2007
- 2000: Medium flow year
  - Other: 1995
- 2001: Low flow year
  - Others: 1996,1997, 1998, 2006

TP Calibration Results

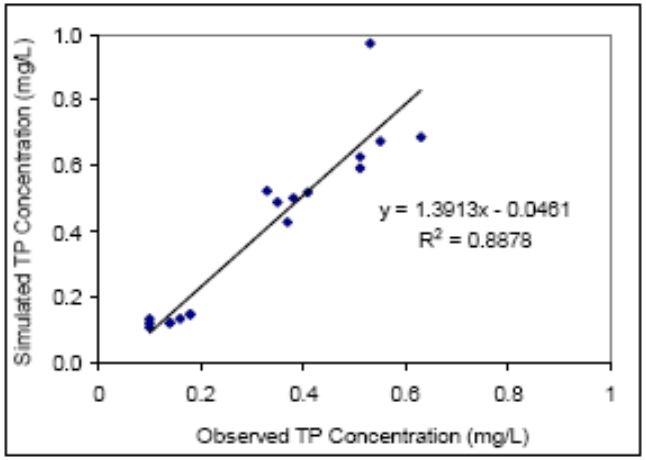
Veterans



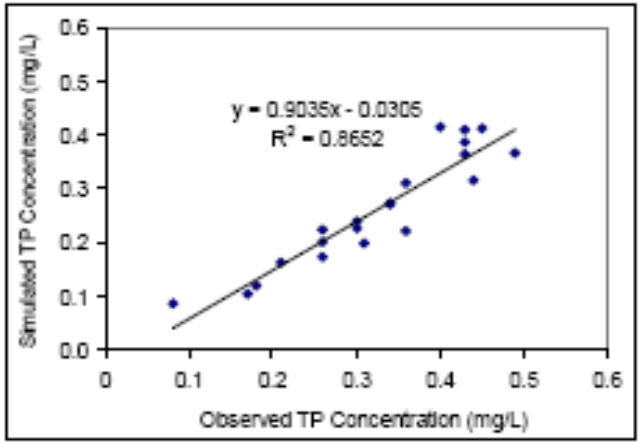
Glenwood



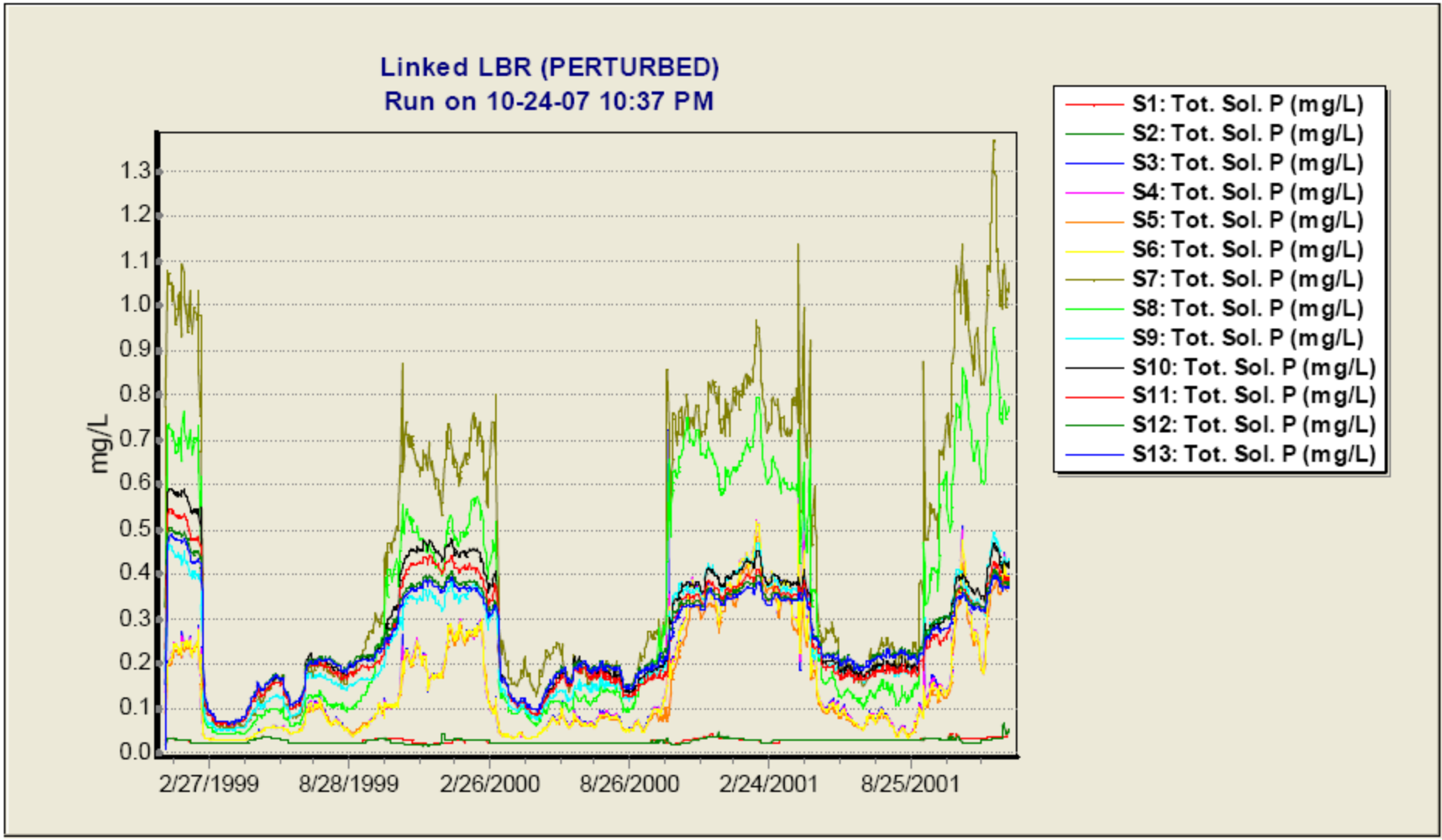
Middleton



Parma



TP for All Model Segments



Model Scenarios

Figure 5. Parma looking downstream toward confluence with Snake River.

Some Results

- Selected Scenarios:
  - 1: Current (calibrated) conditions
  - 3: DEQ-adopted Implementation Plan
  - 8: Same as 3 with point sources to 0.07 mg/L
  - 9: Same as 3 with point sources to 0 mg/L
  - 2a: Current flows with DEQ-adopted IP and 37% sediment reduction
  - 3a: Same as 3 with 37% sediment reduction

Figure 7b:

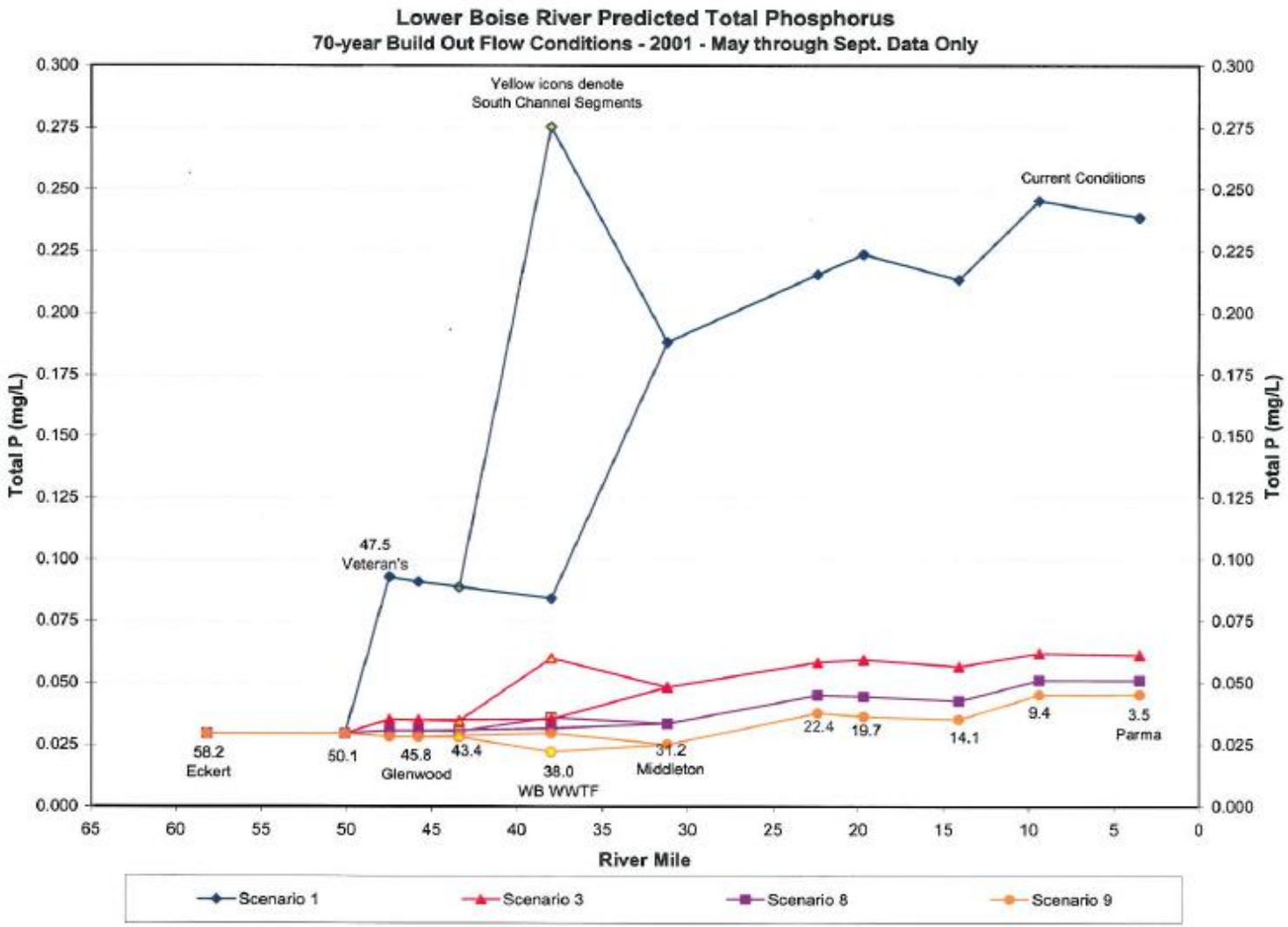
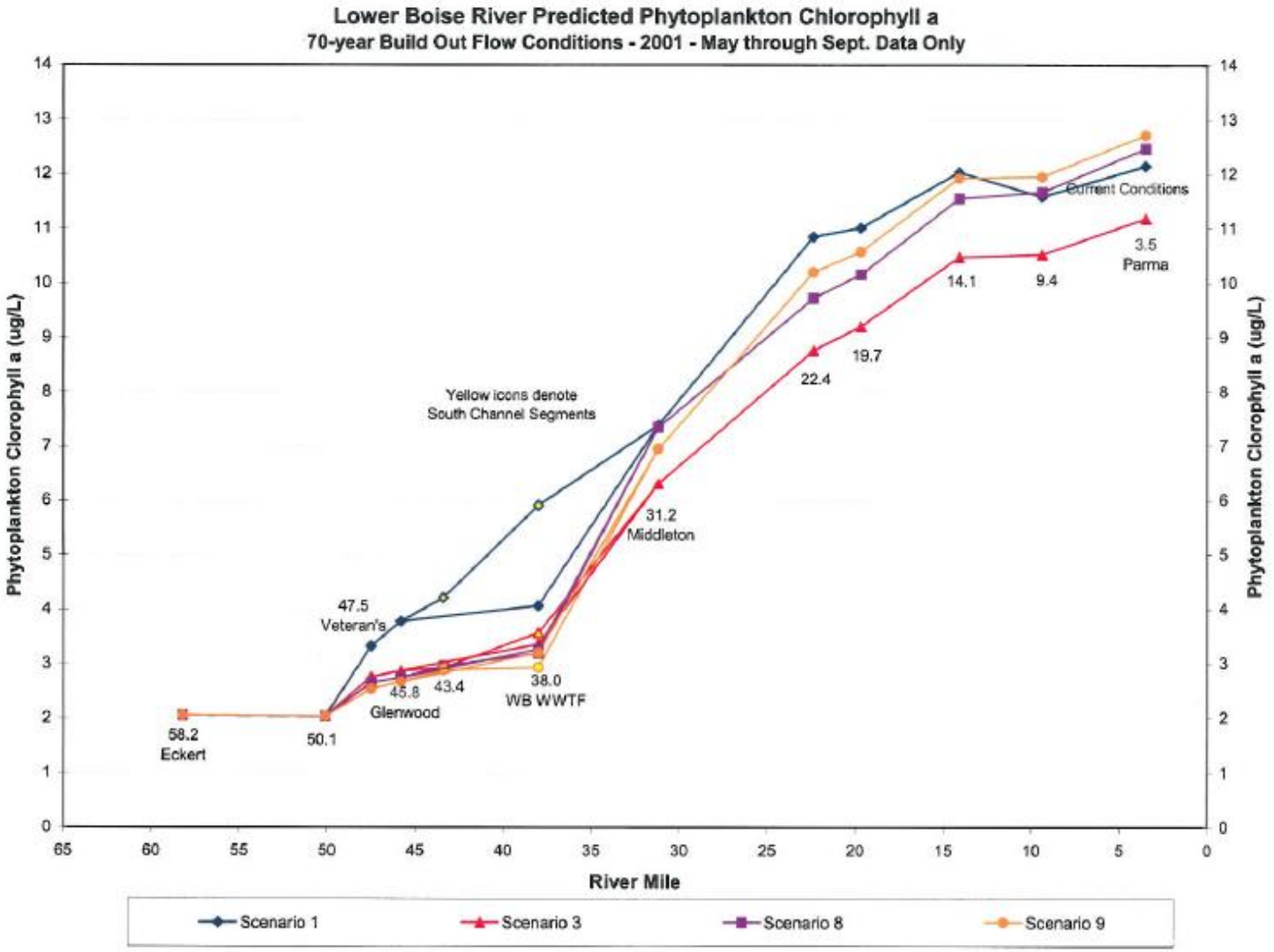

Lower Boise River Predicted Total Phosphorus
70-year Build Out Flow Conditions - 2001 - May through Sept. Data Only
Yellow icons denote
South Channel Segments
Current Conditions
47.5
Veteran's
58.2
Eckert
50.1
45.8
Glenwood
43.4
38.0
WB WWTF
31.2
Middleton
22.4
19.7
14.1
9.4
3.5
Parma
Total P (mg/L)
River Mile
Scenario 1
Scenario 3
Scenario 8
Scenario 9

Figure 7g:


Lower Boise River Predicted Phytoplankton Chlorophyll a
70-year Build Out Flow Conditions - 2001 - May through Sept. Data Only
Phytoplankton Clorophyll a (ug/L)
River Mile
Yellow icons denote
South Channel Segments
Current Conditions
58.2
Eckert
50.1
47.5
Veteran's
45.8
Glenwood
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3.5
Parma
Scenario 1
Scenario 3
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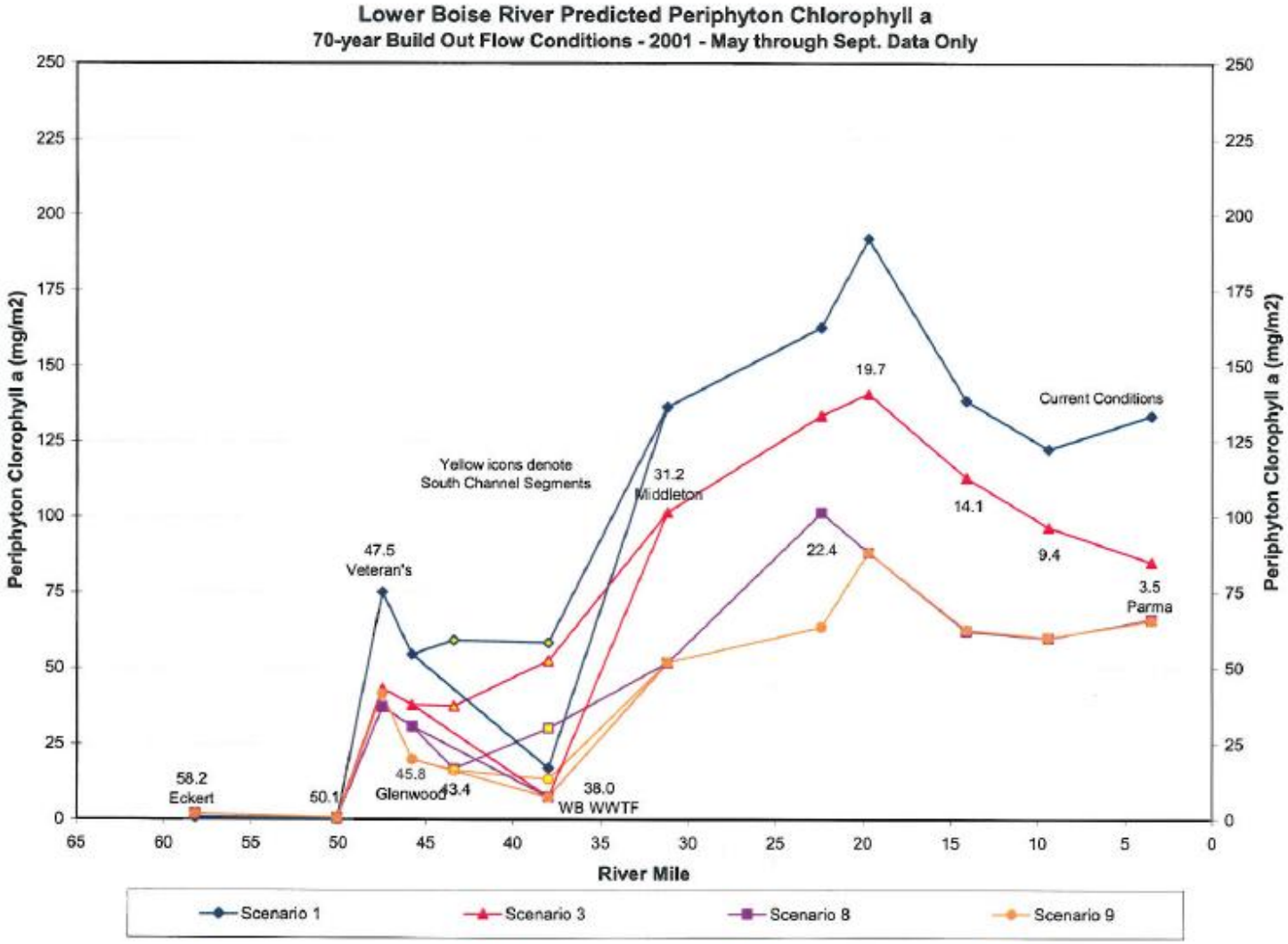
Scenario 9

Figure 7J:


Lower Boise River Predicted Periphyton Chlorophyll a
70-year Build Out Flow Conditions - 2001 - May through Sept. Data Only
Periphyton Clorophyll a (mg/m2)
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Yellow icons denote
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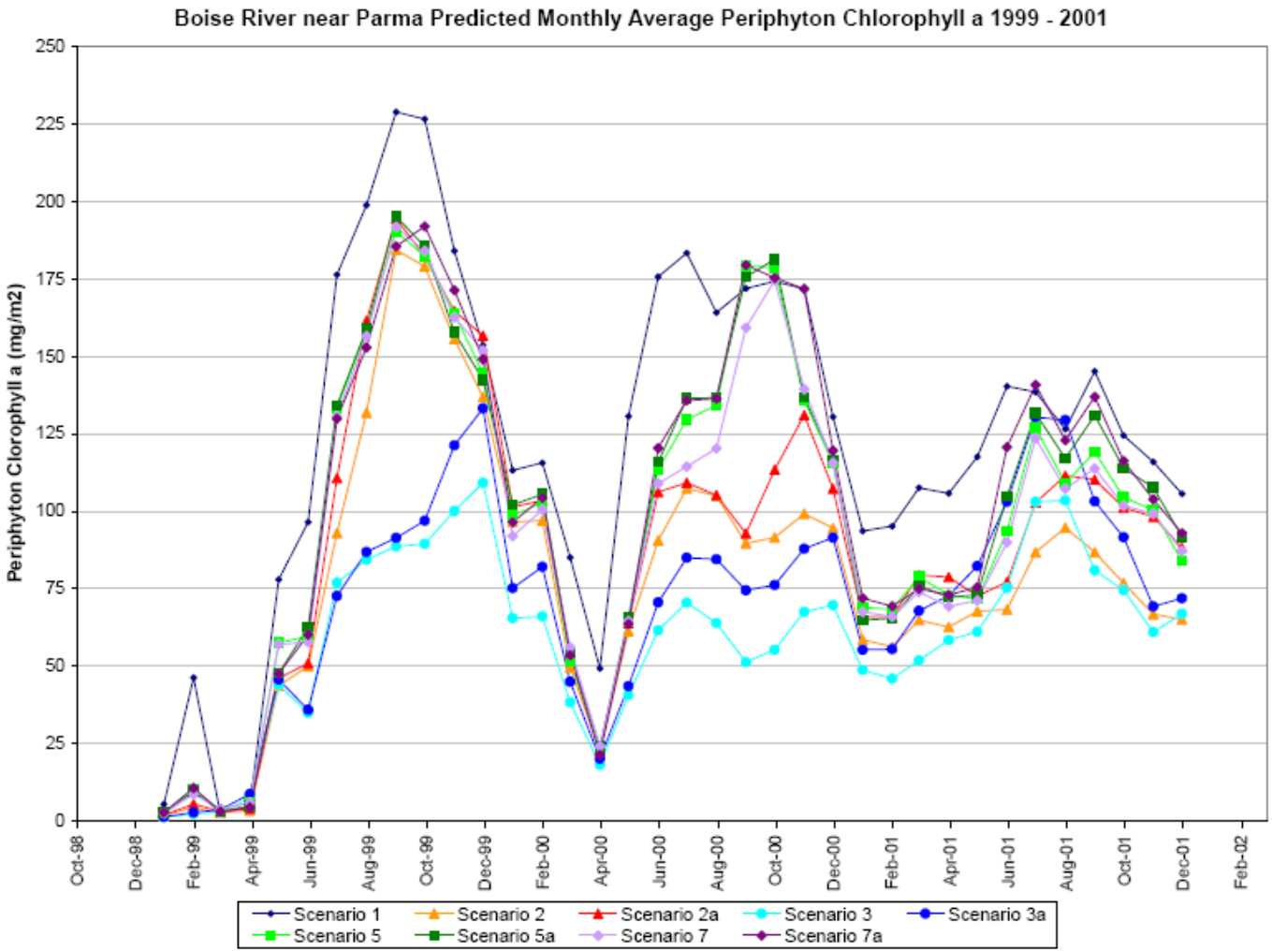
3.5
Parma
Current Conditions
Scenario 1
Scenario 3
Scenario 8
Scenario 9

Effect of 37% TSS Reduction at Parma



Other Key Findings Related to LBR Water Quality

- Phytoplankton chlorophyll concentration is now and will be ~ 15 ug/L at most sensitive location (Parma), even with sediment TMDL reduction goals met
- Periphyton chlorophyll will be less than 150 mg/sq.m at most sensitive location (Middleton) even during low flow year
  - 150 mg/sq.m is recent criterion developed by Montana (needs to be evaluated further for LBR)

Potential Application of AQUATOX for Nutrient Criteria for LBR

Montana Criterion

- 150 mg/m2 (with allowance for statistical exceedances)

Montana Survey Results

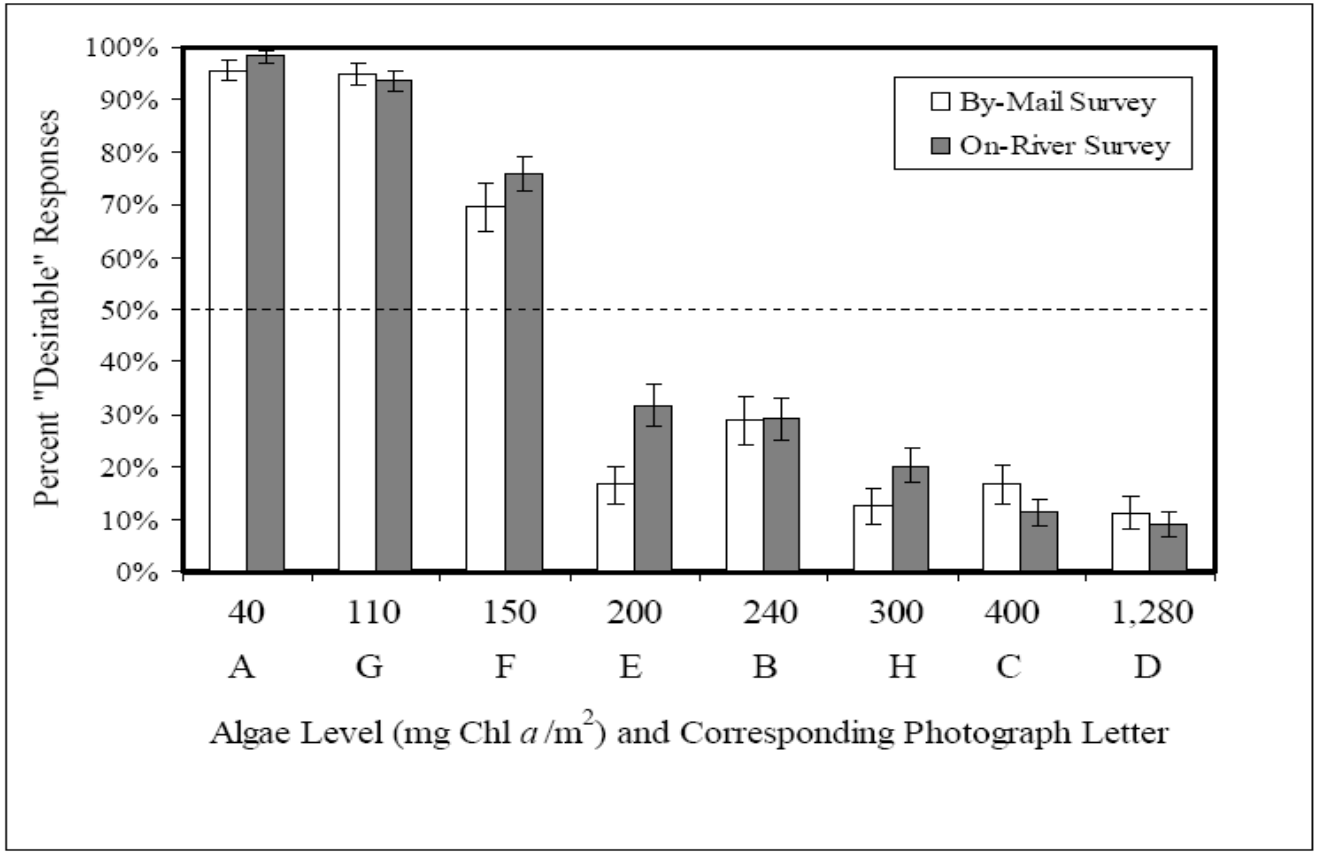
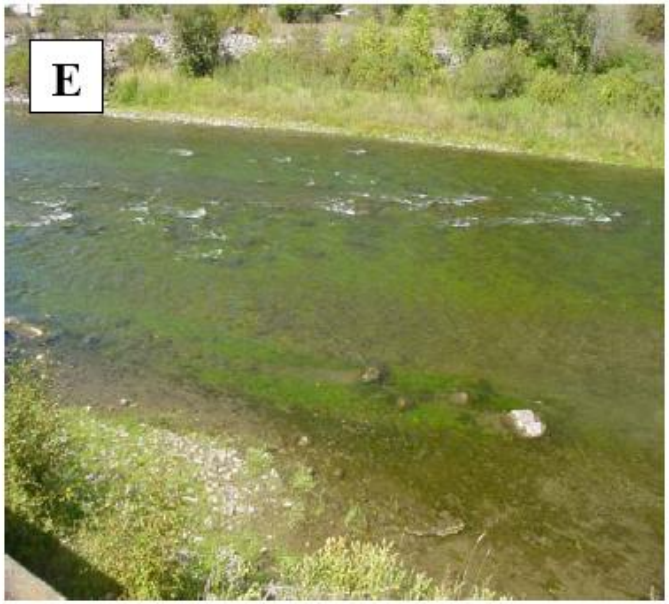
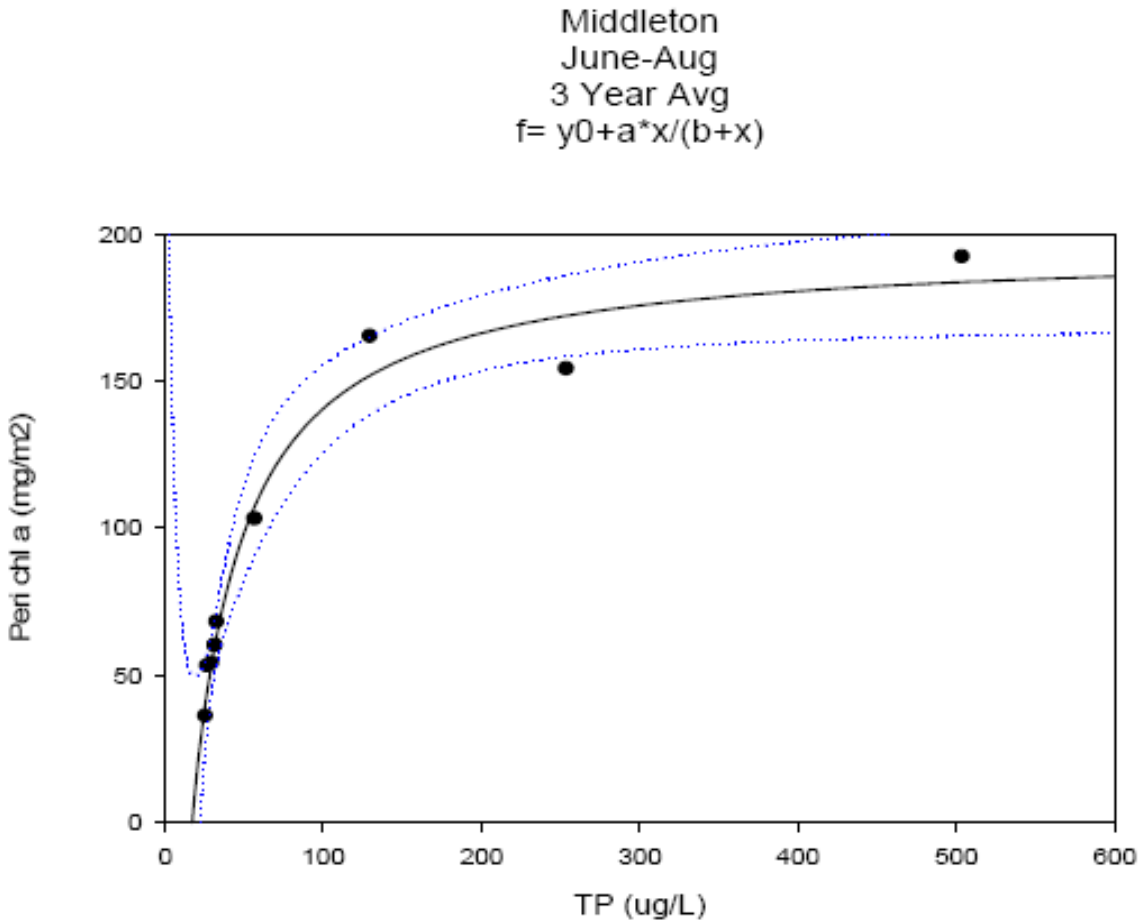


Figure 2. Percent Desirable Responses from the By-Mail and On-River Surveys. Letters designating the survey photographs are sequenced from lowest to highest algae level. Error bars are the 95% confidence level of each proportion, expressed as percent error.

Montana Survey Pics



Potential Application to LBR



Potential Application to LBR

Table 6-1. Aquatox Predicted TP concentration (µg/L) to Achieve Periphyton Chlorophyll *a* Level of 150 mg/m^2				
Water Year and Location	Season			
	May-Sep.	May-Nov.	Oct.-Nov.	Jun.-Aug.
Three-Year (1999 to 2001) Average				
Middleton	160	361	N/A	124
Parma	351	297	208	315