Water Quality Criteria:
Nutrient Conundrum

Module Outline

- 1. History of the Nutrient Criteria Program
- 2. CA Nutrient Numeric Endpoint (NNE) Framework
- 3. Klamath River NNE Case Study
- 4. Stream and Wetlands Policy – Protecting Physical Integrity (Livsey)

Key Take Home Messages

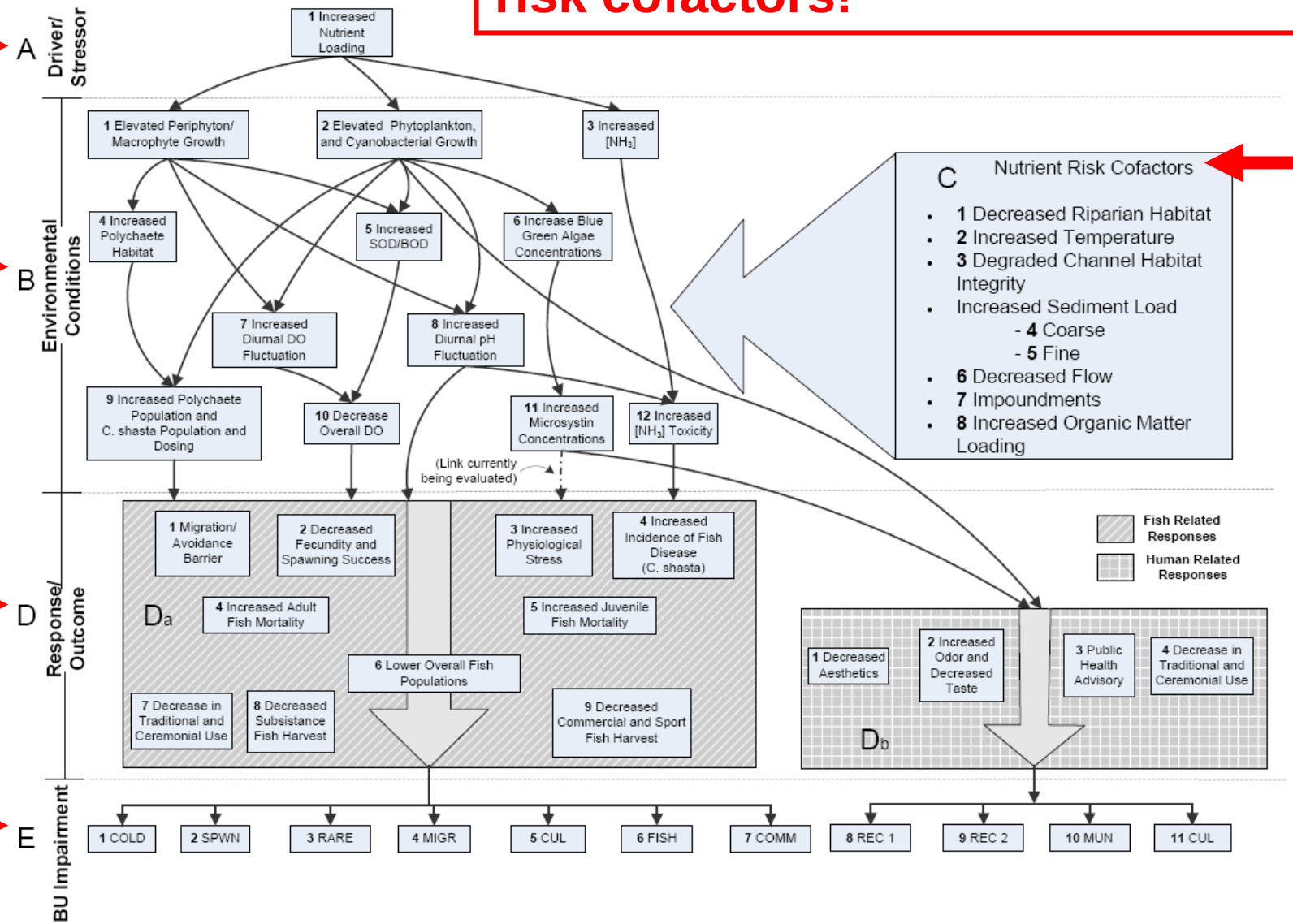
- **Nutrient (phosphorus and nitrogen) related impairments are pervasive;**
- **Numeric Nutrient Criteria provide quantifiable targets for incorporation into NPDES Permits and TMDLs;**
- **Nutrients are not inherently toxic, therefore are “unique” as pollutants, and require a unique approach;**

Key Messages

- Nutrients, which are necessary for aquatic life, generally don't cause impairment, it's the secondary impacts (e.g., low DO) that cause concern.
- "Excess" concentrations of nutrients vary by waterbody type, climate, geologic areas, and other local risk cofactors (e.g., degraded riparian).
- Therefore, Nutrient Criteria cannot be developed as a single number for the Nation due to variability in background conditions and the role of other risk co-factors which affect nutrient processing within ecosystems.

Key Messages

Nutrients have a complex and nonlinear relationship to Beneficial Uses that is influenced by other risk cofactors!



Key Messages

- Nutrient related impacts are many and varied:
  - Algal blooms (scum);
  - Low dissolved oxygen;
  - Extreme pH conditions;
  - Fish disease & fish kills;
  - “Weeds” affecting boating and swimming;
  - Taste/odor; and
  - Additional relationships include: unionized ammonia; pathogens (e.g. microcystin); methyl mercury; arsenate; and trihalomethanes.

History of Nutrient Criteria

- Nutrients (Nitrogen and Phosphorus) were consistently one of the top pollutants on the CWA Section 303(D) Lists to Congress Reports beginning in the early 1990's.
- The "Nutrient Criteria Program" was initiated in 1995.
- 1998 – The "National Strategy for the Development of Nutrient Criteria" identified need for numeric targets to measure effectiveness of watershed management programs

Initial EPA Nutrient Mission

- **Principal Goal: Develop Nutrient Criteria across the nation in 3 years.**
- **Criteria needed to address nutrient pollution, not natural enrichment.**
- **Primary Parameters: Total P, Total N, Chlorophyll-a and some measure of water clarity (e.g., Secchi disk depth, turbidity)**
- **Types: Numeric criteria, or narrative with numeric translator**

Primary Concepts

- Tailor criteria by nutrient ecoregion and waterbody type
- Identify minimally impacted conditions (reference)
- Address causal and response variables
- Utilize local expertise, as in Regional Technical Advisory Groups (RTAGs), or other locally available experts

CA Ecoregions

01 Coast Range

04 Cascades

05 Sierra Nevada

06 Southern & Central CA Chaparral & Oak Woodlands

07 Central CA Valley

08 So. CA Mountains

09 Eastern Cascades Slopes & Foothills

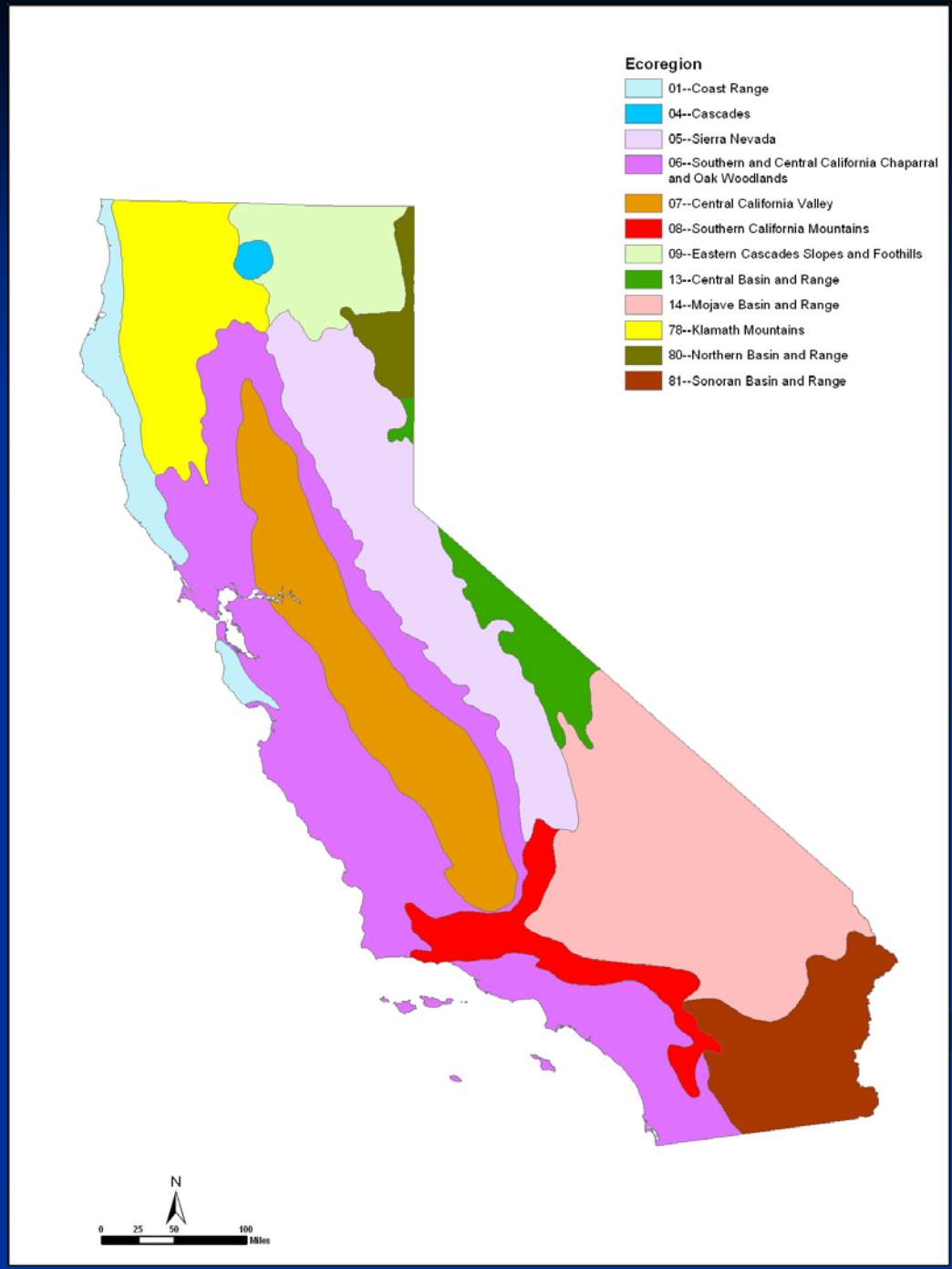
13 Central Basin & Range

14 Mojave Basin & Range

78 Klamath Mountains

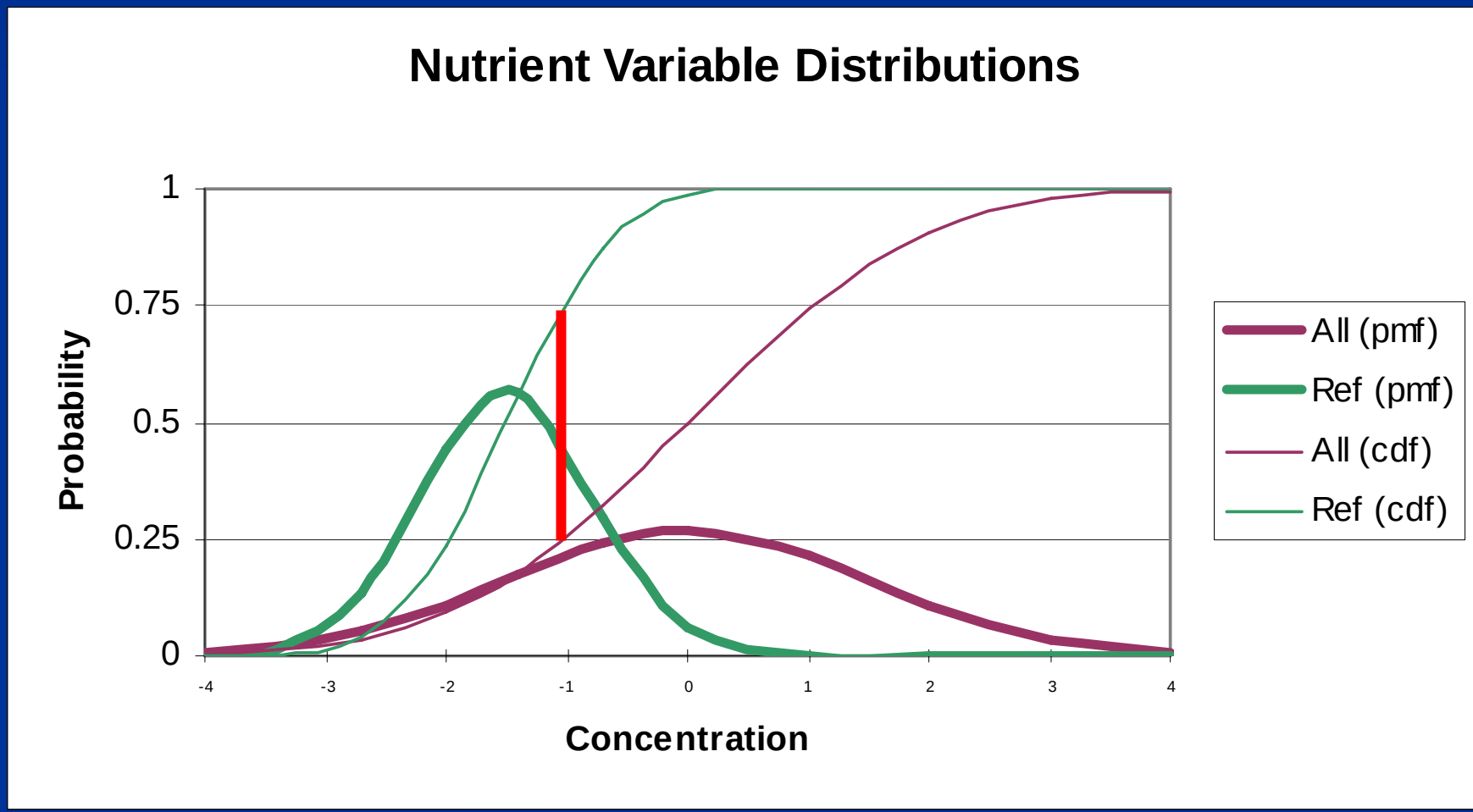
80 Northern Basin & Range

81 Sonoran Basin & Range



Distributional Approach

The 25th or 75th percentiles were an estimate of reference conditions – protective of all uses.



Shift in Policy

- **EPA Responded in 2001 with a policy of "flexibility", encouraging states to use different approaches.**
- **Many states adopted a "stressor-response" approach, where they began extensive field studies to identify the algal (diatom and periphyton) responses to N and P.**

CA Nutrient Numeric Endpoints

- Regional Technical Advisory Group initiated in 1999 to collaboratively develop nutrient criteria – all Regional Boards participated
- Studies undertaken to evaluate alternative options
- Existing approach adopted by Regional Boards and other participating agencies
  -- still under development but basic framework is in place.

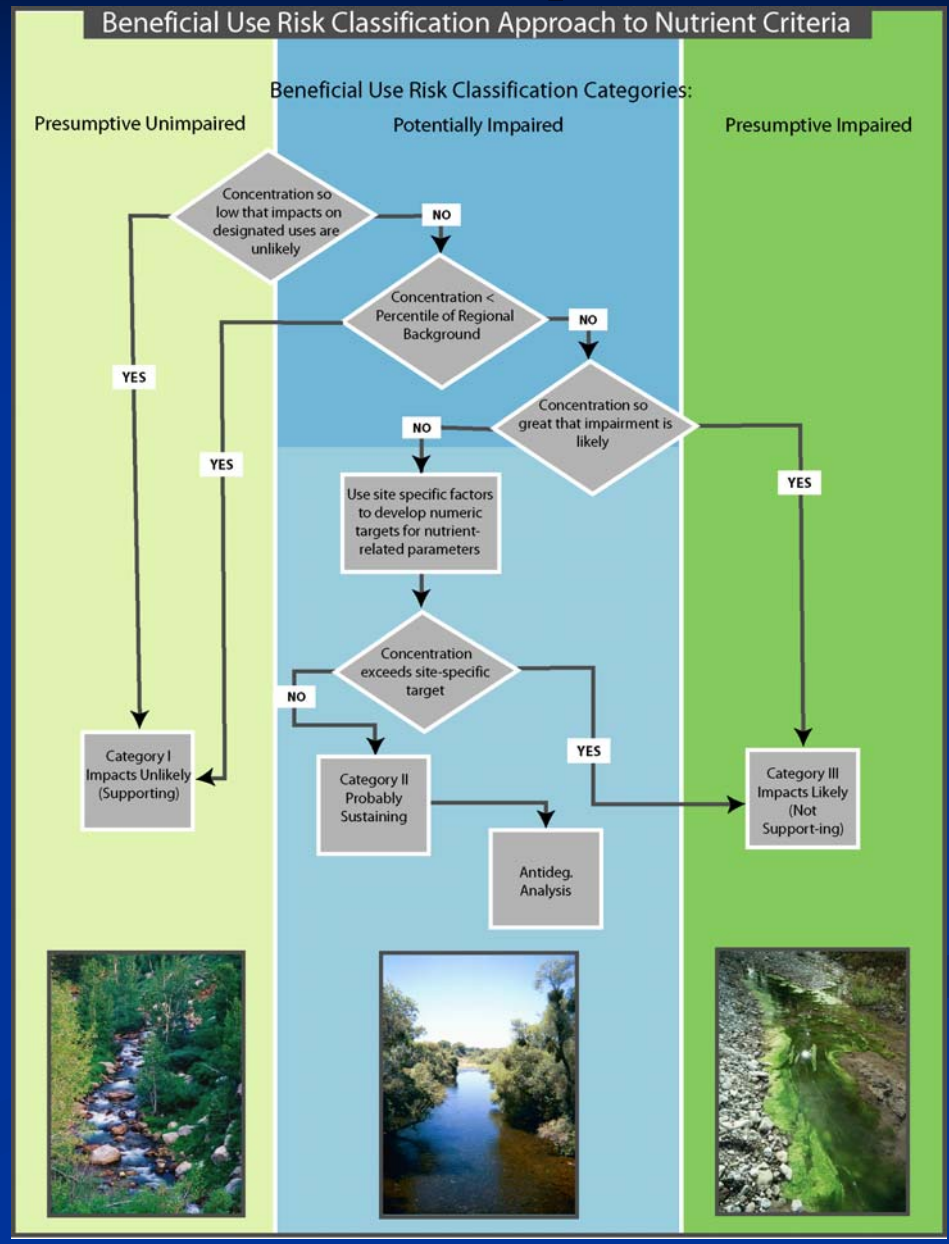
CA Nutrient Numeric Endpoints

Decision framework includes:

- **Risk Based Approach: targets for response variables / secondary indicators – benthic algal biomass, DO, pH**
- **Beneficial Use Risk Categories: (BURCs) BURC 1 – Presumptive Unimpaired; BURC 2 – Potentially Impaired; BURC 3 – Presumptive Impaired**
- **Spreadsheet tools: convert response variable limits (secondary indicator targets) to initial site-specific nutrient concentration goals.**

CA Nutrient Numeric Endpoints

- No clear scientific consensus on precise levels so…….
- Category I: Presumptively Unimpaired
- Category II: Potentially Impaired
- Category III: Presumptively Impaired



Example 303(d) Screening BURC Boundaries

RESPONSE VARIABLE	BURC BOUNDARY	BENEFICIAL USE						
		COLD	WARM	REC-1	REC-2	MUN	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-*a*/m^2) Maximum	I / II	100	150	C	C	100	100	B
	II / III	150	200	C	C	150	150	B
Planktonic Algal Biomass in Lakes and Reservoirs (as µg/L Chl-*a*) summer mean	I / II	5	10	10	10	5	A	B
	II / III	10	25	20	25	10	A	B

A = No direct linkage

B= More research needed to quantify linkage

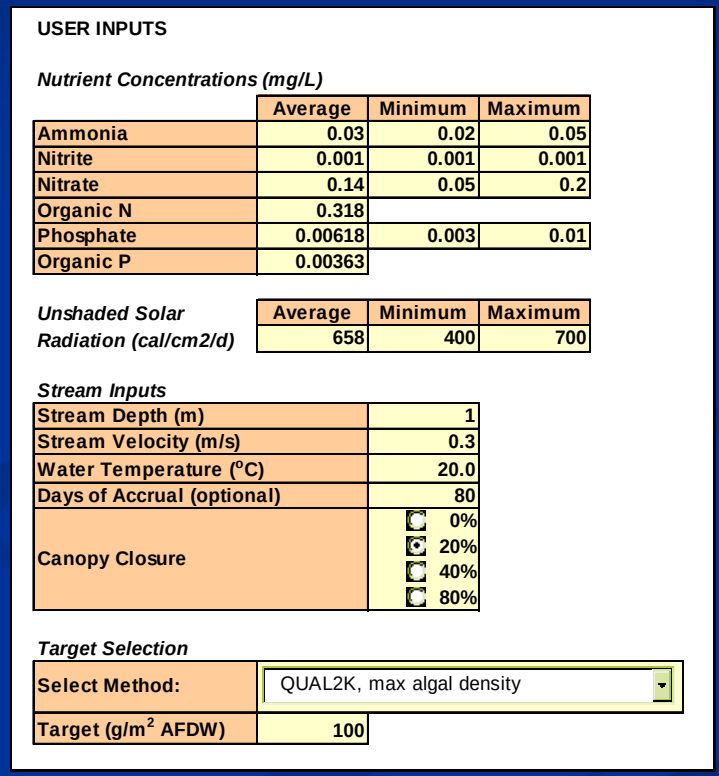
C= Addressed by existing Aquatic Life Criteria

NNE Scoping Tools & Lines of Evidence

- **Spreadsheet tools to convert response variable limits (*targets*) to site-specific nutrient concentration *goals* – used for initial screening – defer to more complete modeling / monitoring studies**
- **Account for exogenous factors**
- **Works for a subset of secondary indicators**
- **Lines of evidence, tools are one component**

Spreadsheet Tools for Estimating Nutrient Concentrations

- **Lakes & Reservoirs: (phytoplankton chl-a) BATHTUB**
- **Streams & Rivers: (benthic algal biomass) various options - QUAL2K, Dodds**



USER INPUTS

Nutrient Concentrations (mg/L)

	Average	Minimum	Maximum
Ammonia	0.03	0.02	0.05
Nitrite	0.001	0.001	0.001
Nitrate	0.14	0.05	0.2
Organic N	0.318		
Phosphate	0.00618	0.003	0.01
Organic P	0.00363		

Unshaded Solar Radiation (cal/cm2/d)	Average	Minimum	Maximum
	658	400	700

Stream Inputs

Stream Depth (m)	1
Stream Velocity (m/s)	0.3
Water Temperature (°C)	20.0
Days of Accrual (optional)	80
Canopy Closure	○ 0% ◉ 20% ○ 40% ○ 80%

Target Selection

Select Method:	QUAL2K, max algal density
Target (g/m^2 AFDW)	100

CA Nutrient Numeric Endpoints
Regulatory Status

- **Estuarine Framework in Development**
- **Possible adoption options:**
  - **Narrative Nutrient Objectives with Nutrient Numeric Endpoint Framework adopted as implementation option.**
  - **Narrative Nutrient Objectives with default Beneficial Use Risk Category Boundaries and NNE Framework as implementation option.**
  - **Other?**

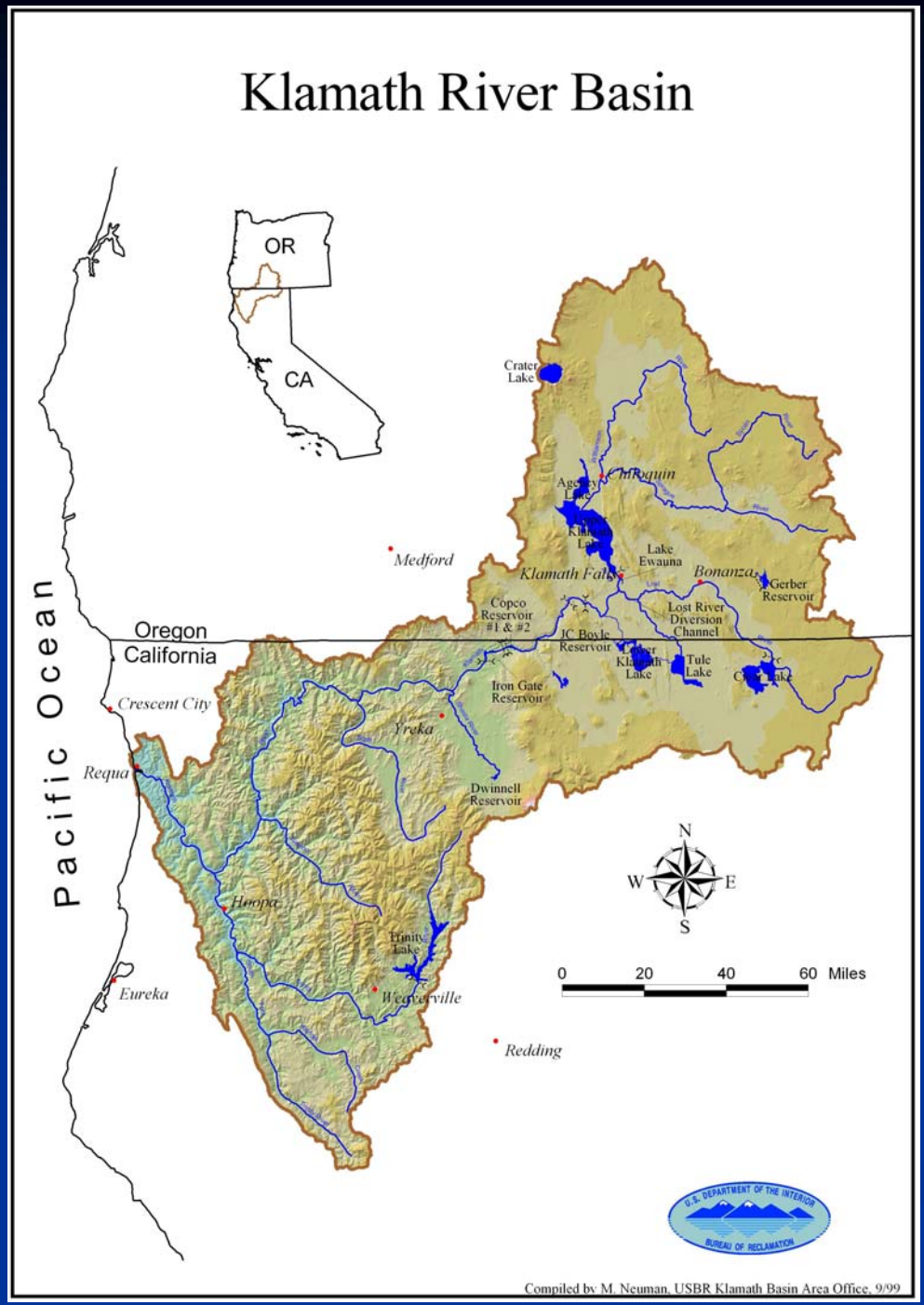
CA Nutrient Numeric Endpoints Next Steps

- Peer Review of five case studies
- Several TMDLs are being developed using the CA NNE
- Biomonitoring capabilities are being developed to expand lines of evidence
- Develop regional ranges for Beneficial Use Risk Categories
- Get EPA to check the Yes column!

Klamath River NNE Case Study

Upper Klamath Lake
Hanks Marsh

Klamath River
Entering Pacific Ocean



Klamath CA NNE Case Study

- Basin: 12,680 sq. Miles
- River ~250 miles
- Five dams
- Population 114,000
- 2/3 Federal land ownership
- Several Federally recognized Tribes
- TMDL listed tributaries

Klamath River Impairments

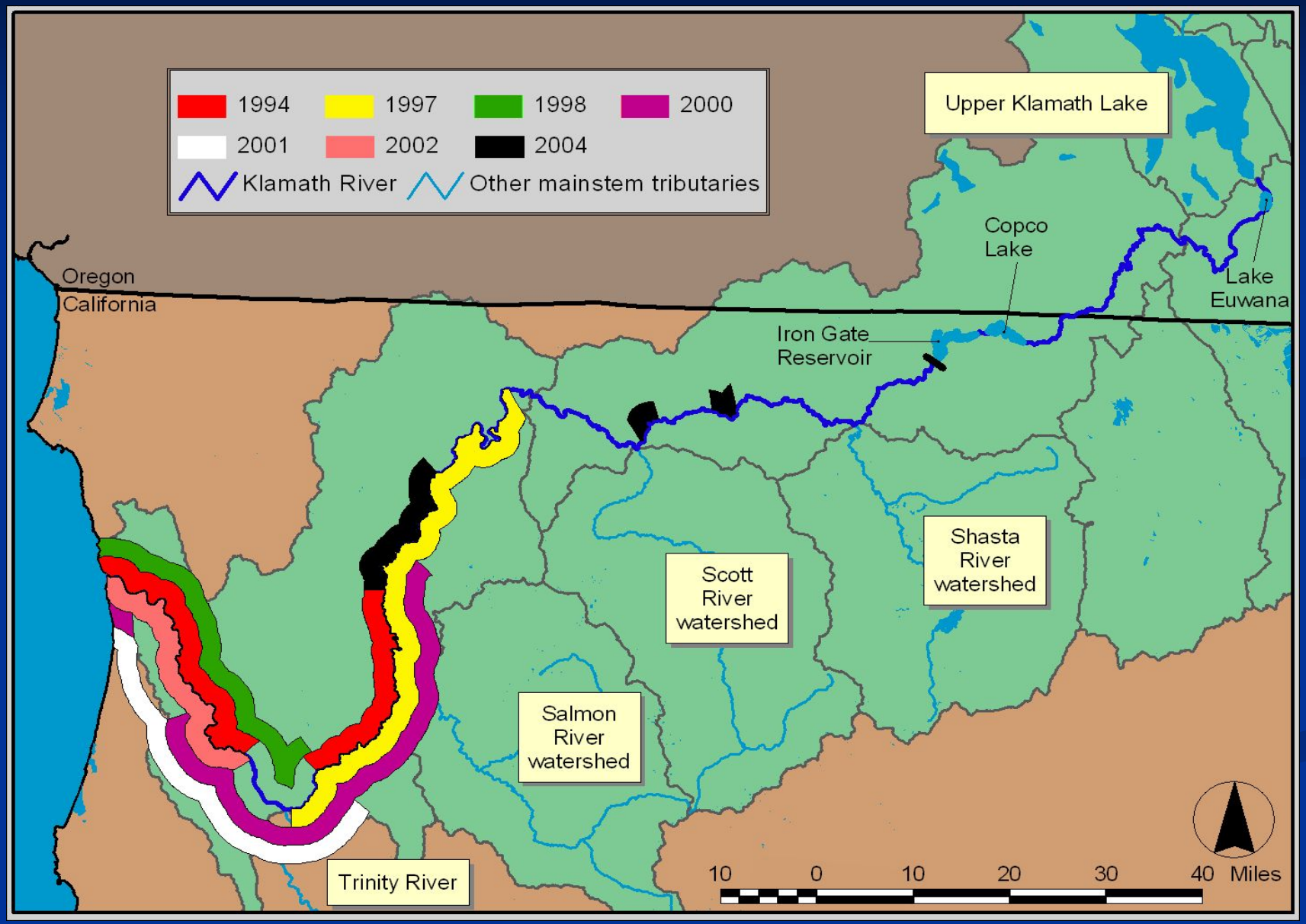
California

- Nutrients
- Organic enrichment
- DO / pH
- Temperature
- Microsystin toxins*

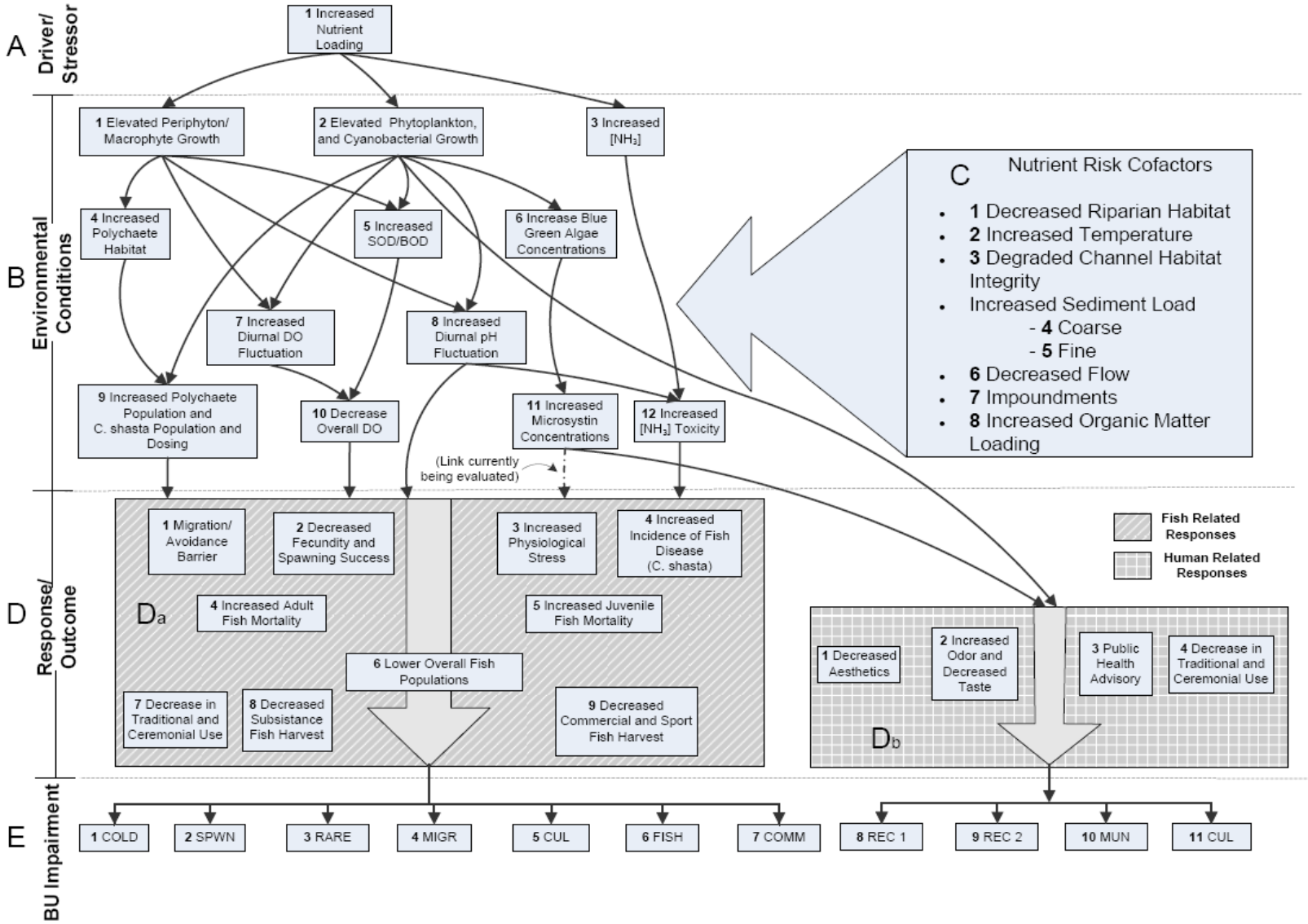
Oregon

- DO
- Chlorophyll a
- Temperature
- pH
- Ammonia

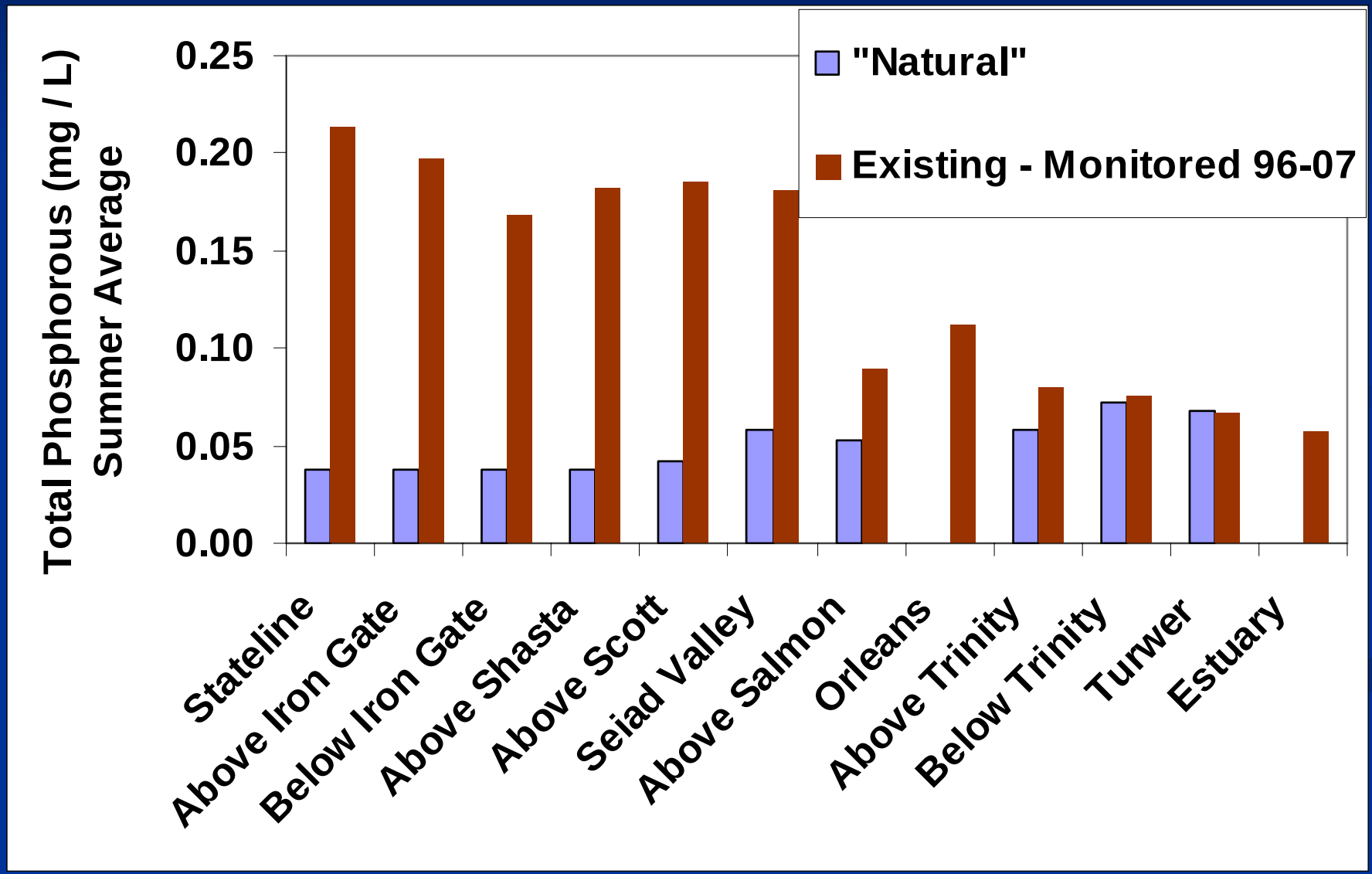
Klamath River Fish Kills



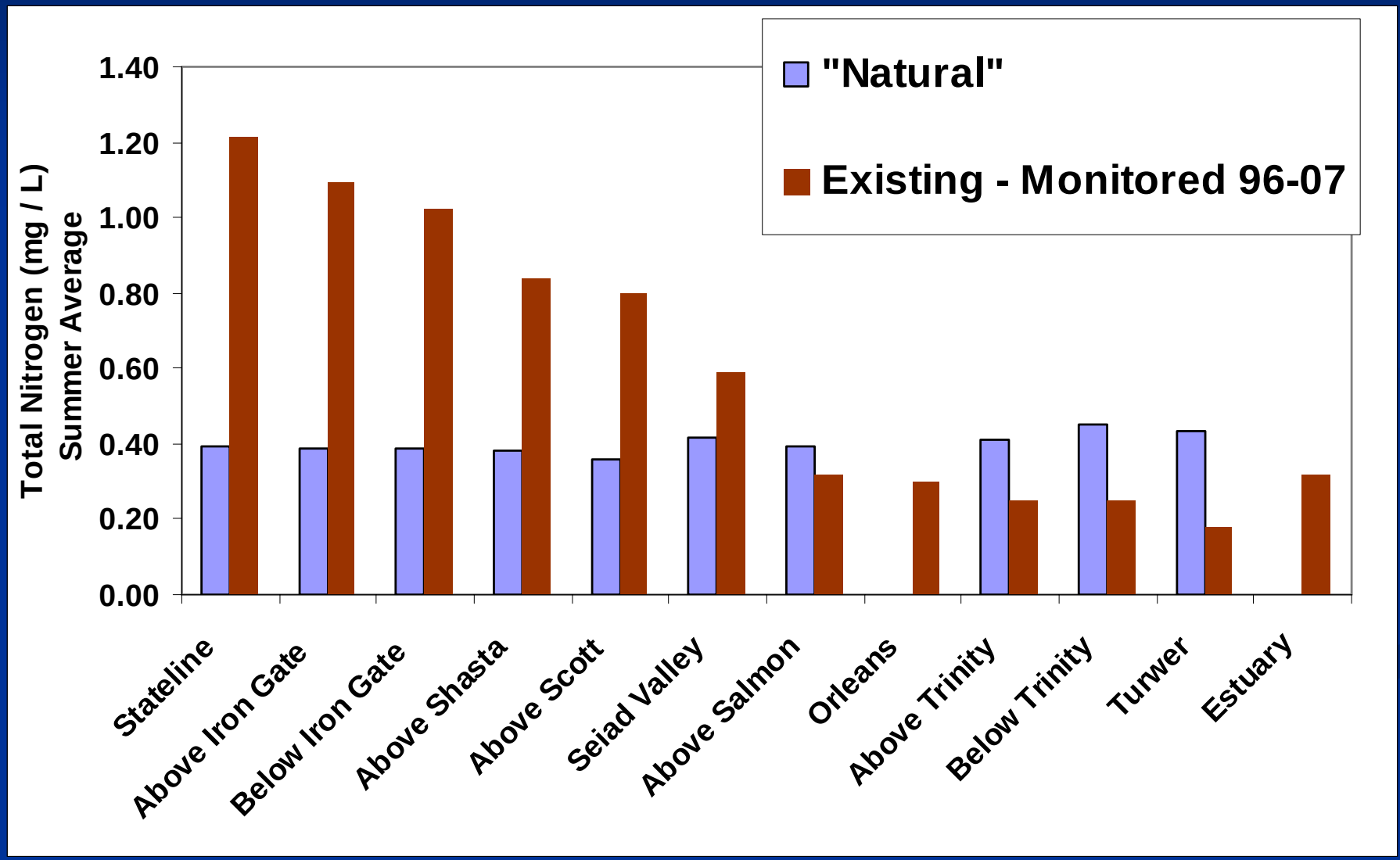
Klamath River – NNE Conceptual Model



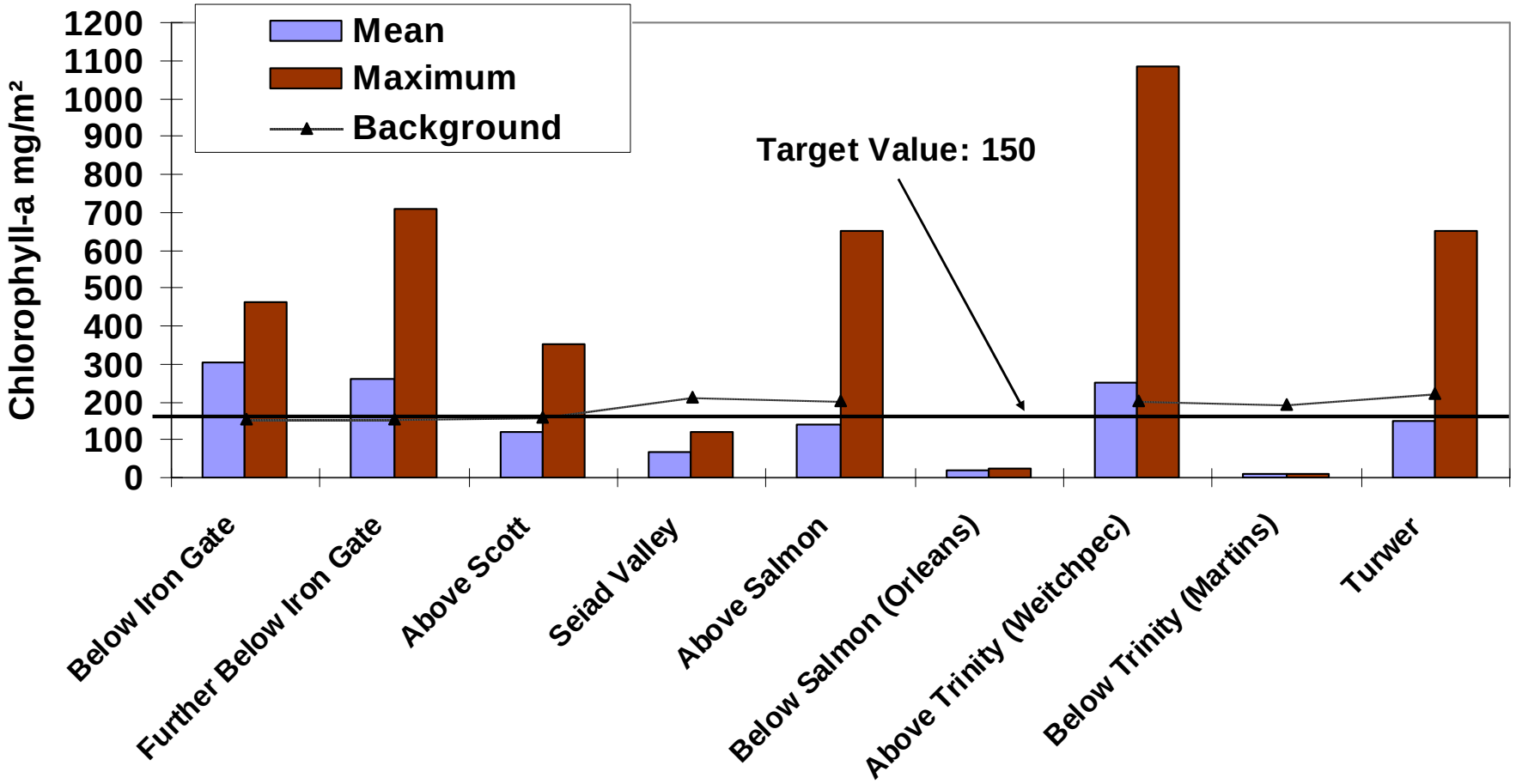
Klamath River – Nutrients



Klamath River - Nutrients

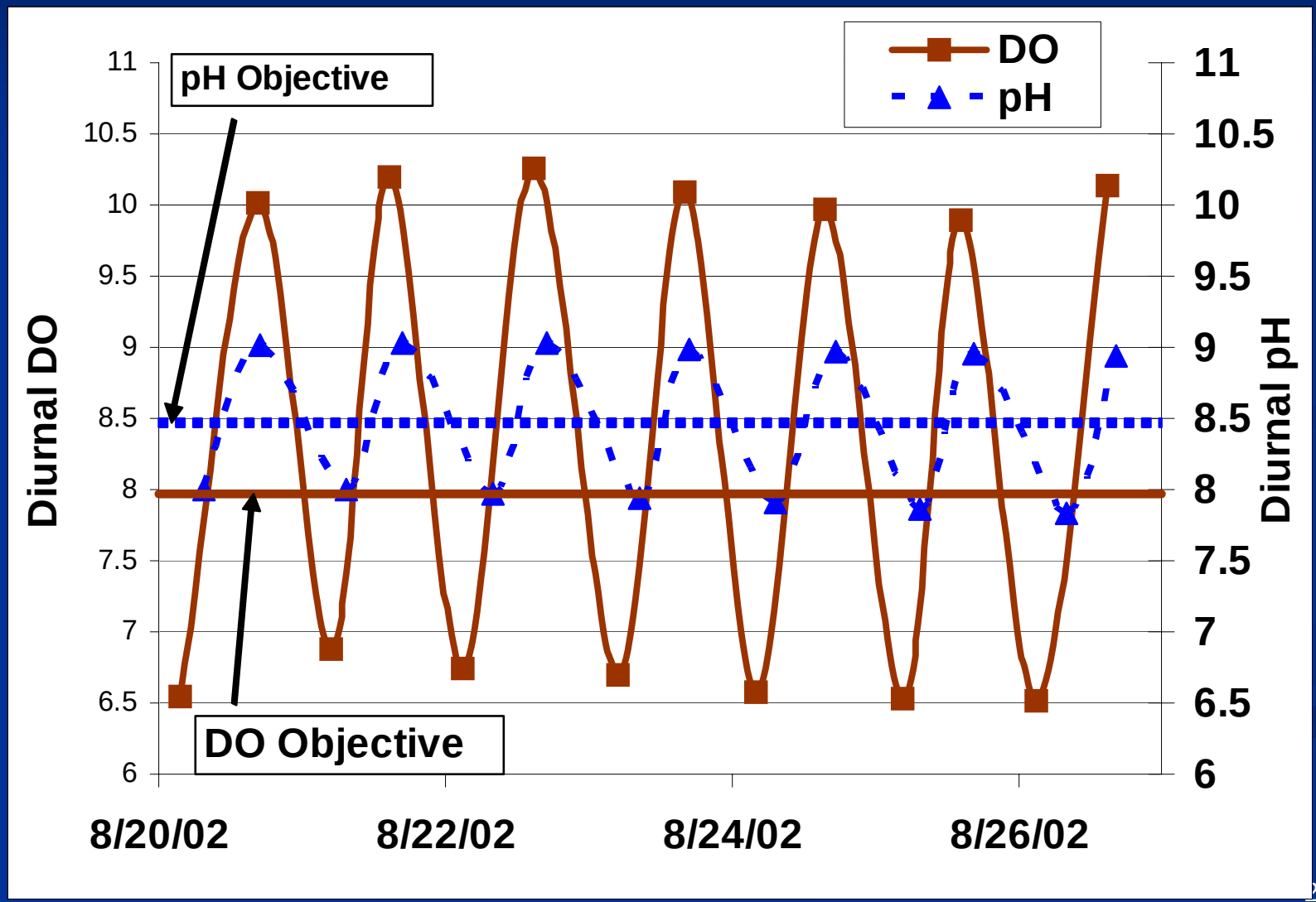


Klamath River - Periphyton



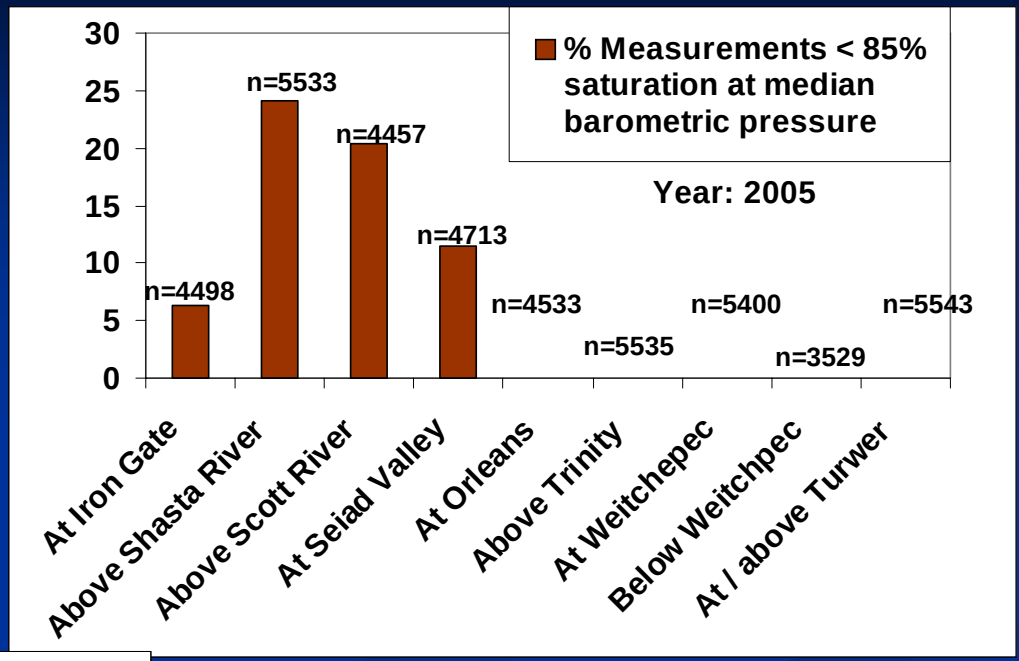
Klamath River – Diurnal DO & pH

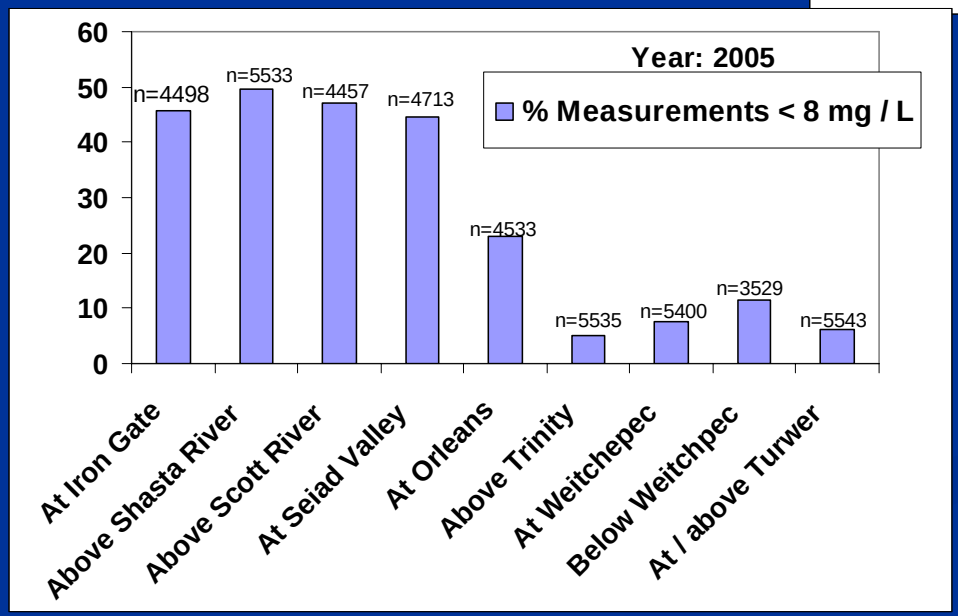
Seiad Valley – Typical Summer Diurnal Pattern



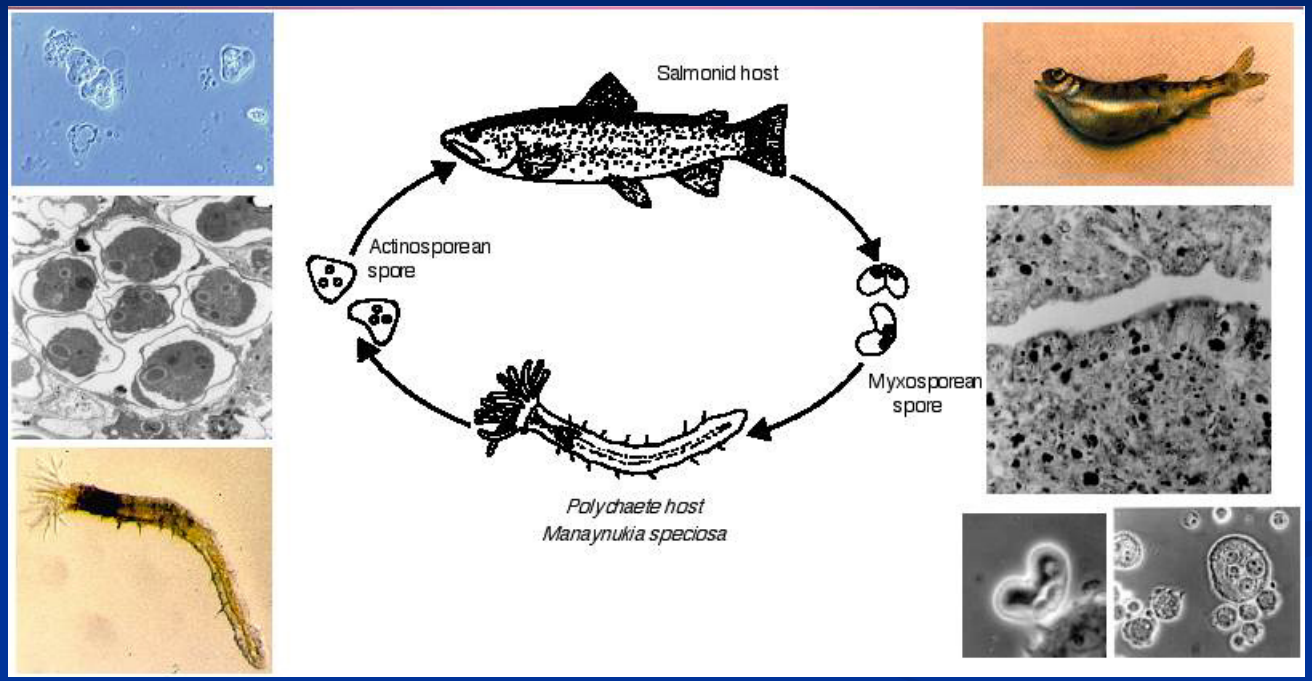
Klamath River - DO

Frequent violation of both existing and proposed DO Water Quality Objectives during summer months.





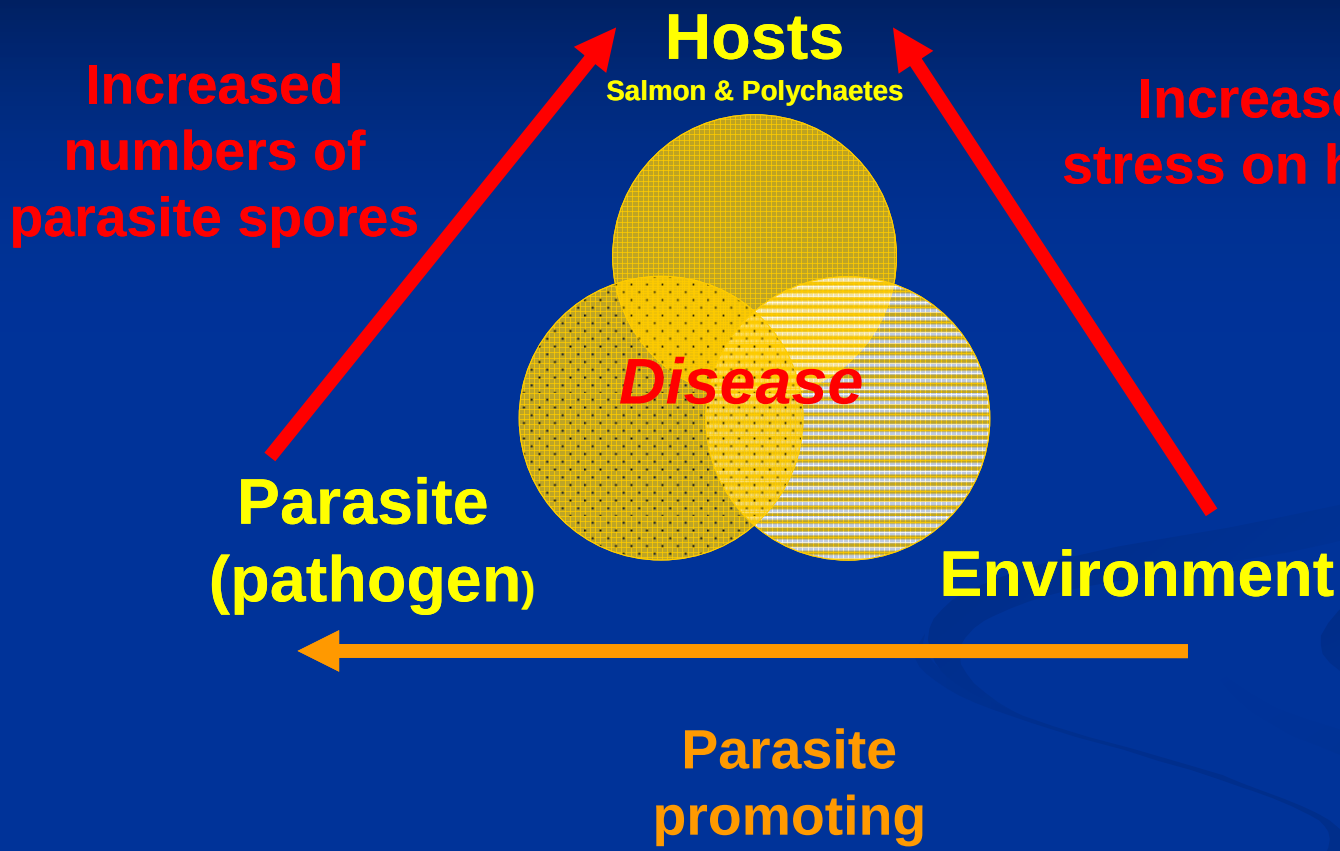
Klamath River – Fish disease



Life cycle of the parasite Ceratomyxa shasta:

- **The parasite is the primary fish health issue in the Klamath River according to USFWS**

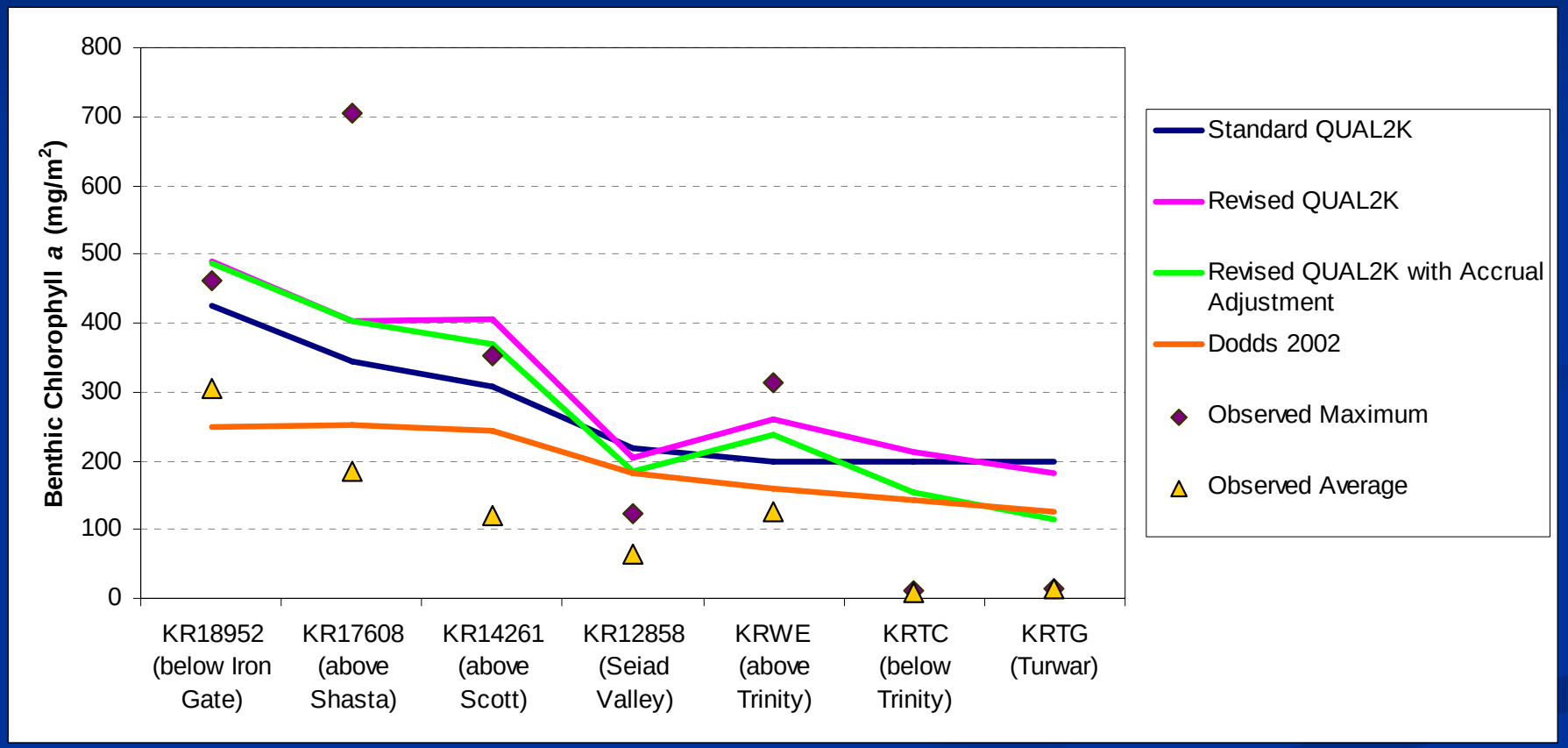
Klamath River – Fish disease



Severity of *Ceratomyxosis* in Klamath River suggests a shift in the host: parasite balance towards *C. shasta*

Klamath NNE Periphyton Biomass Target Analysis below Iron Gate

Predicted and Observed Maximum Chlorophyll *a* (mg /m2)

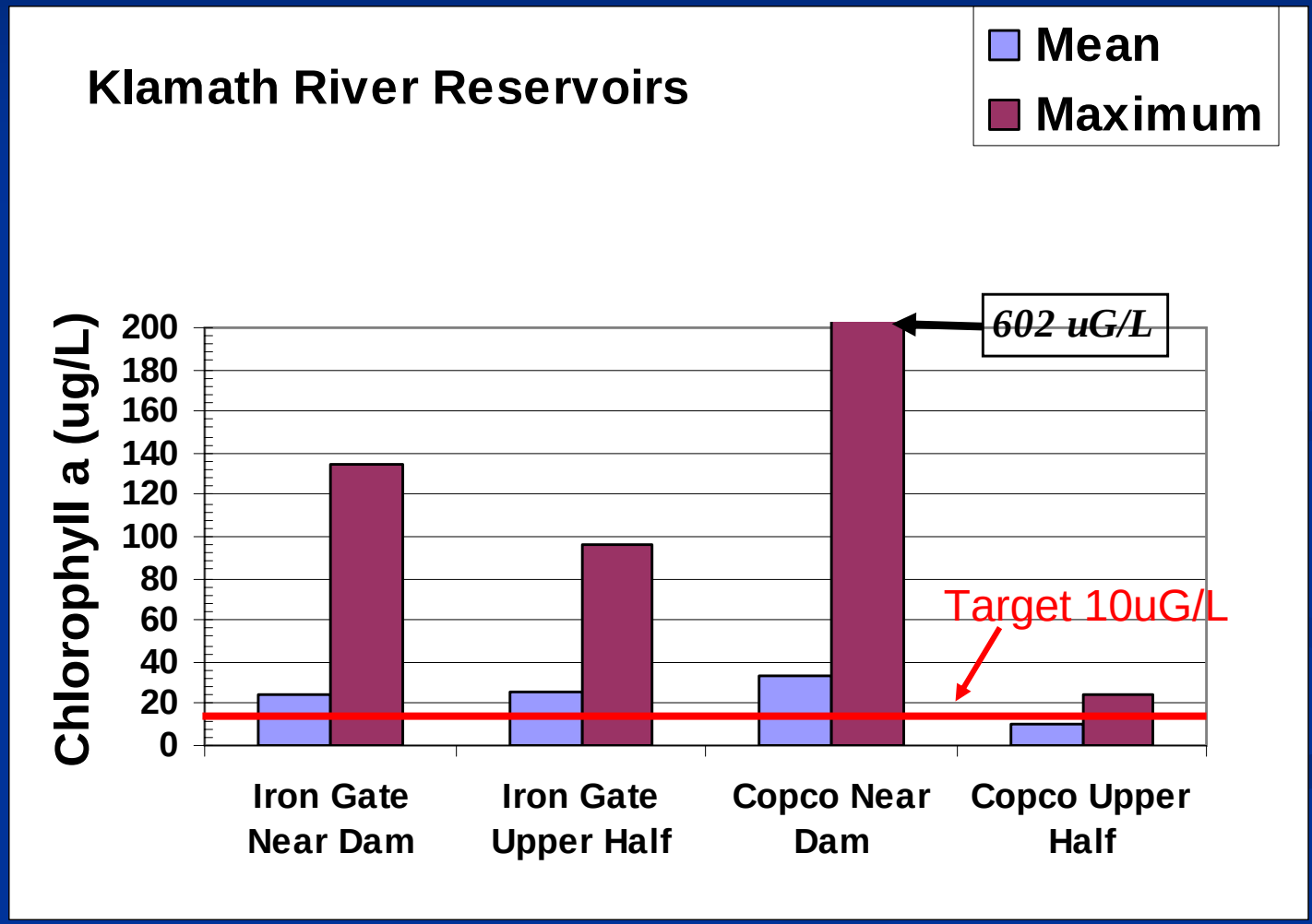


Note: Predicted maxima are spatial averages for reach. Observed data are point measurements. Data for 2004 sampling is shown.

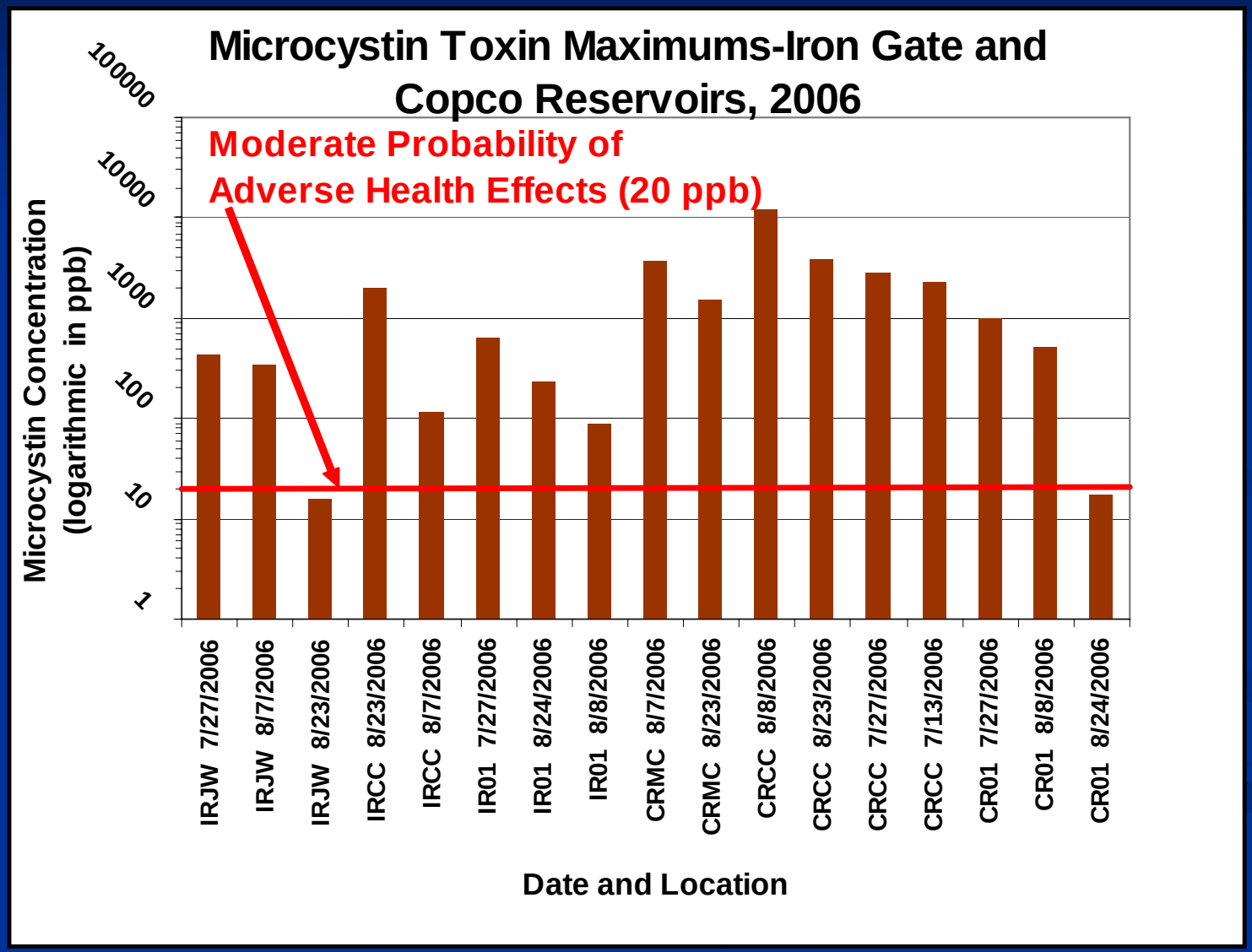
Estimated Reductions from 2005-2007 Levels to achieve 150 mg/m^2

Station	Percent Reduction	TN / TP Current	TN / TP Goal
Below Iron Gate	83% (N)	1.08 / 0.14	0.18 / 0.025
Above Shasta River	78% (N)	1.05 / 0.14	0.23 / 0.032
Above Scott River	70% (N)	0.94 / 0.16	0.28 / 0.039
@ Seiad Valley	21% (N)	0.56 / 0.091	0.44 / 0.061
Above Trinity River	30% (P)	0.24 / 0.056	0.28 / 0.039
Below Trinity River	-	0.21 / 0.050	0.41 / 0.057
@ Turwar	-	0.23 / 0.041	0.51 / 0.071

Klamath River (reservoirs) Chlorophyll a



Klamath River – Blue-green algae



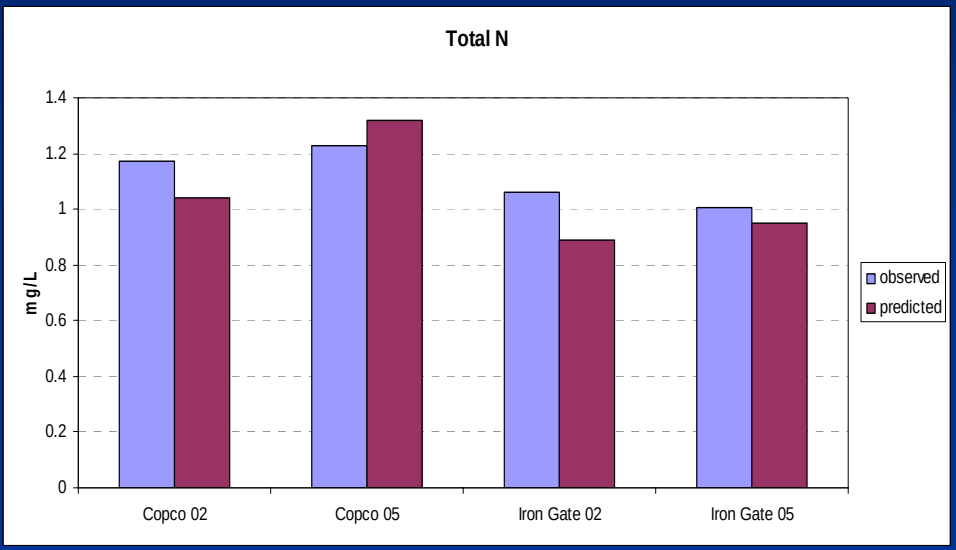
CA NNE Targets for Reservoirs

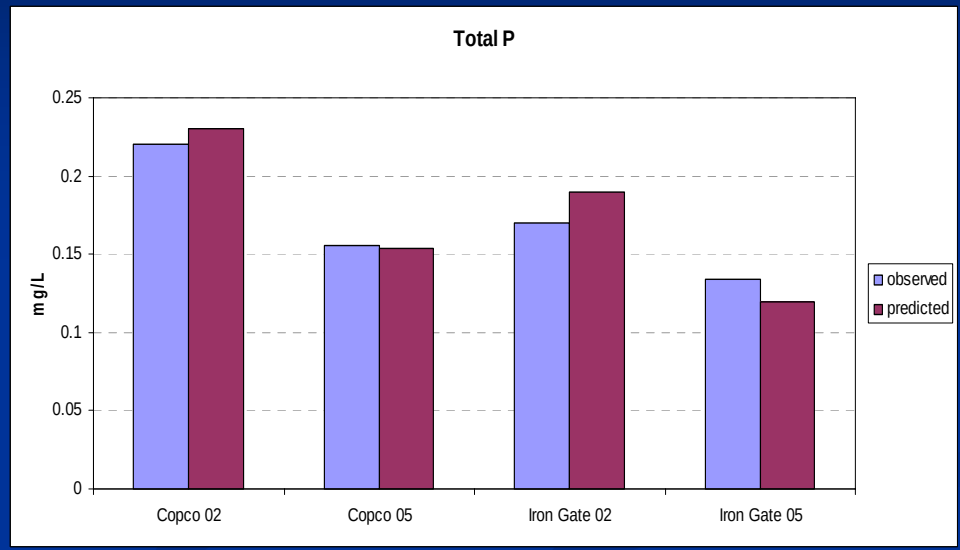
- **Proposed BURC II/III Boundary:**

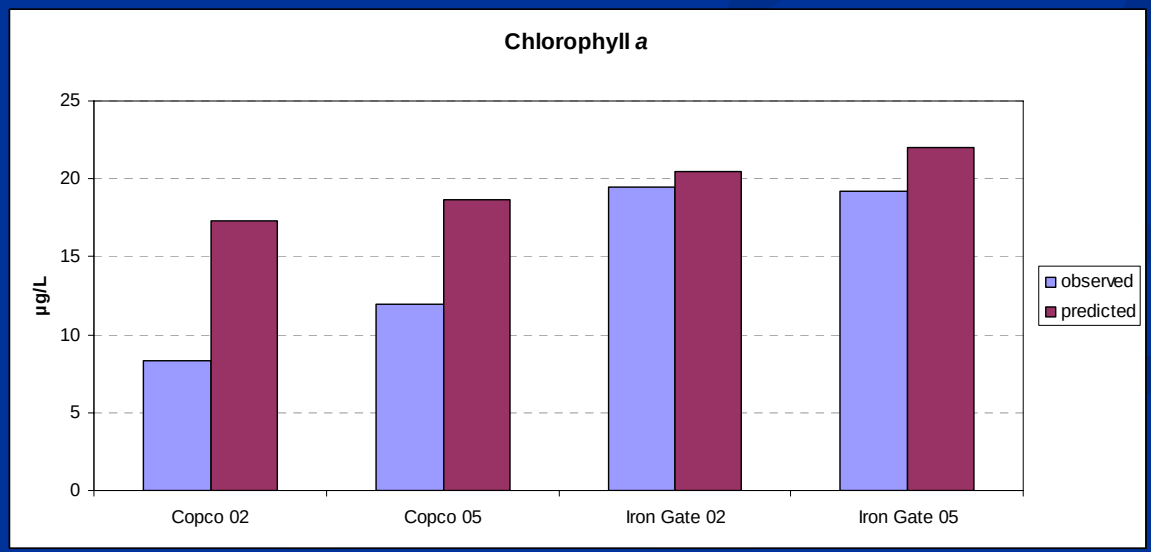
10 µg/L summer average chlorophyll *a*

- **Potential additional target: Reduced predicted cyanobacterial fraction of biomass to < 50% using regression equations relating BGI "blue green index" to TN and TP (see Downing et al., 2001)**

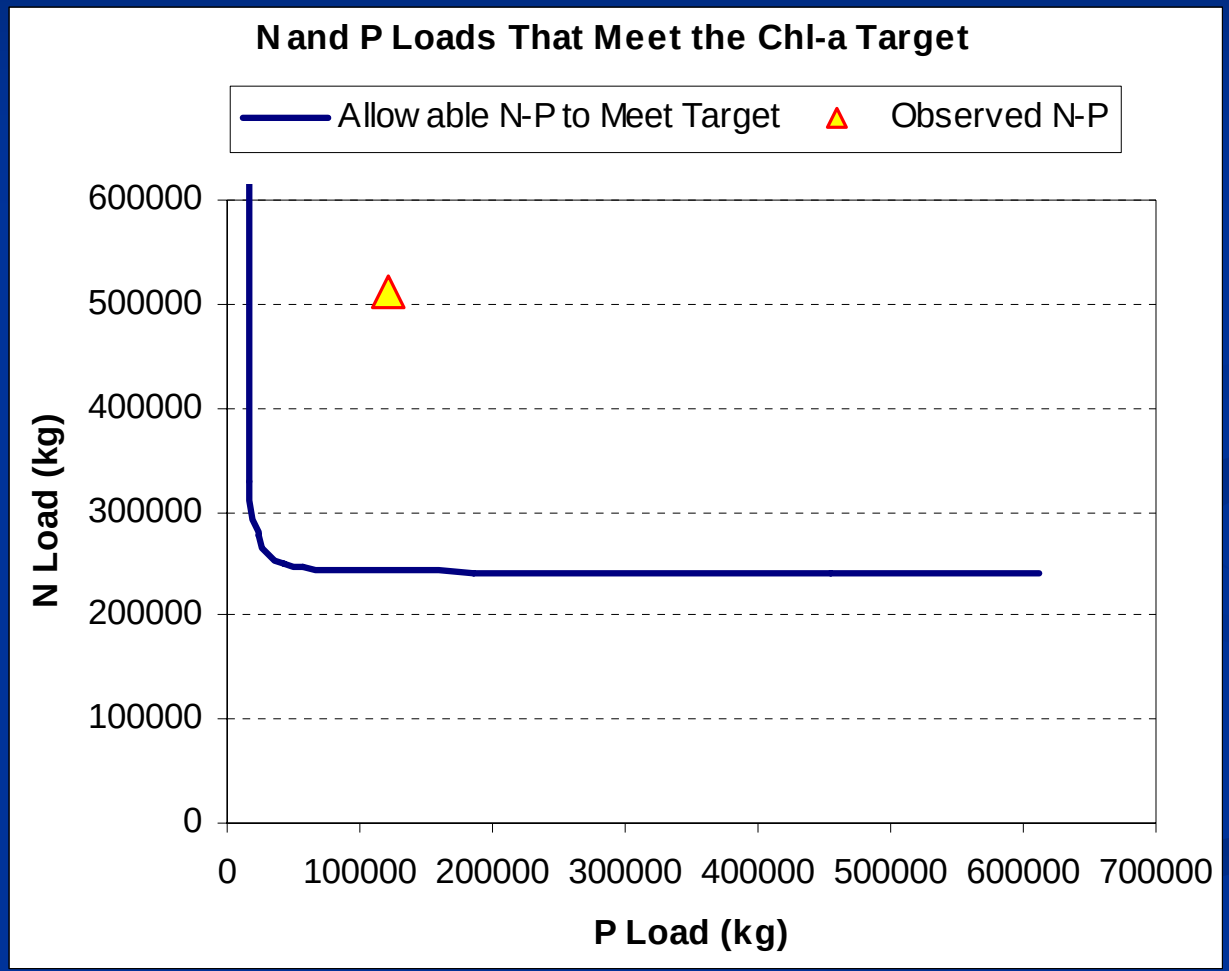
BATHTUB Scoping Tool Predicts Observed TN, TP, Chlorophyll *a*







Tool Predicts TN and TP Loads that Achieve Target



Reductions to Meet Chl-a Target in Reservoirs

- **Reduce TP by 80 to 92%; *or* Reduce TN by 53 to 67%.**
- **Reductions very similar to reductions needed to achieve DO targets using CE-QUAL-W2 model**
- **Average cyanobacterial fraction of algal biomass predicted to be reduced to about 50%**

Klamath River NNE Conclusions

The following nutrient risk co-factors impact Water Quality / Beneficial Use Support and will need to be addressed in any recovery plan:

- **Reduced wetland area and function in upper basin**
- **River hydrologic regime**
- **Impoundments**
- **Temperature**
- **Riparian shading**
- **Excess Sediment**
- **Stream channel degradation**

For Further Information

- **http://http://rd.tetratech.com/epa/**
- **http://n-steps.tetratech-ffx.com/**
  - Archived Webcasts
  - Elements of a criteria plan
  - Repository of nutrient information materials
  - 9000+ Article Bibliography
  - News from EPA and States