MEMORANDUM

Subject: A suggestion for a PCB TMDL decision process for determining the basis for reductions, given the incorporation of "long term average" language for human health criteria into the WQS

To: Mark Richards
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Below is a potential decision process for determining the basis for PCB reductions, given the incorporation of the following language into the WQS: **Human health criteria are based on the assumption of average amount of exposure on a long-term basis.**

- Determine whether the TMDL calibration model output is normal/lognormal or whether the distribution is neither.
    - If the model output is normally distributed, select the arithmetic mean as the measure of central tendency for aggregating model output over the simulation period.
    - If the model output is lognormally distributed, select the geometric mean as the measure of central tendency for aggregating model output over the simulation period.
    - If model output distribution is neither normal nor lognormal, a median of the model output will need to be the measure of central tendency for aggregating model output over the simulation period.

- Determine which specific statistic of central tendency of the model output should be evaluated against the endpoint.
    - If the mean of model output is **greater than** the endpoint:
        - Use the upper 95% CL of the mean as the basis for reductions.

    - If the mean of model output is **less than** the endpoint and the:
        - Upper 95% confidence limit of the mean (arithmetic or geometric) is greater than the endpoint, use this statistic as the basis for reductions. If the upper 95% CL is less than the endpoint, find the daily value closest to the upper 95% CL that is above the endpoint but is less than the 90^{th} percentile of a normal curve

composed from the mean and standard deviation of the model output.[1] Use this value as the basis for reductions.

- If the median of model output is **greater than** the endpoint:
  - Use the upper 95% CL of the median as the basis for reductions.

- If the median of model output is **less than** the endpoint and the:
  - If the upper 95% confidence limit of the median is greater than the endpoint, use this statistic as the basis for reductions. If the upper 95% CL is less than the endpoint, find the daily value closest to the upper 95% CL that is greater than the endpoint but no greater than the 90th percentile of the model output dataset. Use this value as the basis for reductions.

Equations

Upper 95% confidence limit of the arithmetic mean

= Arithmetic Mean + 1.96 * (standard deviation of daily averages)/sqrt(count of daily averages)

Upper 95% confidence limit of the geometric mean

= exp(arithmetic mean of log-transformed daily values) + 1.96 * exp(standard deviation of log-transformed daily averages)/sqrt(count of daily averages)

Upper 95% confidence limit of the median

Assuming you have 365 days' worth of daily values, the upper 95% confidence limit of the median will be the 202nd value in the dataset sorted from lowest to highest (the median is the 183rd value). This is calculated following the equation below.

$= 365 * 0.5 + 1.96*\text{sqrt}(365* 0.5*(1-.05))$

The result of this equation is rounded up to the nearest whole number

[1] My reasoning for this is that if a value is higher than the 90th percentile, it occurs so rarely that it should not be the driver of a TMDL centered around a long-term average. Note: the 90th percentile you would use as a reference would NOT be one computed directly from the model output. It would be the 90th percentile of a standard normal distribution with a mean and standard deviation derived from the model output. This can be calculated in Excel using this formula: =NORMDIST(value,mean,standard deviation,TRUE). If the result is greater than 0.90, then the value is greater than the 90th percentile of the theoretical distribution of daily PCB values.

An Example using Model Output of the Lower New River

The Lower New River model output does not exhibit a normal or lognormal distribution. I used the results generated from the calculator here: https://contchart.com/goodness-of-fit.aspx to make this inference. As shown in the table below, there can be substantial differences among statistics drawn from the same data, so it is important to choose carefully.

The median of the calibration ("existing") model output is greater than the endpoint, 45 ppq (see table below). So we would use the upper 95% confidence limit of the median to drive reductions. By doing so, we would be saying that we are 95% confident that the long-term average will be less than the endpoint once reductions are met.

New River model output statistics:

Arithmetic Mean Statistics	**PCB Value (pq/L)**
arithmetic mean	352
upper 95% CL	388
90th percentile of a normal distribution with mean = 352 and STDEV = 356	808
Geometric Mean Statistics	**PCB Value (pq/L)**
geometric mean	277
upper 95% CL	277
90th percentile of a lognormal distribution with Ln mean =5.624765 and Ln STDEV = 0.6069389	603
Median Statistics	**PCB Value (pq/L)**
median	241
upper 95% CL	258
90th percentile of model output	615

Why not always base reductions on the upper 95% confidence limit of the median? Medians are frequently chosen to represent the central tendency of environmental data since often the distribution of this kind of data is unknown. Medians are also less sensitive to outliers. However, when the distribution *is* known, a mean becomes a superior way of representing central tendency, as it is a statistical model composed from the entire dataset.

Why not always base reductions on the 90th percentile? While I think you could certainly select this statistic to add additional assurance that the long-term average will meet the endpoint, it would be a stretch to call this a measure of central tendency. The only case where I think it would defensible to use this statistic to drive reductions would be when a waterbody is only marginally impaired. Ideally, the calibration model output should show exceedances of the endpoint at or very close to the mean or median of daily averages.