# AGENDA

## USEPA-NACWA Meeting on Nutrient Permitting

## February 12, 2015 1-3 pm

I. Welcome and introductions
II. Focused topic: Modifying the TSD approach to WQBEL calculation
    I. Frequency and duration considerations
    II. Probability bases
    III. Limit expression
III. Focused topic: Empirical alternative to TSD approach
IV. Status of training materials and next steps

# NACWA Participants

- Chris Hornback, NACWA
- Jim Pletl, Hampton Road Sanitation District
- Clifton Bell, Brown and Caldwell
- Denny Parker, Brown and Caldwell

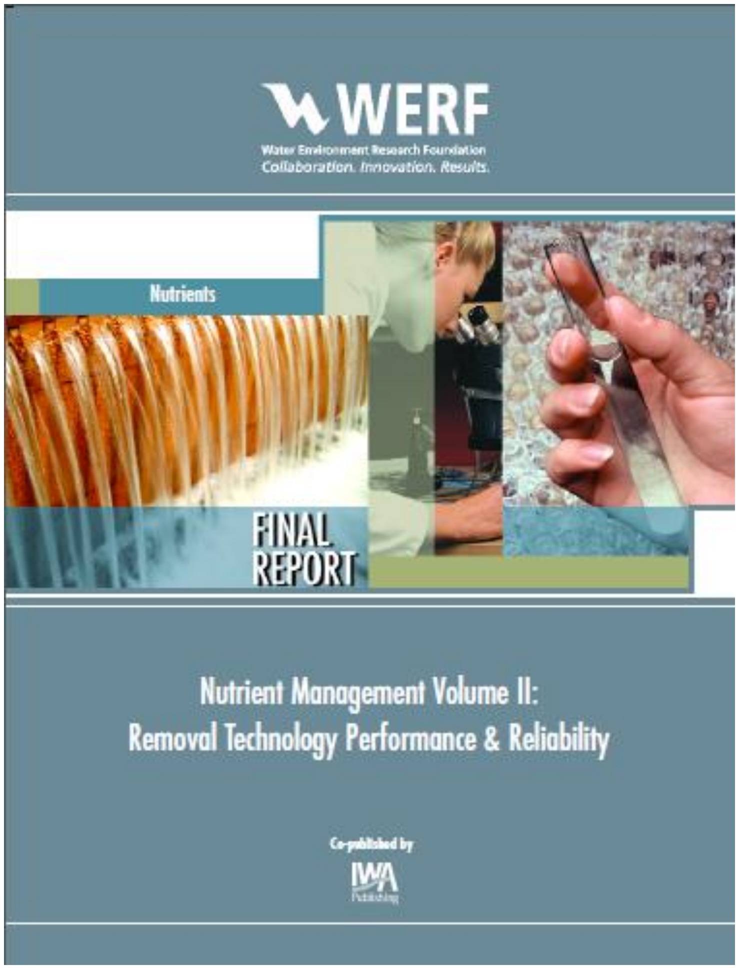
# Key Recommendations from 2014 Review

| Category | No. | Summary |
|---|---|---|
| Deriving WLAs | 1 | Allow load-response linkages as alternative to concentration-based targets. |
| | 2 | Bioconfirmation to inform WLAs. |
| | 3 | Consider preferential nutrient controls. |
| | 4 | Tailor critical conditions and frequency components. |
| | 5 | Full mix for nutrients; explore nutrient assimilation zones. |
| | 6 | Watershed-based permitting. |
| Calculating WQBELs | 7 | Use appropriate averaging periods. |
| | 8 | Verify or modify assumptions regarding effluent distribution & variability. |
| | 9 | Choose appropriate probability bases. |
| | 10 | Consider using WLAs as WQBELs. |
| | 11 | Consider empirical alternatives to TSD approach. |
| Treatability | 12 | Do not set WQBELs to unattainable levels. |

# Focused Topic: Modifying the TSD Approach for Nutrients

- Goals
  - Match frequency and duration aspects of water quality goals.
  - Use the appropriate degree of conservativeness
- Several interrelated recommendations
  - Averaging periods
  - Critical conditions & frequency
  - Probability bases

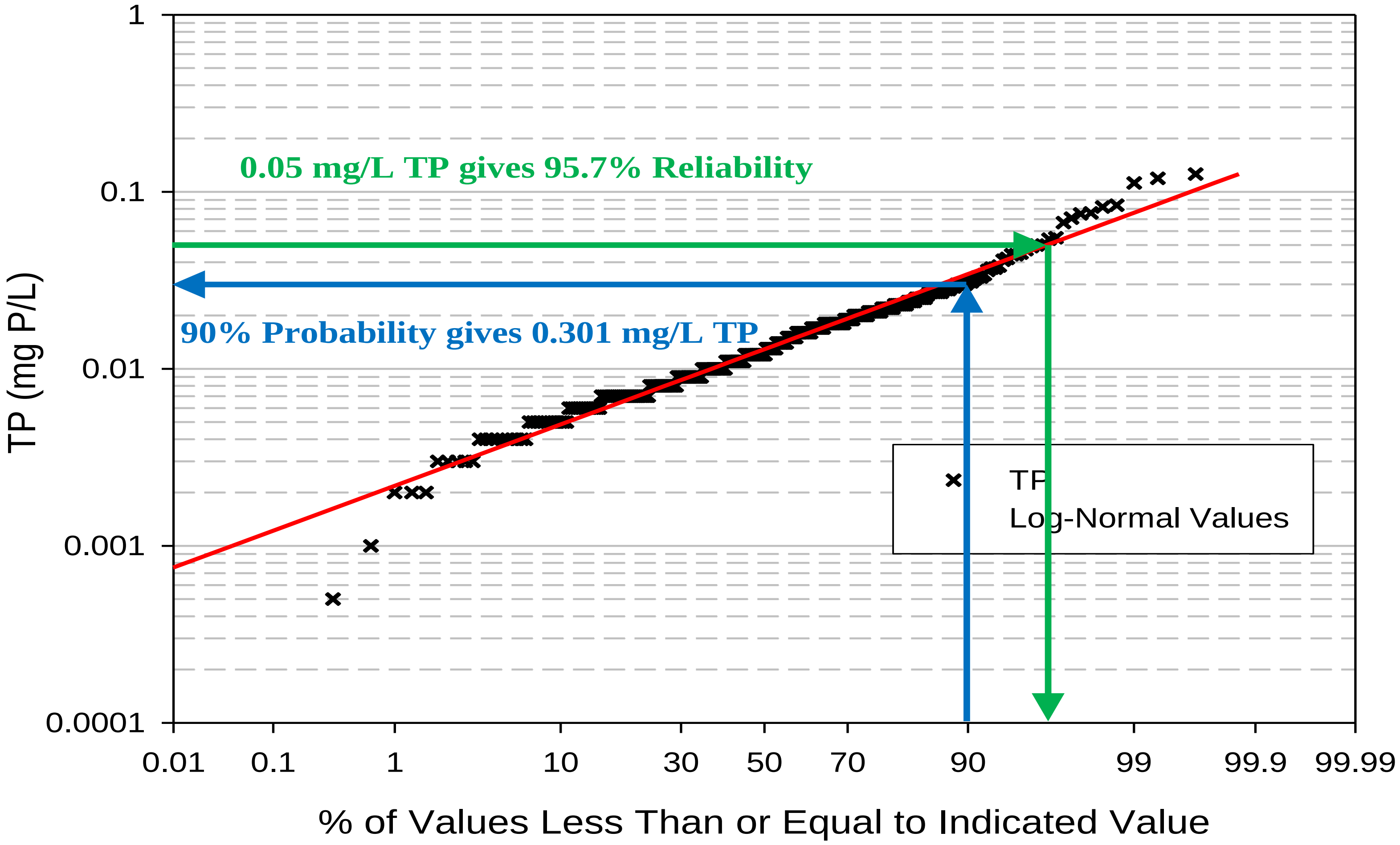
# Key Source Material: Research by the Water Environment Research Foundation



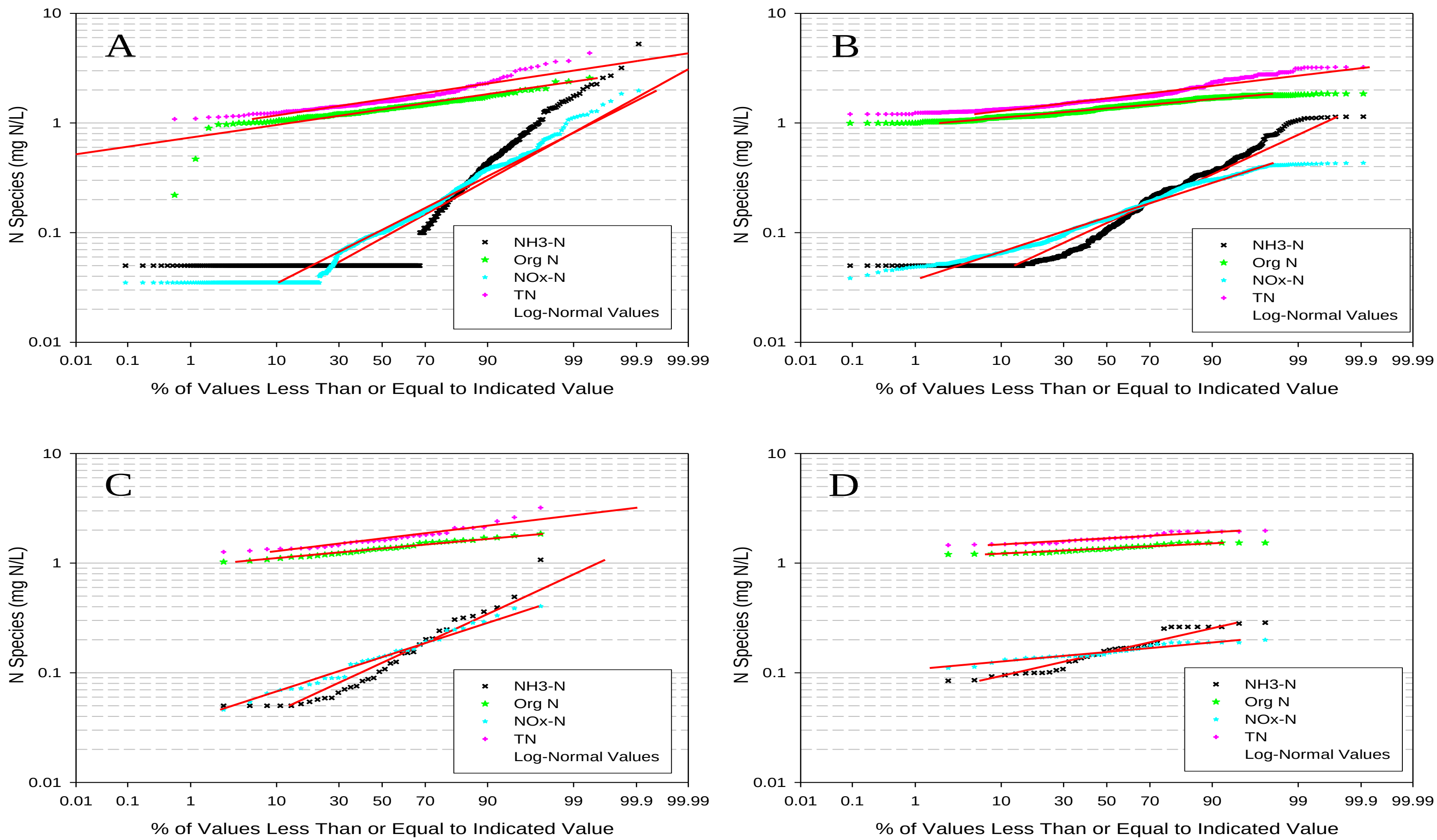

Bott and Parker, 2011

- Nutrient impacts are seldom responsive to short term variations
- Study of long term statistics on the performance on exemplary nutrient removal plants
- Examples of nutrient permit bases
- Conclusions about type of technology on performance statistics

# Understanding Statistics Key to Forming Permits: Example Daily TP Values for the Iowa Hill WRF



# Probability Plots for TMWRF: A - Daily, B - 30 day Rolling Average, C - Monthly Average, D – Annual Average




TMWRF: Truckee Meadows Water Reclamation Facility

# Statistics and Permit Violations

| Number of Exceedances Per Five-Year NPDES Permit Period for Daily, Monthly, and Annual Average Permits for Given Percentile Values (after Bott and Parker, 2011) | | | |
|---|---|---|---|
| Percentile Less than Stated Concentration | Expected Number of Daily Average Exceedances (with Daily Sampling) | Expected Number of Monthly Average Exceedances | Expected Number of Annual Average Exceedences |
| Total reporting events in 5 years | 1,826 | 60 | 5 |
| 50 | 912 | 30 | 2.5 |
| 90 | 183 | 6 | 0.5 (or 1 per 2 permit periods) |
| 95 | 91 | 3 | 0.25 (or 1 per 4 permit periods) |
| 99 | 18 | 0.6 (or 1 per 2 permit periods)* | 0.05 (or 1 per 20 permit periods) |

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TMWRF Example. If the TN limit is 3 mg/L, during a five year permit period:

- If a daily limit, 70 violations
- If a monthly limit, 2 violations
- If an annual limit: no violations

# Technology Choice Impacts Nitrogen Removal Plant Performance

| 95th Percentile Monthly Average TN for Three Categories of Nitrogen Removal Plants (after Bott and Parker, 2011) | | | | | |
|---|---|---|---|---|---|
| Separate Stage | TN, mg/L | Combined | TN, mg/L | Multiple Stage | TN, mg/L |
| River Oaks, FL | 2.3 | Kalkaska, MI | Approx. 3.0 | Fiesta Village, FL (Denite Filter) | 2.2 |
| Western Branch, MD | 2.4 | Parkway, MD | 5.1 | 5 A2/O Plants with Denite Filters, FL | 3.0 |
| Truckee Meadows, NV | 2.5 | Eastern WRF, FL | 6.7 | | |
| Tahoe-Truckee, CA | 3.1 | Piscataway, MD | 7.2 | | |
| Scituate, MA | 3.8 | 10 Bardenpho Plants, FL | 3.5 | | |
| Howard F Curran, FL | 3.0 | | | | |

# Technology Choice Impacts Phosphorus Removal Plant Performance

| 95th Percentile Monthly Average TP for Three Categories of Phosphorus Removal Plants (after Bott and Parker, 2011) | | | | | |
|---|---|---|---|---|---|
| Multiple Stage | TP, mg/L | Single Stage Chemical Addition | TP, mg/L | Little or No Chemical Addition | TP, mg/L |
| F. Wayne Hill, GA | 0.0902 | Iowa Hill WRF, CO | 0.0306 | Kalispell, MT | 0.168 |
| ASA, VA | 0.101 | Pinery, CO | 0.0363 | Kelowna, BC | 0.217 |
| Clark County, NV | 0.153 | Cauley Creek, GA | 0.116 | | |
| Rock Creek, OR | 0.151 | | | | |
| Blue Plains, DC | 0.161 | | | | |

# Key BNR Technology Takeaways

- Averaging periods and nutrient limits can be set so low that they are no proven technologies that will meet them.
- Impacts from nutrient discharges seldom cause short term responses, so using longer term averages in permits is appropriate.
- Historically, many nutrient removal plants have been permitted based on annual averages.
- Setting permit numbers arbitrarily low will militate against the use of technologies that are lower in cost and use less chemicals.
- The goal: finding technologies that are both protective of the environment, technologically achievable and sustainable.

# Averaging Periods: Water Bodies Respond to Time-Integrated Nutrient Loads

Rivers & Streams

$$\int Weeks$$

Lakes & Reservoirs

$$\int Months - Year +$$

Estuaries

$$\int Months - Year +$$

# Averaging Period Used Repeatedly in WLA / WQBEL Calculations

- Water quality criteria
- Dynamic WLA modeling
- Reasonable potential analysis
  (as recommended by NACWA)
- Calculation of the LTA from WLA
- Calculation of time-averaged WQBELs from the LTA

# Longer averaging periods for nutrients is a well-established concept

"…states may adopt seasonal or annual averaging periods for nutrient criteria instead of the 1-hour, 24-hour, or 4-day average durations typical of aquatic life criteria for toxic pollutants."

-USEPA Permit Writer's Manual

# Precedents for expressing WQBELs with longer averaging periods

## Rivers and Streams

- Wisconsin
- 6-month (growing season) average

## Lakes and Reservoirs

- California
- Annual average

## Estuaries

- Virginia
- Annual average

# Critical Conditions & Frequency

- Toxics
  - 7Q10 or 1Q10 streamflow
  - 1 in 3 year exceedance

- Recommendations for Nutrients
  - Tailor critical condition to:
    - Averaging period of water body response
    - Allowable frequency of exceedance
  - Set allowable frequency of exceedance based on
    - Nature of impairment
    - Averaging period
    - Recovery time
    - Natural variability
  - Allowable frequency should not be rarer than 1 in 3 year for shorter averaging periods.

# Examples

- Florida NNC for lakes and reservoirs: Annual geometric mean to be met 2 out of 3 years.
- Chesapeake Bay TMDL: WLAs based on annual hydrology with 1 in 10 year exceedance rate.

# Probability Bases in the TSD

| Step | 95% | 99% |
| --- | --- | --- |
| Reasonable potential analysis | Less conservative | More conservative |
| Calculation of LTA from WLA | Less conservative | More conservative |
| Calculation of WQBEL from LTA | More conservative | Less conservative |

# Bases of Recommendation for Less Conservative Probability Bases for Nutrients

- Nature of nutrient vs. toxic impacts
- Longer averaging periods mean fewer opportunities for exceedance; i.e. rarer exceedances associated with a specific probability basis.

*Tie back to acceptable frequency of excursion*

# Consequences of exceedance inform the needed degree of conservativeness

- Human health – short term effects
- Human health – long term effects
- Aquatic life – lethality
- Aquatic life – reproduction effects
- Aquatic life – growth effects
- Aquatic life –community shifts along an ecological gradient.
- Aesthetics

# Example 1: Reasonable potential analysis

- A WWTP discharges to a river
- In-stream criterion is 0.070 mg/L TP expressed as a 6-month growing season average.
- Steady-state critical condition selected to represent lowest 6-month streamflow with recurrence interval of 5 years
- 90$^{th}$ percentile of the predicted **6-month average** in-stream concentration at a 90$^{\%}$ confidence level = 0.070 ug/L
- Conclusion of RPA: No limit needed.

# Example 1: Reasonable potential analysis (continued)

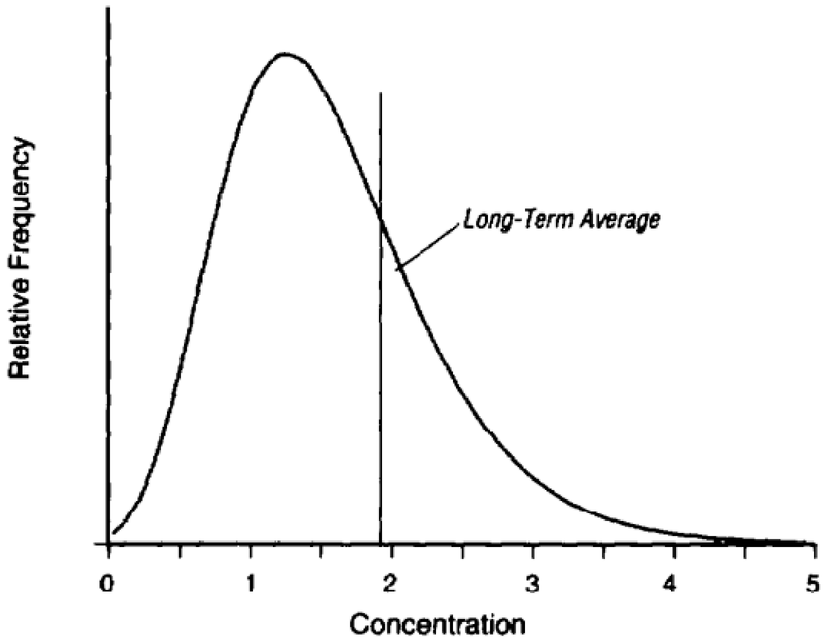
- Is this RPA conservative enough?
- Frequency considerations
  - Critical streamflow: 1 in 5 years = 0.2
  - Effluent concentration exceeds 90th percentile: 1 in10 years = 0.1
  - Risk of Exceedance = 0.2 x 0.1 = 0.02 **(1 out of 50 years)**

# Example 2: LTA calculation from steady-state WLA model

- WWTP discharges to river with periphyton criteria expressed as 30-day average, applicable April - September.
- Steady-state WLA model uses 30-day, 3-year biological design condition.
- WWTP to receive AML

# Example 2: LTA calculation from steady-state WLA model (cont.)

- Calculate LTA from WLA
  - Effluent with target distribution will “rarely” exceed the WLA
  - 95th percent probability basis: 1 month out of 20




$$LTA = WLA\, e^{(0.5\sigma_{30}^2 - z\sigma_{30})}$$

# Example 2: LTA calculation from steady-state WLA model (cont.)

- Is this conservative enough?
- Frequency considerations
  - Critical condition: 1 month in 18 months= 0.06
  - 30-day average exceeds WLA concentration 1 in 20 months= 0.05
  - Risk of Exceedance = 0.06 x 0.05 = 0.002 **(1 out of 360 months = 1 out of 30 years)**

# Example 3: WLA / WQBEL calculation from dynamic model

- WWTPs discharge upstream of reservoir with spring (3-month avg.) and summer (3-month avg.) phosphorus criteria.
- Dynamic model identifies LTAs associated with 1 in 5 year exceedance of criteria.
- WQBELs expressed as monthly average load limits.

$$AML = LTA \bullet e^{[z\sigma_n - 0.5\sigma_n^2]}$$

where $\sigma_n^2 = \ln(CV^2/n + 1)$
$z = 1.645$ for 95th percentile probability basis, and
$z = 2.326$ for 99th percentile probability basis

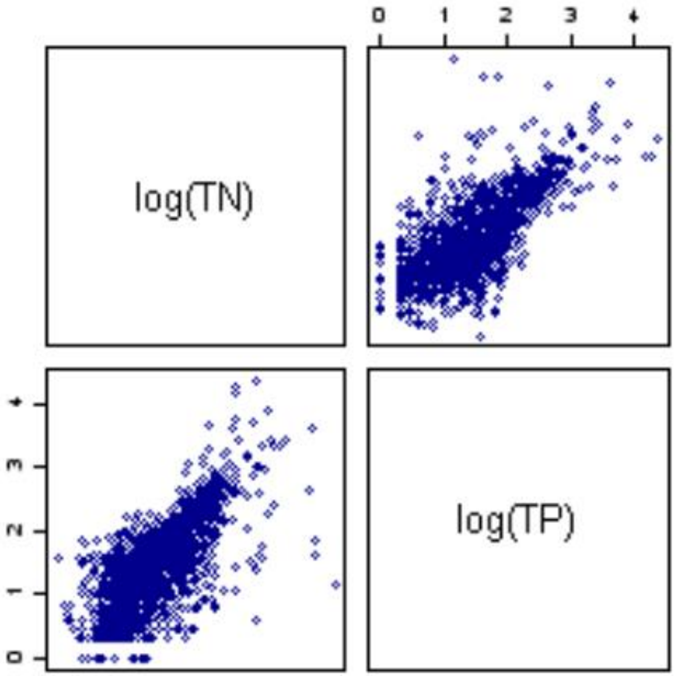
# Example 3: WLA / WQBEL calculation from dynamic model

*If LTAs are achieved….*

| AML based on 95th percentile | AML based on 99th percentile |
| --- | --- |
| • ~3 violations in 5-year permit term | • ~1 violation in 5-year permit term |

# Examples of built-in conservativeness

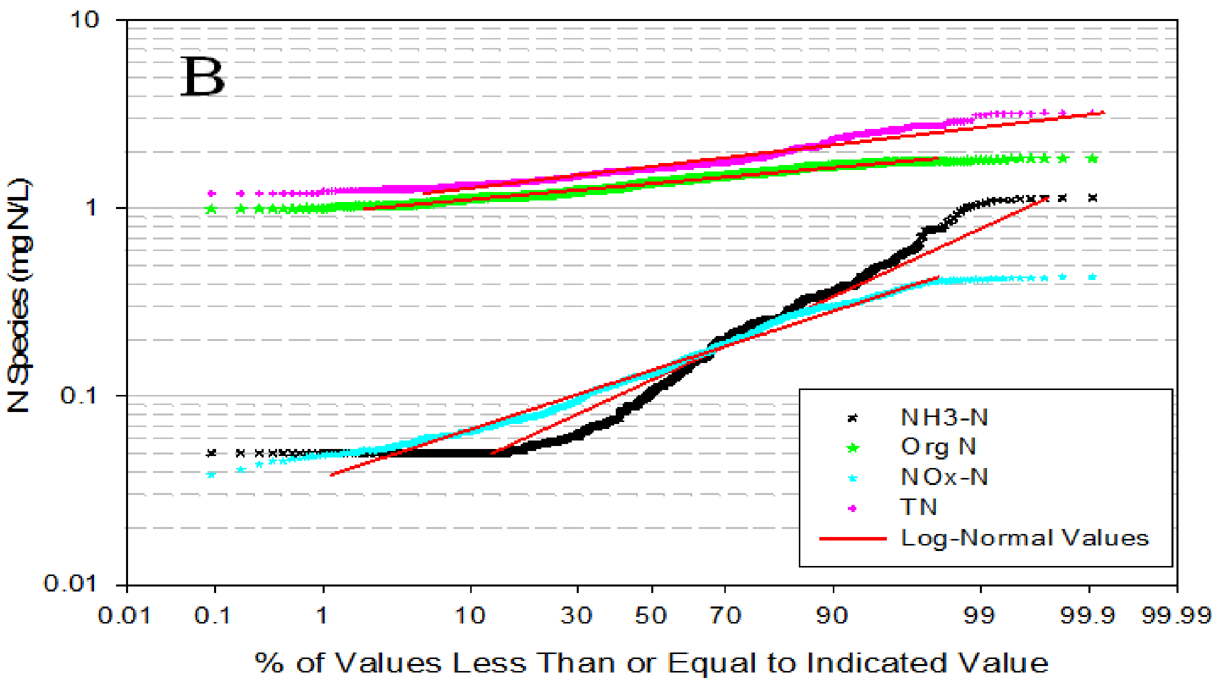
- Unlikelihood that maximum discharge rates coincide with critical low flow conditions
- Unlikelihood of all facilities simultaneously discharging at maximum rate
- Conservative modeling assumption
- Exceedance of nutrient concentration criteria does not always cause exceedance of response variable




*e.g., 50% probability of impairment when TP > 0.150 mg/L*

# Assumptions Regarding Lognormality and CV

- Findings of review:
  - Nutrient distributions can depart from lognormality, esp. at high percentiles
  - CV highly variable



# Assumptions Regarding Lognormality and CV (cont.)

- Insufficient information to recommend alternative defaults
- Recommend facility-specific confirmation
- Similar to TSD recommendation for toxics

# Empirical Alternative to TSD Method

- Concept: Instead of assuming a distribution (e.g., lognormal), use the observed empirical distribution.
- Adjust observed distribution
  - To meet WLA…
  - …but without assuming technologically unattainable levels

# Example #4: Empirical Alternative

- Facility has multi-year nutrient database
- WLA based on 10 mg/L TN expressed as 30-day average
- Currently not achieving this level

# Example #4: Empirical Alternative (cont.)

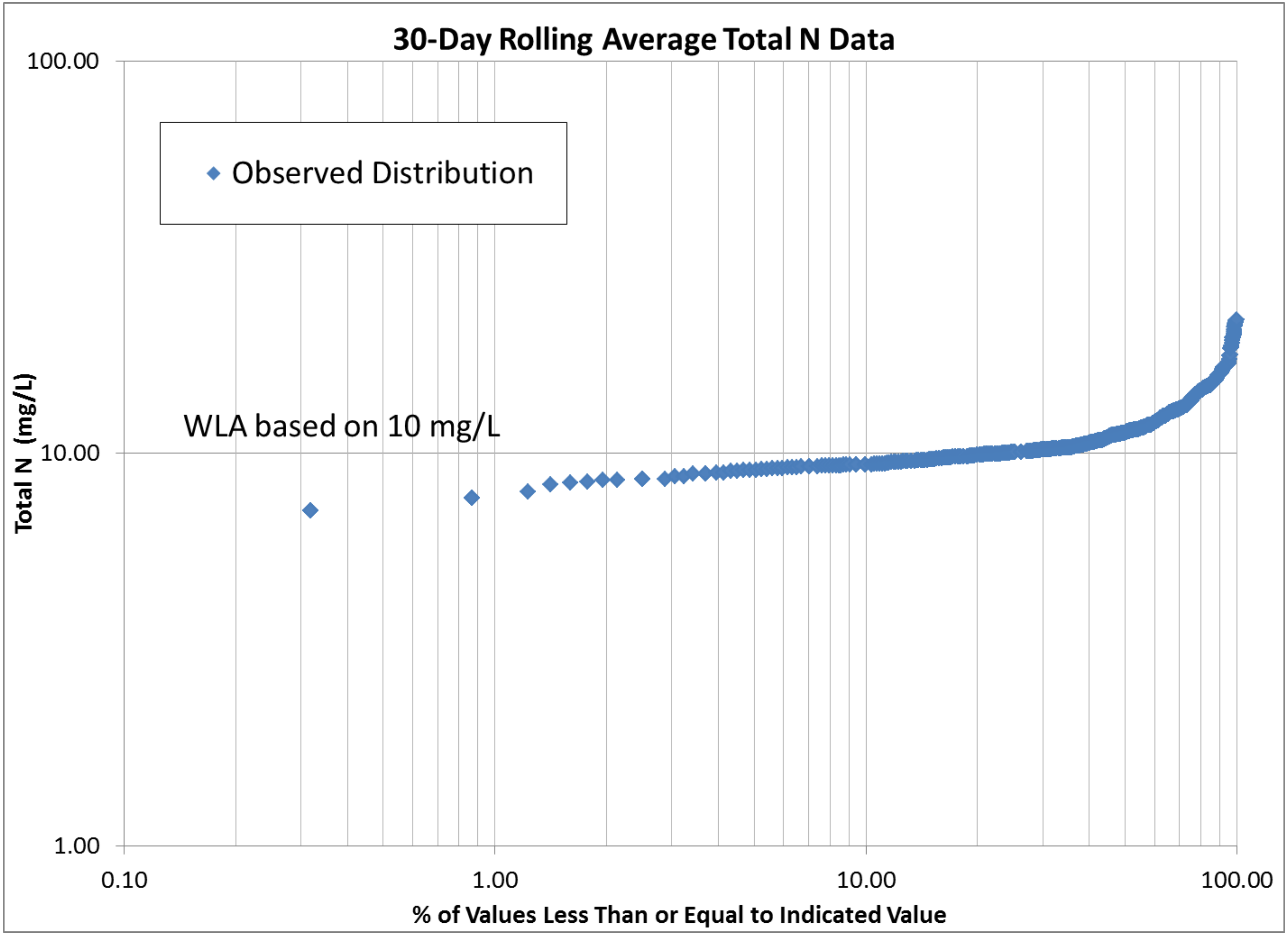
- Step 1: Express the WLA as a time-averaged target concentration at design flow.
- Step 2: Use time-averaged data to create a concentration-probability plot

$$p = \left(\frac{rank}{n+1}\right)$$

*p* = Weibull probability

*rank* = rank of each time-averaged concentration

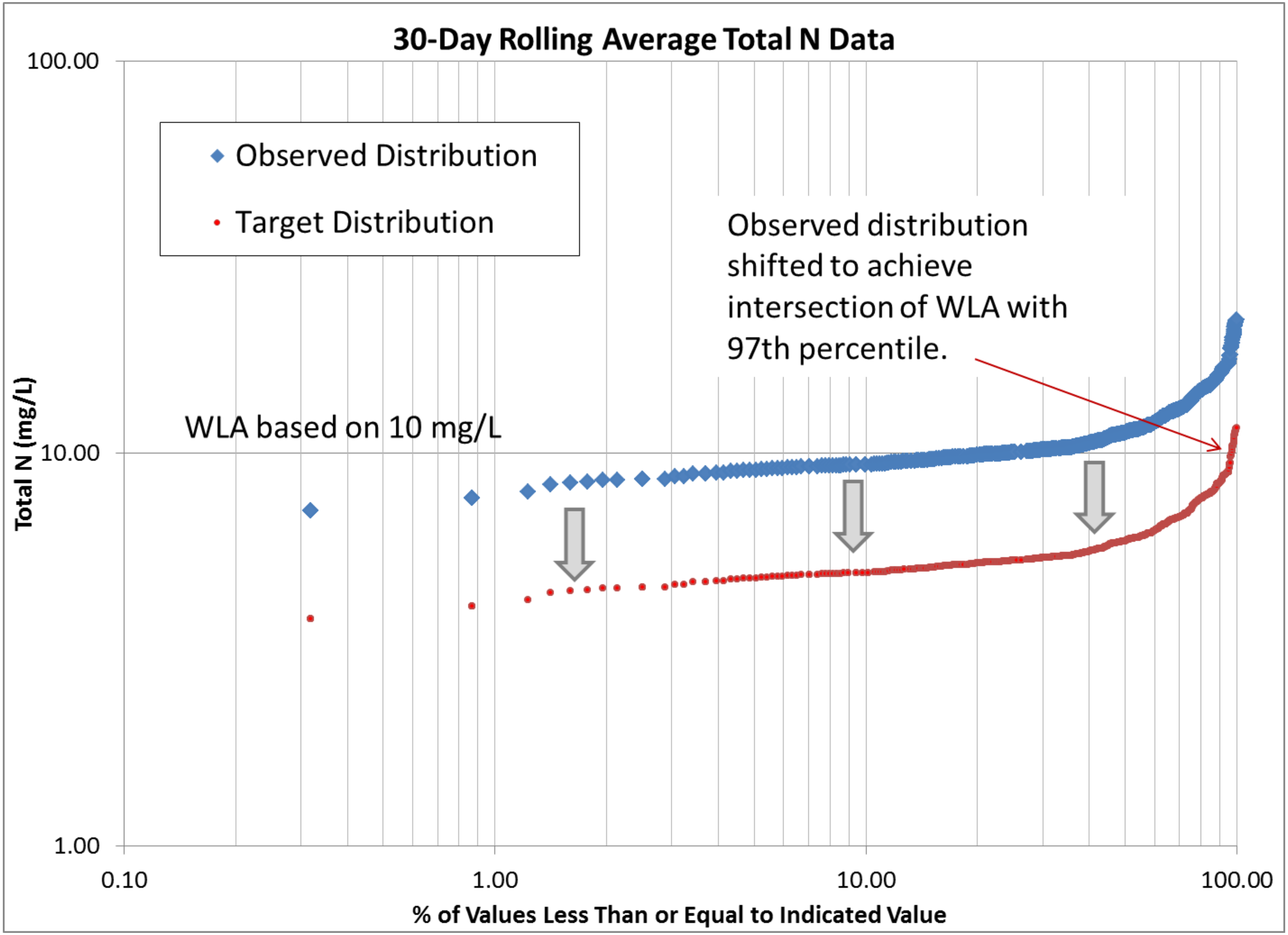
*n* = number of time-averaged concentrations in data set


30-Day Rolling Average Total N Data
Observed Distribution
WLA based on 10 mg/L
Total N (mg/L)
100.00
10.00
1.00
0.10
1.00
10.00
100.00
% of Values Less Than or Equal to Indicated Value

# Example #4: Empirical Alternative (cont.)

- Step 3: Choose probability basis (90th-99th percentile).
- Step 4: Adjust observed time-averaged concentrations to meet WLA at desired percentile

Assumption: Ratio of median to upper percentile is constant (Analgous to assumption of constant CV)


30-Day Rolling Average Total N Data
Observed Distribution
Target Distribution
Observed distribution shifted to achieve intersection of WLA with 97th percentile.
WLA based on 10 mg/L
Total N (mg/L)
100.00
10.00
1.00
0.10
1.00
10.00
100.00
% of Values Less Than or Equal to Indicated Value

# Example #4: Empirical Alternative (cont.)

- Step 5: Consider technology-based floors to treatment.
- Step 6: Set WQBELs based on percentiles of the target distribution, expressed at the appropriate averaging period

# Empirical Alternative to TSD Method

## Advantages

- Requires no assumption re. distribution
- Can directly consider lower limit to treatability

## Disadvantages

- Data intensive
- Like TSD approach, requires assumption regarding future variability
- Does not apply to extremely low limits

# Key Recommendations from 2014 Review

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| | 2 | Bioconfirmation to inform WLAs. |
| | 3 | Consider preferential nutrient controls. |
| | 4 | Tailor critical conditions and frequency components. |
| | 5 | Full mix for nutrients; explore nutrient assimilation zones. |
| | 6 | Watershed-based permitting. |
| Calculating WQBELs | 7 | Use appropriate averaging periods. |
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| Treatability | 12 | Do not set WQBELs to unattainable levels. |

# Abbreviations

- AML Average monthly limit
- CV Coefficient of variation
- LTA Long-term average
- TSD USEPA Technical Support Document for Water Quality-Based Toxics Control
- WLA Wasteload allocation
- WQBEL Water quality based effluent limit