Upper Neuse River Basin Association

North Carolina Nutrient Criteria Update Draft Reservoir Pilot Outcomes

Clifton Bell | September 3, 2019

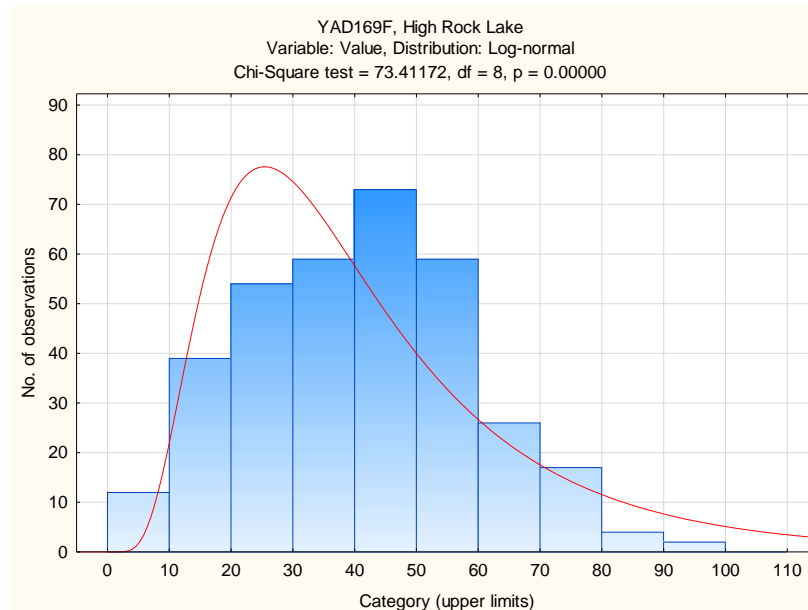# "Working Draft" Chlorophyll-a Criteria for Lake Pilot

Some places the SAC could have landed on CHLa for the lake pilot

- No consensus

- Recommend no change to NC's existing CHLa criterion

- Recommend new CHLa criterion that reflects HRL's existing condition

- Recommend new CHLa criterion that is lower than HRL's existing condition

Basis for Seasonal Geometric Mean Recommendation

- A measure of overall trophic status to protect against a variety of effects over different time scales.

- Geomean is measure of central tendency for log-normal or asymmetric variables (USEPA, 2012)

- Precedents (e.g., Florida, Virginia, Missouri)

YAD169F, High Rock Lake
Variable: Value, Distribution: Log-normal
Chi-Square test = 73.41172, df = 8, p = 0.00000

Is High Rock Lake Nutrient Impaired?

No
- Good fishery

- Few "nuisance" blooms or user complaints
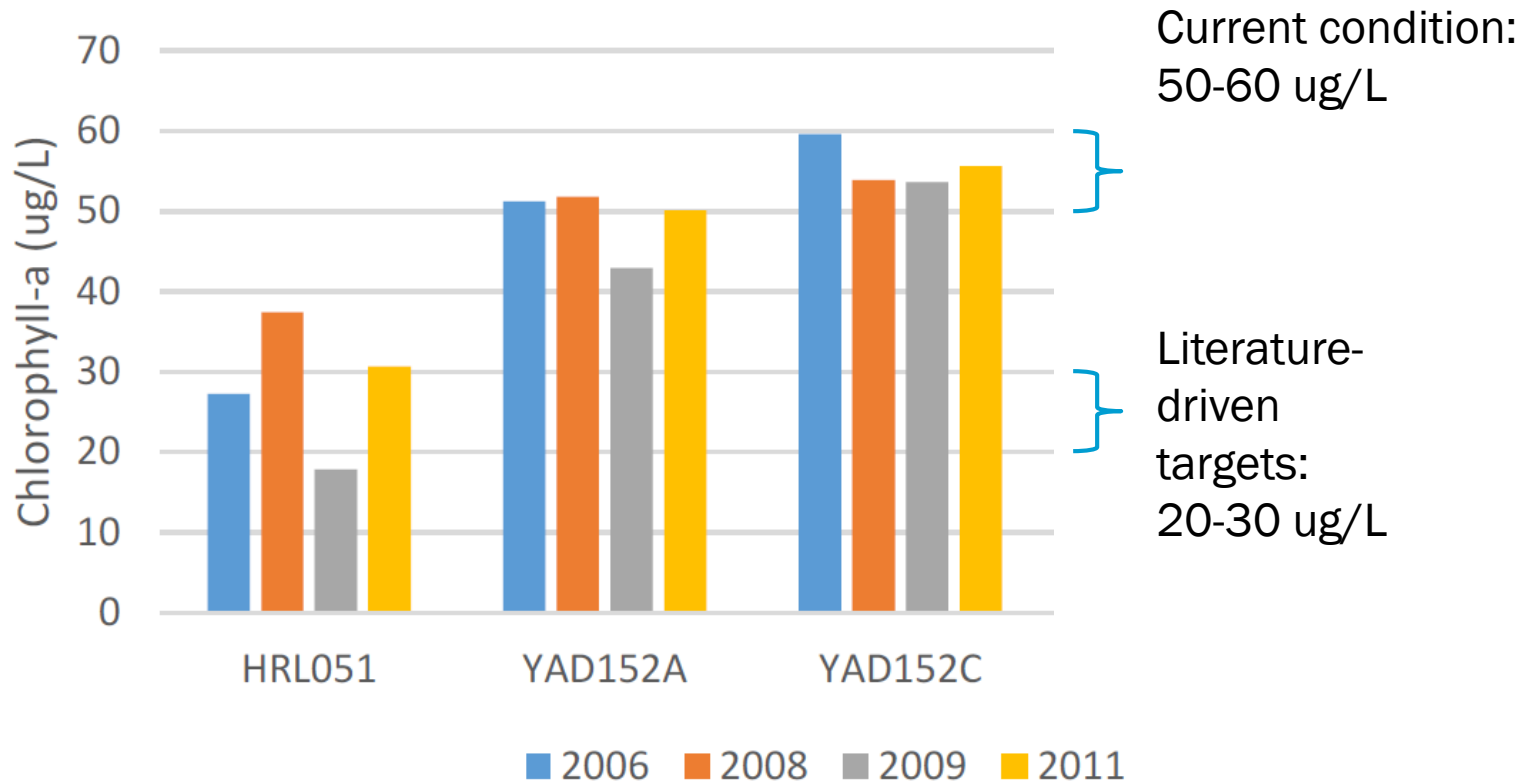
- Algal toxins low

- Raw water treatable

Yes
- High cyanobacteria density

- Water often very green/low clarity

- High pH

- Large daily swings in DO saturation

Large potential difference in CHLa targets

Current condition:
50-60 ug/L

Literature-driven targets:
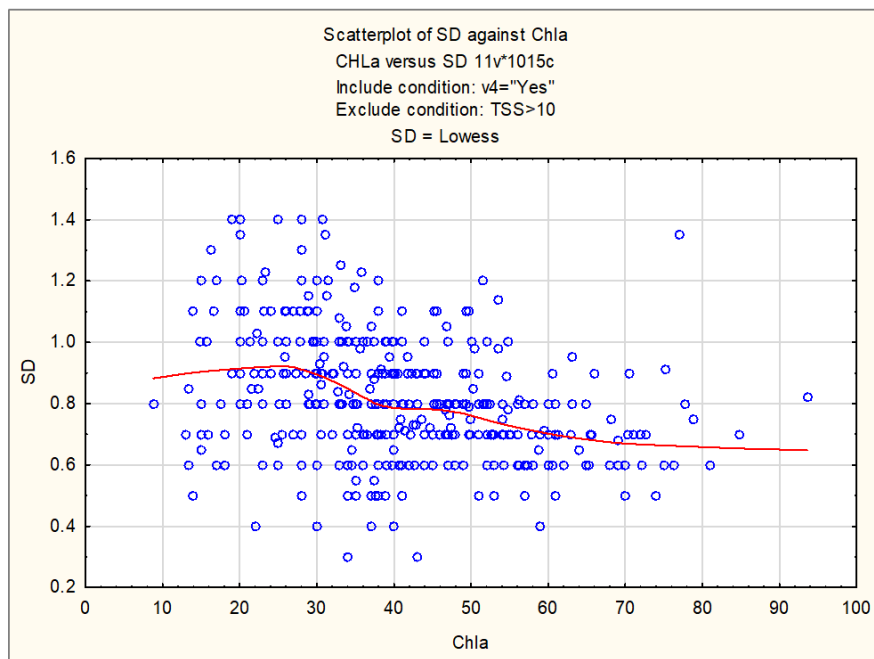20-30 ug/L

Threshold-Based vs. Continuum of Risk

Hard Threshold-Based

- Swimmers require Secchi depth of x, which occurs at CHLa of y_1.

- Microcystin exceeds threshold x at CHLa threshold y_2

- … etc.

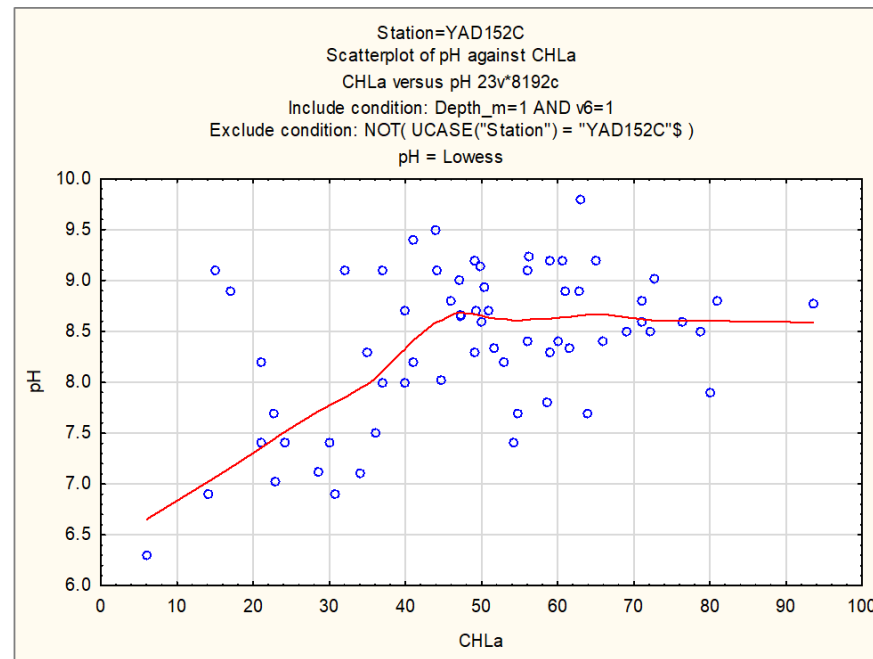- *CHLa target based on controlling (most stringent) linkage.*

Imprecise Continuum of Risk

- Some people's aesthetic enjoyment probably decreases with CHLa above y.

- Other lakes show increasing risk of toxin exceedances when CHLa exceeds y.

- … etc.

- *Choose a CHLa target based on partially subjective judgment of risk.*

CHLa-Indicator Relations for High Rock Lake

Scatterplot of SD against Chla
CHLa versus SD 11v*1015c
Include condition: v4="Yes"
Exclude condition: TSS>10
SD = Lowess

Station=YAD152C
Scatterplot of pH against CHLa
CHLa versus pH 23v*8192c
Include condition: Depth_m=1 AND v6=1
Exclude condition: NOT(UCASE("Station") = "YAD152C"$)
pH = Lowess

Weak relation with clarity   Threshold relation with pH

SAC discussed 25- 40 ug/L as the potential range of interest

Current condition: 50-60 ug/L

Lower end based on literature, fishery protection: 25 ug/L
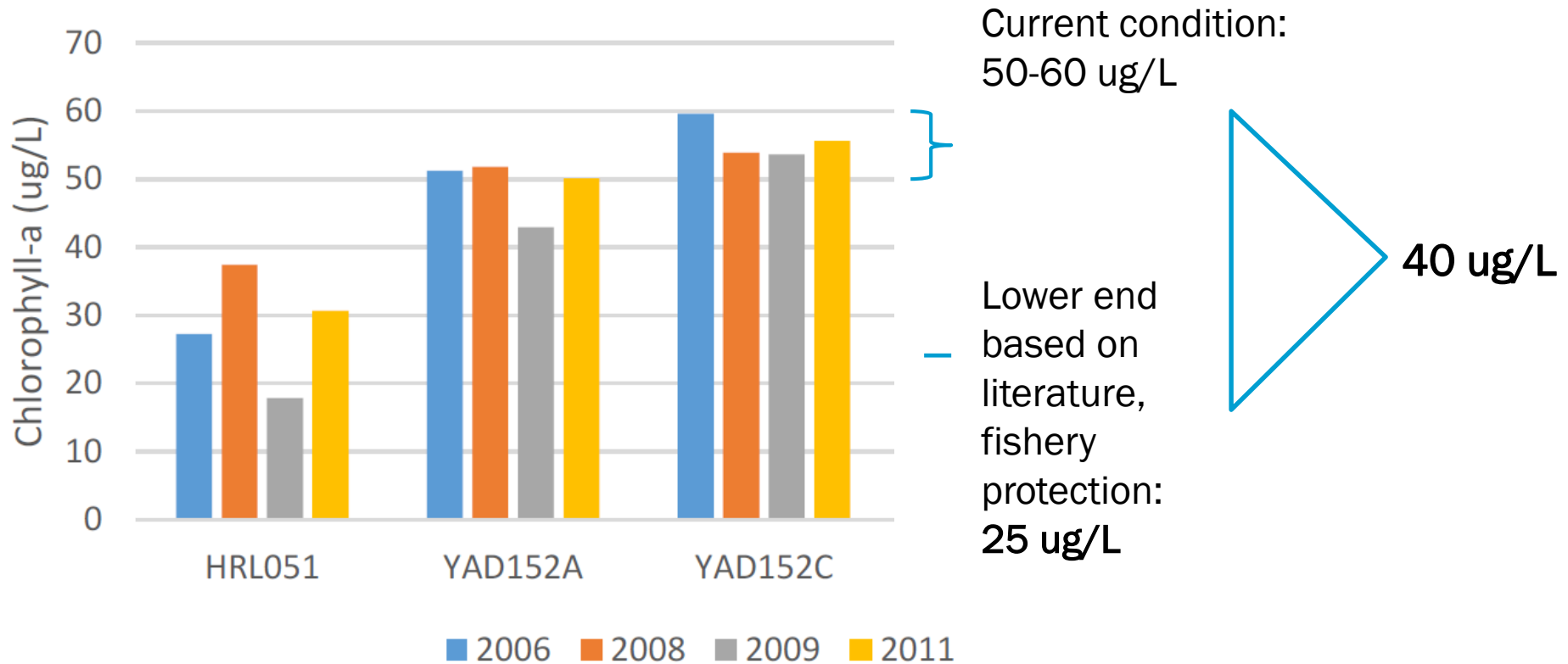
40 ug/L

# Examples of Chlorophyll Criteria Proposals Considered by SAC in 2018

- 24 ug/L, arithmetic mean, allowable 1-in-3 year exceedance

- 35 ug/L, geometric mean, multi-year average

- 40 ug/L, geometric mean, allowable 1-in-3 year exceedance

The surviving chlorophyll-a proposal from December 2018

- <u>Magnitude</u>: 35 ug/L

- <u>Frequency/duration</u>: "Seasonal geomean for samples collected from the months of April-October for the assessment period."

- <u>Basis</u>:
  - "Support for warmwater fishery while lowering potential for future impacts to aquatic life, recreation, and drinking water."
  - "Derived from 25-40 ug/L range for warmwater reservoirs. Near the upper end…due to mostly favorable indicators."

Draft Criteria Would Require Chlorophyll-a Reductions in High Rock Lake

High Rock Lake - Center Line Stations
Growing Season Geometric Mean
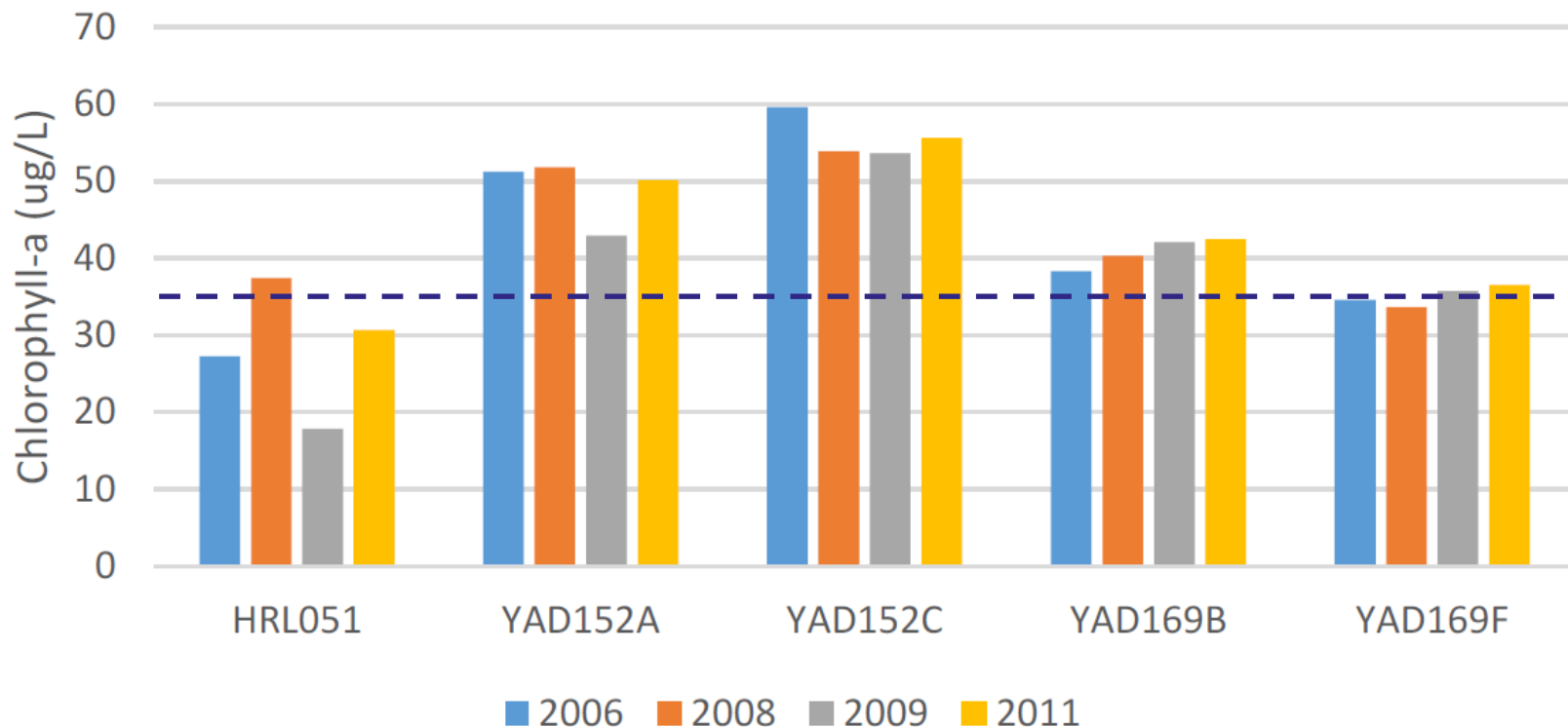
Some Outstanding Questions

- Spatial application (Every station? Lake average?)
- Number of years to include
- Statistical test
- Add not-to-exceed CHLa criteria?

Potential Elements of a Framework for Site-Specific Chlorophyll-a Criteria

The High Rock Lake pilot was useful, but...

- NC cannot devote the same level of time, data collection, modeling, and analysis to every lake/reservoir in the state.

- By 2028, NC plans to complete development reservoir criteria <u>statewide</u>.

- <u>Question</u>: How could lessons learned from High Rock lake inform a statewide framework?
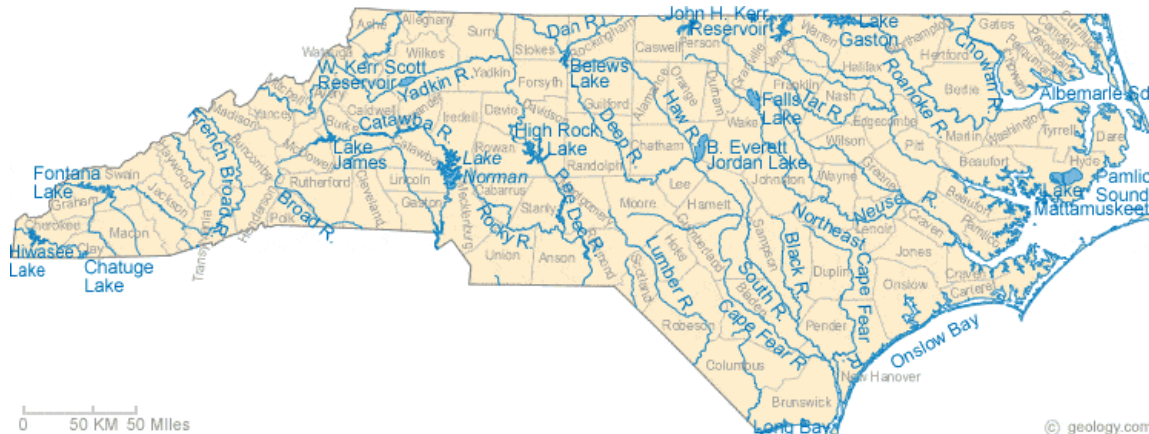
Desired Characteristics of the Framework

- Produces site-specific criteria that are protective of designated uses.

- Reduces assessment/management errors
  - Type I – False finding of impairment
  - Type II – False finding of attainment

- Considers both literature and lake-specific information.

- Not overly burdensome for DWR to apply.

Importance of Site-Specific Flexibility

- Not all water bodies experience the same effects at the same chlorophyll-a concentrations.

- Relatively wide spread in target values by use.

- From NCDP: "DWR is committed to evaluating nutrients and developing nutrient criteria on a site-specific basis."

- This doesn't mean we can't constrain the range of appropriate values.
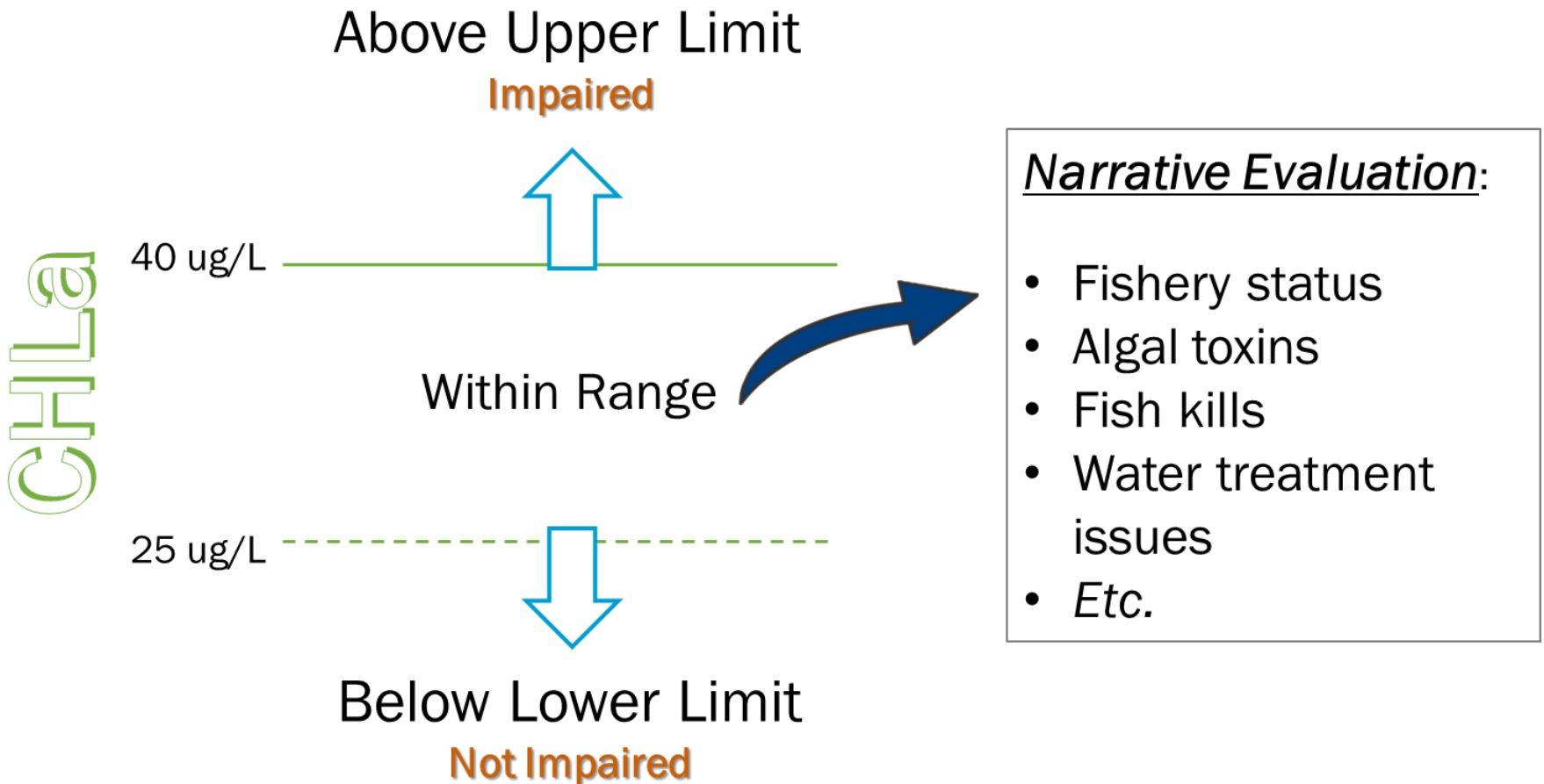
Steps of a Framework Discussed by the SAC

1. Apply CHLa- based screening range.

2. Perform narrative assessment for nutrient-related impairments.

3. Apply decision guidelines for determining impairment status of water bodies within screening range.

4. Apply decision guidelines for setting site-specific criteria within screening range.

Step 1: Apply CHLa- based screening range as first step in determining impairment status.

Above Upper Limit
Impaired

40 ug/L

Within Range

25 ug/L

Below Lower Limit
Not Impaired

CHLa

Narrative Evaluation:

- Fishery status
- Algal toxins
- Fish kills
- Water treatment issues
- Etc.

Step 2: Perform narrative assessment for nutrient-related impairments.

Facilitate this step with working list of indicators

- Primary indicators:
  - More direct indicator of use attainment
  - Well-established threshold or criterion exists
- Secondary indicators:
  - Less direct indicator of use attainment
  - Well-established threshold or criterion does not exist

Examples of Indicators: Aquatic Life

Use Category	Indicator	Primary or Secondary Indicator	Narrative or Numeric Indicator	Threshold(s) or Bases for Evaluation
Aquatic Life	DO conc.	P	Num.	4-5 mg/L (NC criteria)
	DO satur.	S	Num.	250-300% (based on sci. lit. of O_2-only gas bubble disease)
	pH	P	Num.	9.0 (NC criteria)
	Algal toxins	P	Num.	Various thresholds
	%Cyanobact.	S	Num.	% biovolume, % count (%biovolume more useful for judging zooplankton support)
	Fishery status	P	Narr.	Characterization based on NC WRC sampling
	Fish kills	P	Narr.	Occurrence & frequency
	Fish abnorm.	S	Narr.	Some might be related to nutrients (e.g., signs of gas bubble disease)

Examples of Indicators: Public water supply

Use Category	Indicator	Primary or Secondary Indicator	Narrative or Numeric Indicator	Threshold(s) or Bases for Evaluation
Public water supply	Algal toxins	P	Num.	Various thresholds
	T&O-causing compounds	S	Num.	Various thresholds
	Algal-related treatability challenges	P	Narr.	Severity & frequency

Examples of Indicators: Recreation

Use Category	Indicator	Primary or Secondary Indicator	Narrative or Numeric Indicator	Threshold(s) or Bases for Evaluation
Recreation	Algal toxins	P	Num.	Various thresholds
	Secchi depth	S	Num.	0.5 – 1.0 m
	Nuisance blooms; mats or extensive scums	P	Narr.	Severity & frequency

Step 2: Perform narrative assessment for nutrient-related impairments. (cont.)

Category #1: Indicator shows use clearly not met.

Category #2: Indicator does not directly show impairment, but suggests elevated risk of impairment.

Category #3: Indicator supports finding of use attainment.

Step 3: Apply decision guidelines for determining impairment status of water bodies within screening range.

- Finding of impairment based on red primary indicators.

- Finding of attainment based on:
  - No red indicators
  - No more than 50% yellow indicators

- "Indeterminate" or "insufficient information" is a valid outcome.

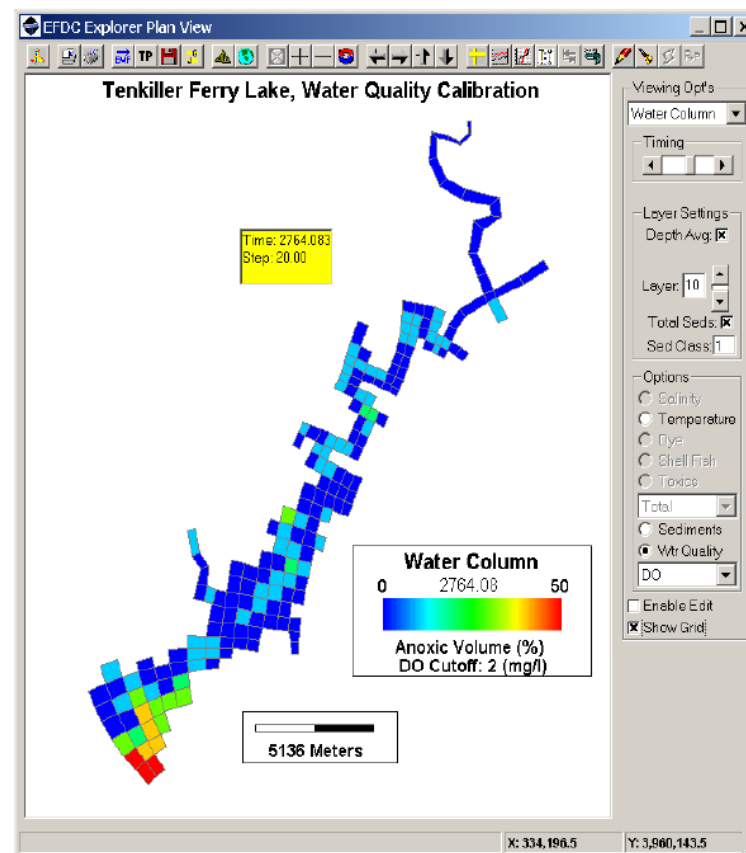# Step 4: Apply decision guidelines for determining site-specific criteria

Existing CHLa	Does not Fail Narrative Assessment	Fails Narrative Assessment
Above screening range	• Criterion is upper end of screening range, barring special demonstration.	• Set criteria within screening range. • Prof. judgment based on severity and existing CHLa levels • Use CHLa-indicator linkages if available.
Within screening range	• Antidegradation policy applies • Option for criteria based on existing condition, considering variability • Use CHLa-indicator linkages if available.	• Bottom of screening range is default • Default can be overridden by CHLa-indicator linkages if available.
Below screening range	• Criterion is bottom end of screening range, barring special demonstration. • Antidegradation policy applies	• Case-by-case • Use CHLa-indicator linkages if viable.

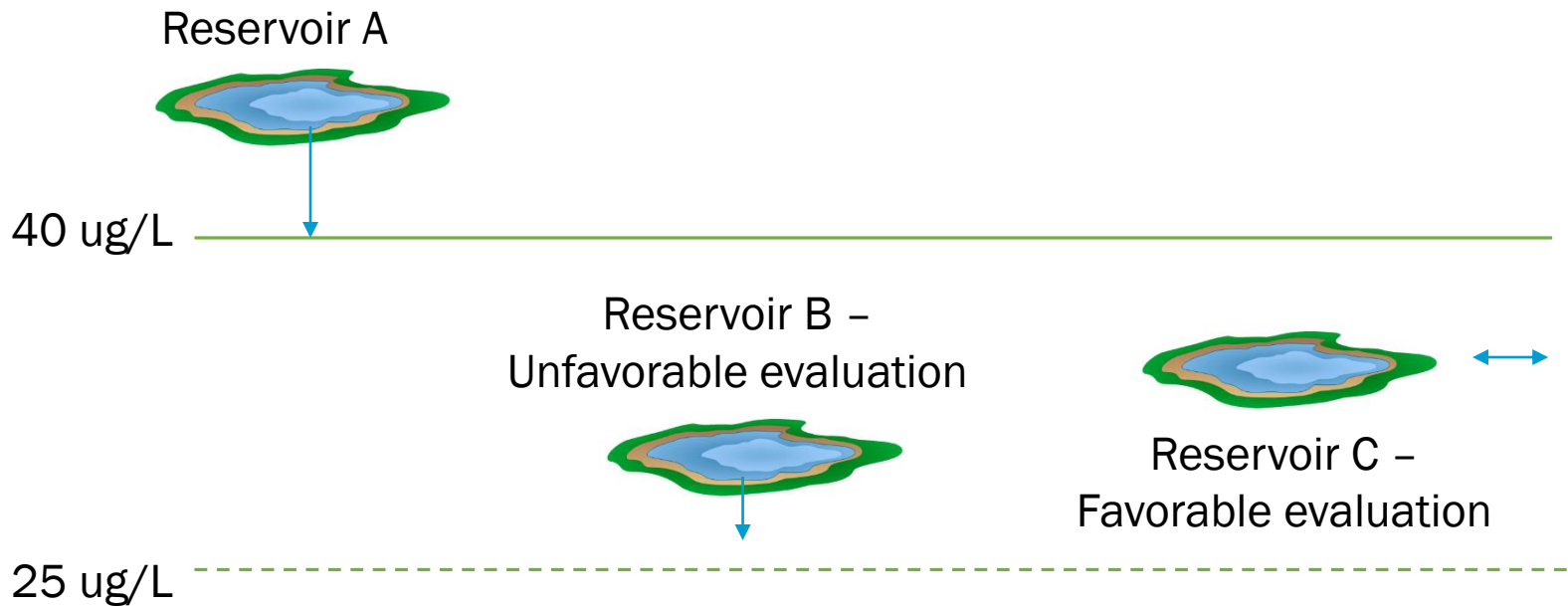# Use CHLa-indicator relations as data/resources allow.

Empirical
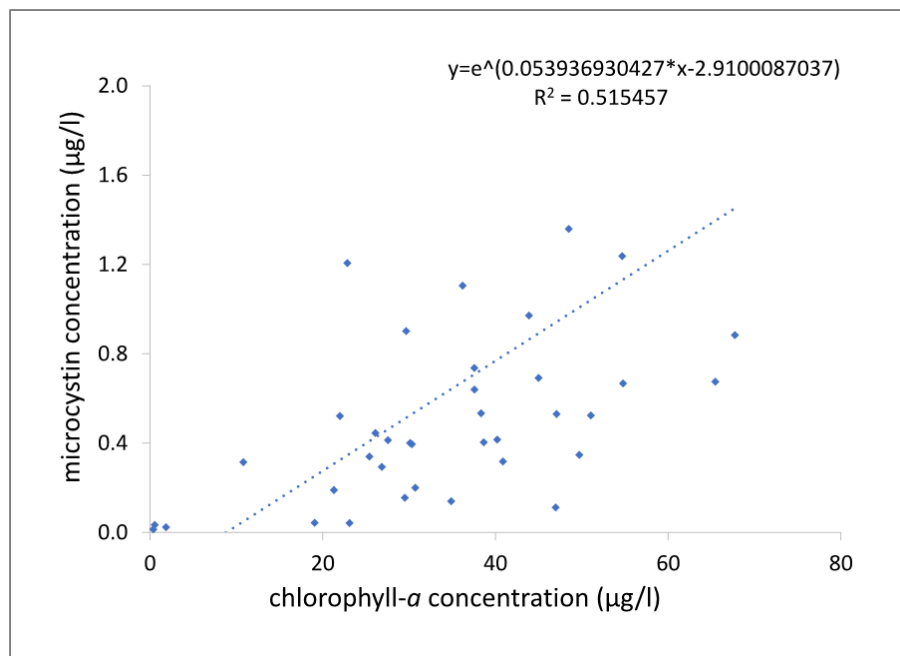
Deterministic models (if available)

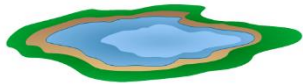# Conceptual Approach for Setting Site-Specific Chlorophyll-a Goals

Reservoir A

40 ug/L

Reservoir B –
Unfavorable evaluation

Reservoir C –
Favorable evaluation

25 ug/L

CHLa

Example Application of Framework to High Rock Lake

Brown AND Caldwell

Step 1: Apply Screening Range

HRL up to 55 ug/L

High Rock Lake Impaired Based on CHLa alone

CHLa

40 ug/L ————————————————————————

25 ug/L -

Step 2: Perform narrative assessment for nutrient-related impairments.

Use Category	Indicator	Primary or Secondary Indicator[1]	Narrative or Numeric Indicator	Threshold(s) or Bases for Evaluation	Indicator Status under HRL's Existing CHLa Conditions[2]
Aquatic Life	DO concentration	Primary	Numeric	4-5 mg/L (NC criteria)	HRL not impaired for DO. Surface DO favorable. Bottom DO strongly affected by stratification.
	DO saturation	Secondary	Numeric	250-300% (based on sci. lit. of O_2-only gas bubble disease)	2016 monitoring showed 90th percentiles of 98% -188% with instant. max. values of 148%-265% depending on station.
	pH	Primary	Numeric	9.0	HRL currently impaired for pH. Proposed adjustments to pH monitoring method would lessen impairment but some stations (e.g., YAD152C) would still be marginal.
	Algal toxins	Primary	Numeric	Various thresholds	Algal toxins present but in low concentrations. General concern over toxin potential.
	%Cyanobact.	Secondary	Numeric	% biovolume, % count (%biovolume more useful for judging zooplankton support)	%Counts high but %biovolume adequate to support high trophic levels.
	Fishery status	Primary	Narrative	Characterization based on NC WRC sampling	Meets fishery use.
	Fish kills	Primary	Narrative	Occurrence & frequency	No nutrient-related fish kills on record.
	Fish abnormalities	Secondary	Narrative	Some might be related to nutrients (e.g., signs of gas bubble disease)	NC WRC: No signs of gas bubble disease in HRL fish.
Public water supply	Algal toxins	Primary	Numeric	Various thresholds	Algal toxins present but in low concentrations. General concern over toxin potential.
	T&O-causing compounds	Secondary	Numeric	Various thresholds	Town of Denton does not report T&O problems.
	Treatability challenges	Primary	Narrative	Occurrence & frequency	Town of Denton does not report algae-related treatability problems.
Recreation	Algal toxins	Primary	Numeric	Various thresholds	Algal toxins present but in low concentrations. General concern over toxin potential.
	Secchi depth	Secondary	Numeric	0.6 – 1.0 m	CHLa sufficiently high to reduce SD < 1.0 m and impart green color to water. Unclear how this relates to regional user expectations or actual use.
	Nuisance blooms; mats or extensive scums	Primary	Narrative	Occurrence & frequency	Algae in HRL tends to be dispersed in water column.

Step 3: Apply decision guidelines for determining impairment status of water bodies within screening range.

- Skip this step; HRL above screening range.

Step 4: Apply decision guidelines for determining site-specific criteria

Existing CHLa	Does not Fail Narrative Assessment	Fails Narrative Assessment
Above screening range	• Criterion is at or near upper end of screening range, barring special demonstration.	• Set criteria within screening range. • Prof. judgment based on severity and existing CHLa levels • Use CHLa-indicator linkages if available.
Within screening range	• Antidegradation policy applies • Option for criteria based on existing condition, considering variability • Use CHLa-indicator linkages if available.	• Bottom of screening range is default • Default can be overridden by CHLa-indicator linkages if available.
Below screening range	• Criterion is bottom end of screening range, barring special demonstration. • Antidegradation policy applies	• Case-by-case • Use CHLa-indicator linkages if viable.