Supporting Development of Nutrient Criteria Lakes and Reservoirs in Northern Plains States

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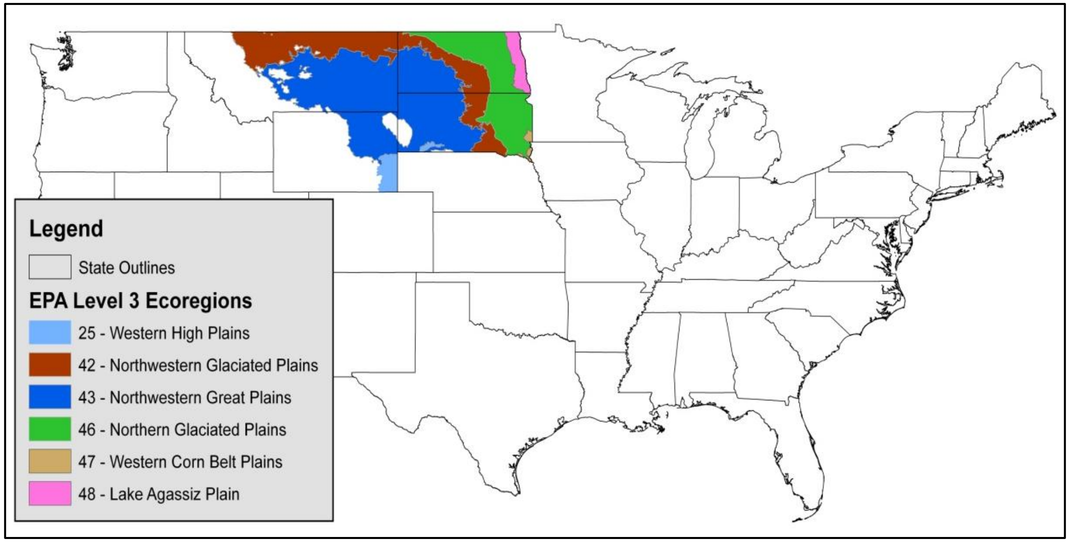
Background

- EPA working with states to develop nutrient criteria
- States generally lack information for "reference" conditions



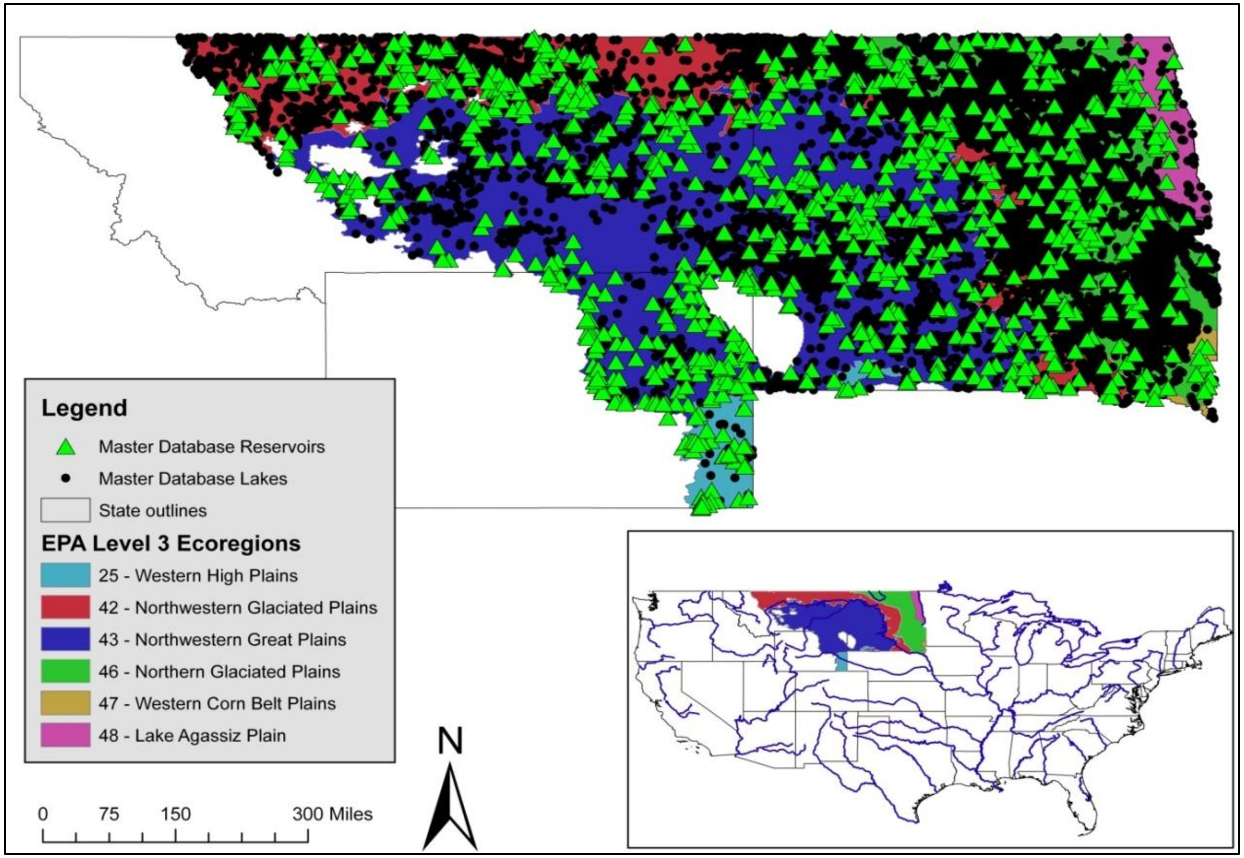
- Use a regional model to simulate conditions
  - Based on findings in ND work
  - Stochastic: incorporates uncertainty and represents regional conditions/resources (e.g., range of morphometries)
  - Calibrate to existing conditions; simulate "reference" and/or "desired" conditions

Master Databases

Master Databases:
19,938 lakes
1,065 reservoirs

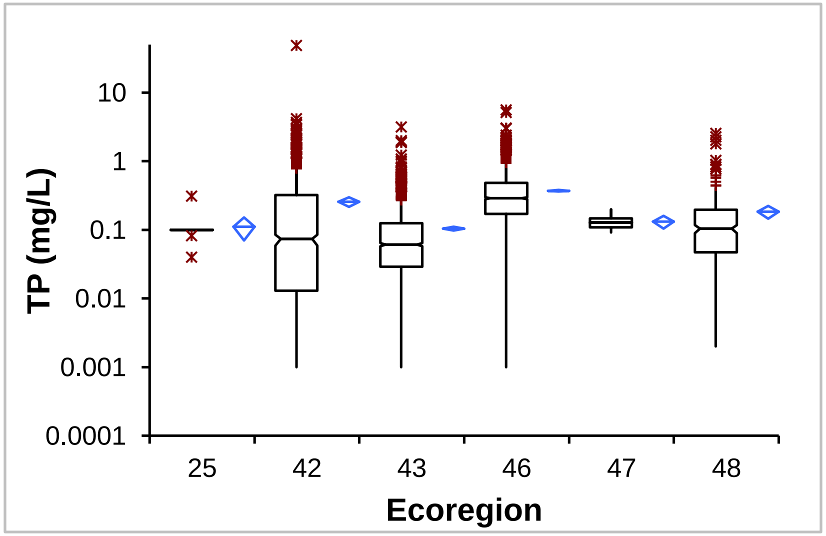
Waterbodies with needed morphometry:
57 lakes (all in ND)
375 reservoirs

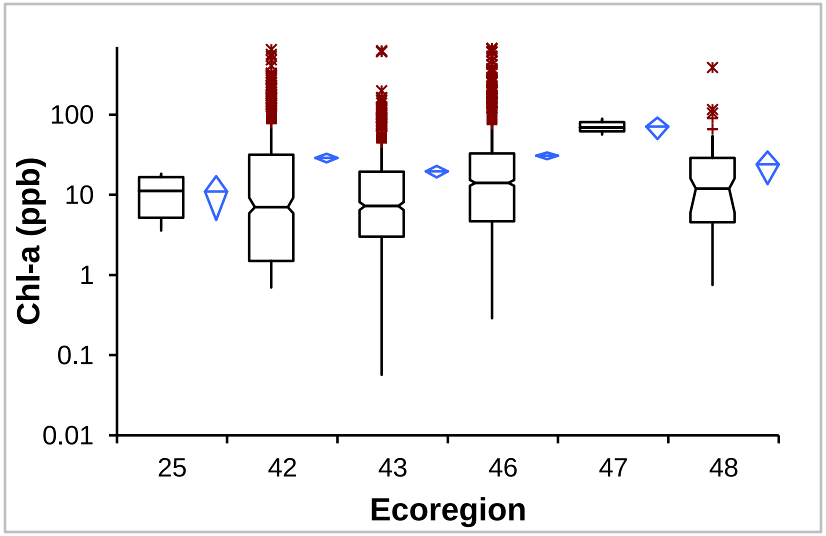
Reservoirs with needed water quality:
178 reservoirs



	North Dakota	South Dakota	Montana	Wyoming
# Reservoirs	306	237	309	213
Reservoirs w. WQ	87	88	0	3

Grouping Reservoirs





<u>Kruskal-Wallis Test Results</u>

TP, Chl-a & secchi by Ecoregion – $p<0.0001$

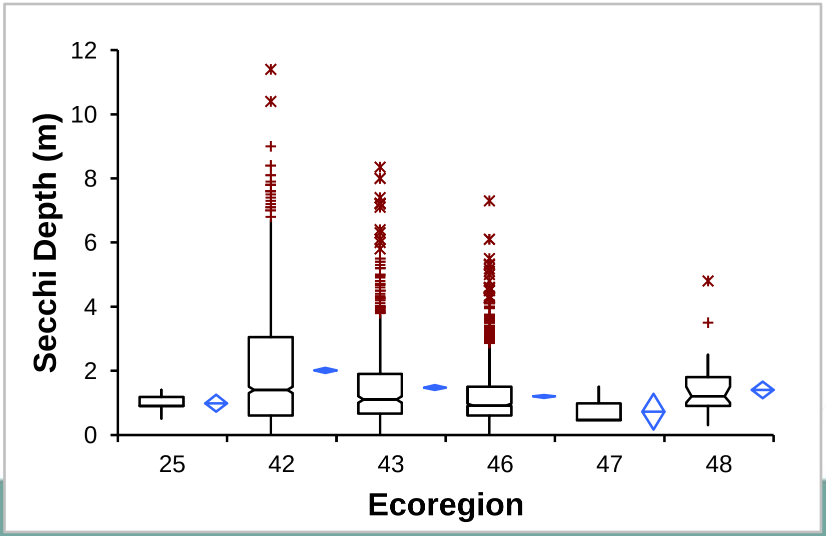
i.e., All distributions not equal

<u>Bonferroni Contrast Tests</u>

(pairwise analysis)

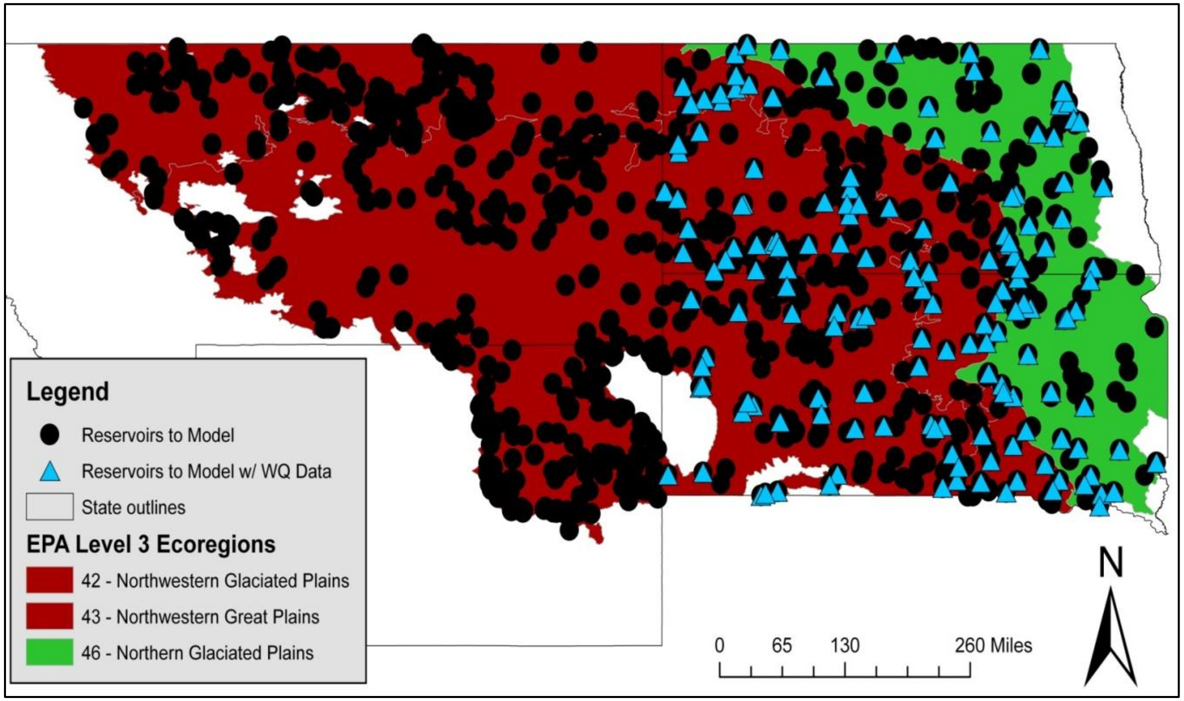
Show mixed results

All distributions are not different



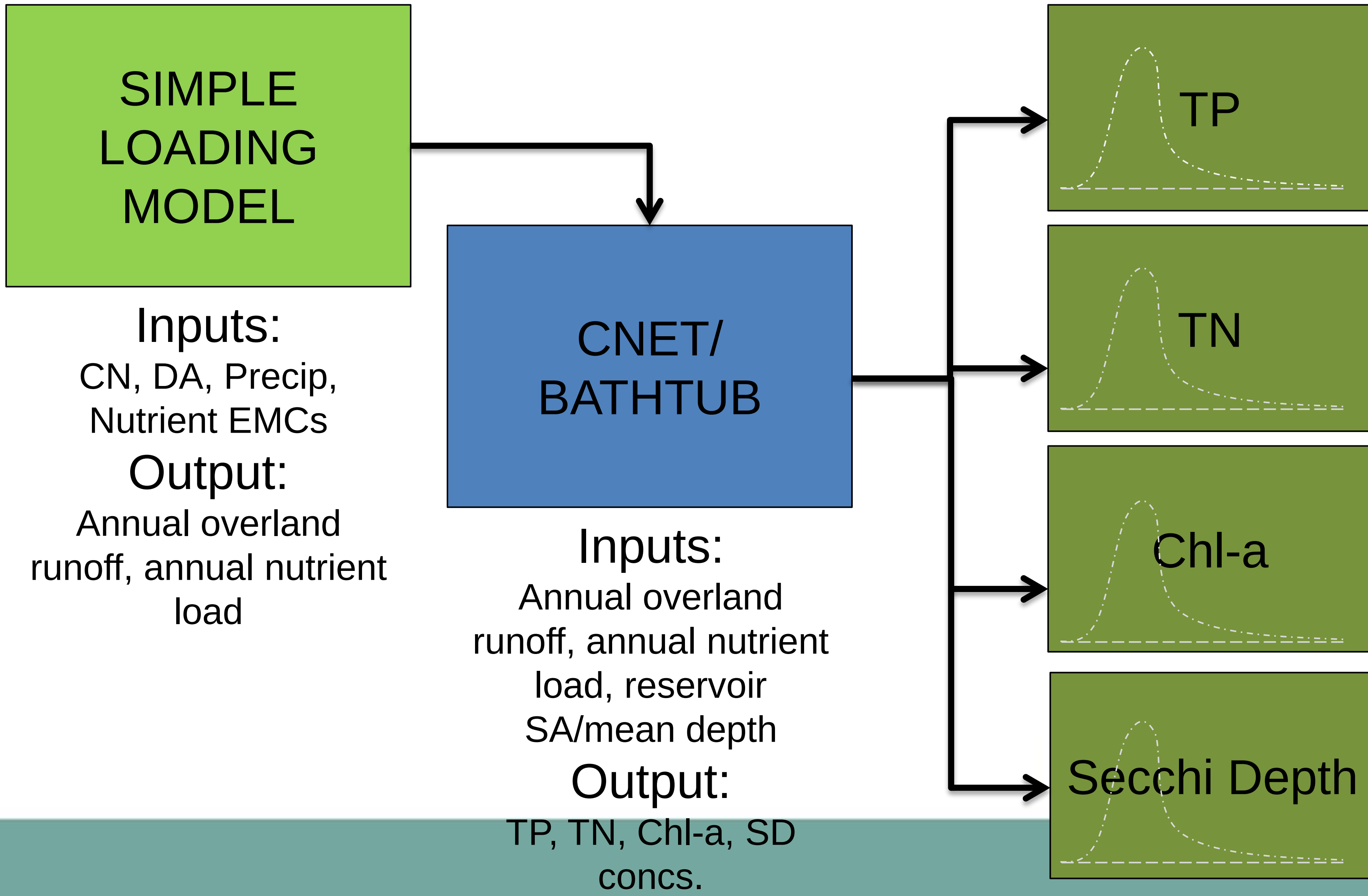
Modeling Approach

For purposes of likelihood of implementation, model by 42/43 and 46; exclude largest reservoirs

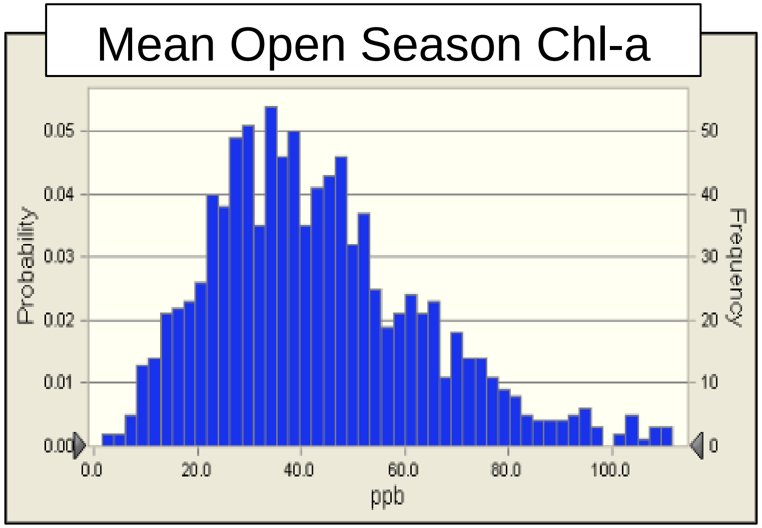


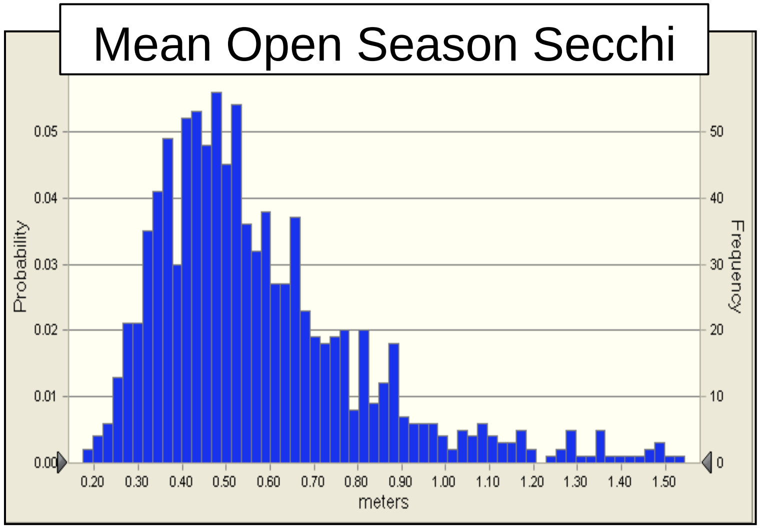
	North Dakota	South Dakota	Montana	Wyoming
# Reservoirs	274	218	293	149
Reservoirs w. WQ	75	82	0	0

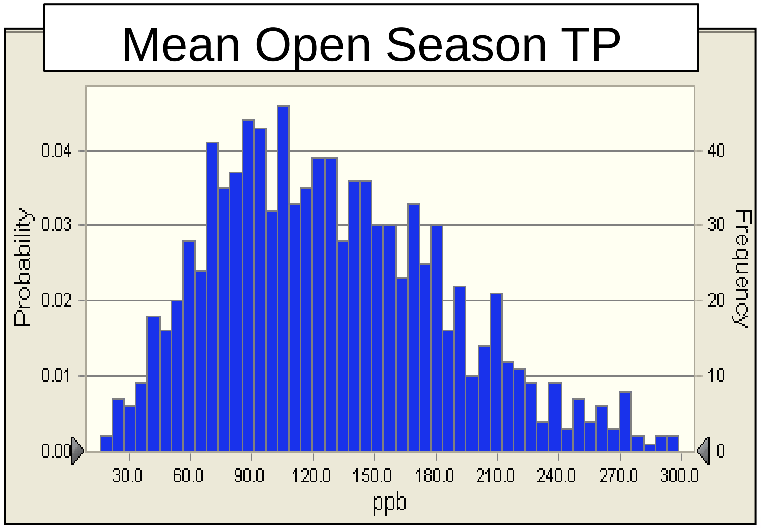
Stochastic Modeling Approach

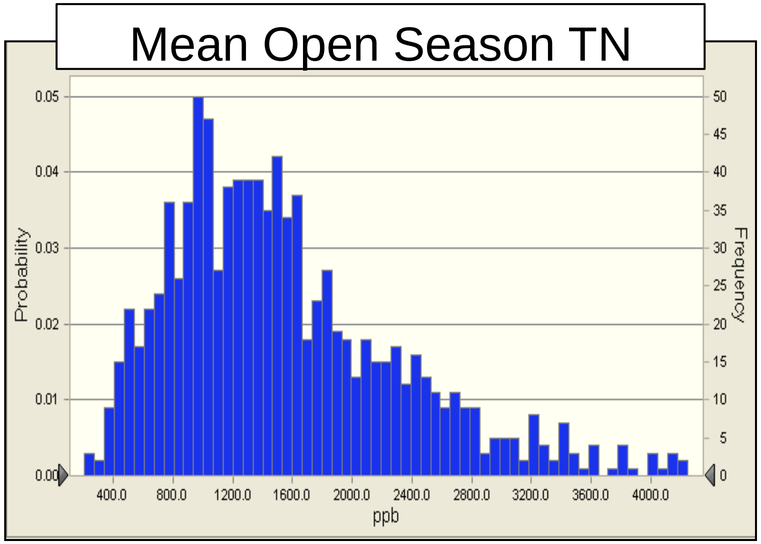


Receiving Model Outputs



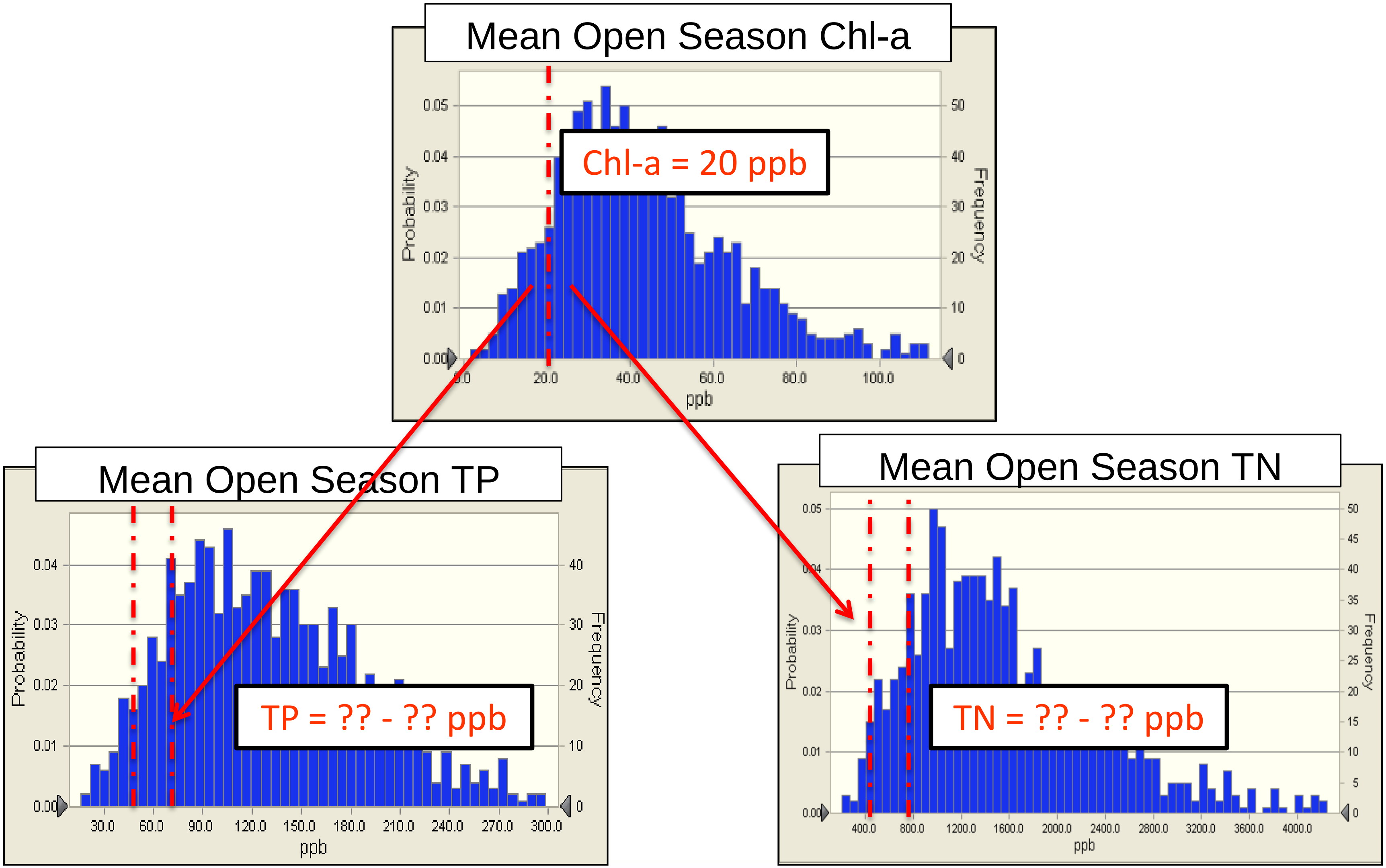






Existing Conditions

Identify Response (Chl-a) Threshold



Conclusions

- Another example of stochastic modeling to support nutrient criteria development
- Work would benefit from more data
- Results useful as guidance for policy decisions

Thank you.

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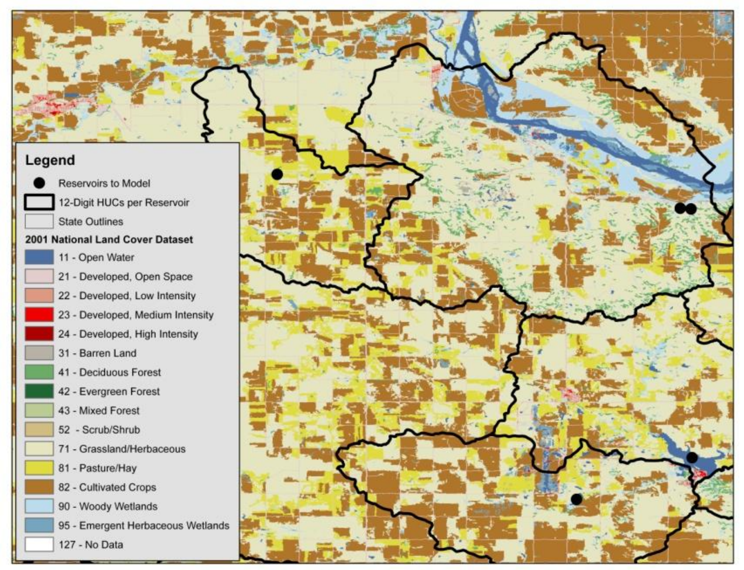
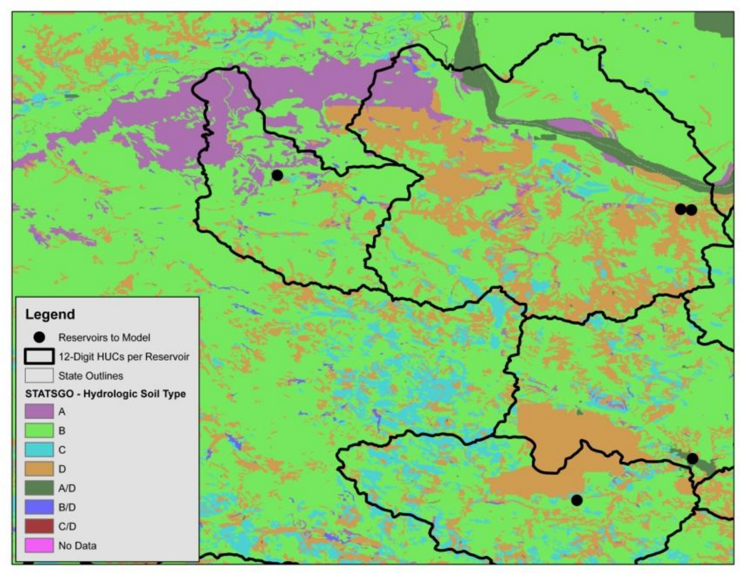
CN Development

- Represent reservoir DA (for loading model inputs) as intersecting HUC12
- Compute rasters of CN by combining data on LULC and soil type
- Compute weighted avg CN per general LU type in each HUC12
- Create distribution of CNs per general LU





Chl-a Response Modeling

<u>Chl-a vs. TP:</u>

Chl-a (mg/m^3) = [CB] * 0.28 * TP (mg/m^3)

Where: CB = Chl-a model calibration factor

<u>Chl-a vs. combined nutrient:</u>

$X_{pn} = [TP^{-2} + ((TN-150)/12)^{-2}]^{-0.5}$

$B_x = X_{pn}^{1.33} / 4.31$

$G = Z_{mix} (0.14 + 0.0039 * Fs)$

$B = CB * B_x / [(1 + 0.025 * B_x * G) * (1 + G * a)]$

Where:
- X_{pn} = Composite nutrient concentration (mg/m^3)
- B_x = Nutrient-potential Chl-a concentration (mg/m^3)
- G = Kinetic Factor
- Z_{mix} = Mean depth of mixed layer (m)
- F_s = Summer flushing rate (yr^{-1})
- a = Nonalgal turbidity (m^{-1}) = 1/S – 0.025 * B
- CB = Chl-a model calibration factor

Secchi Depth Response Modeling

<u>Secchi Depth vs. TP:</u>

Secchi (m) = [CS] * 48 / TP (mg/m^3)

Where: CS = Secchi depth model calibration factor

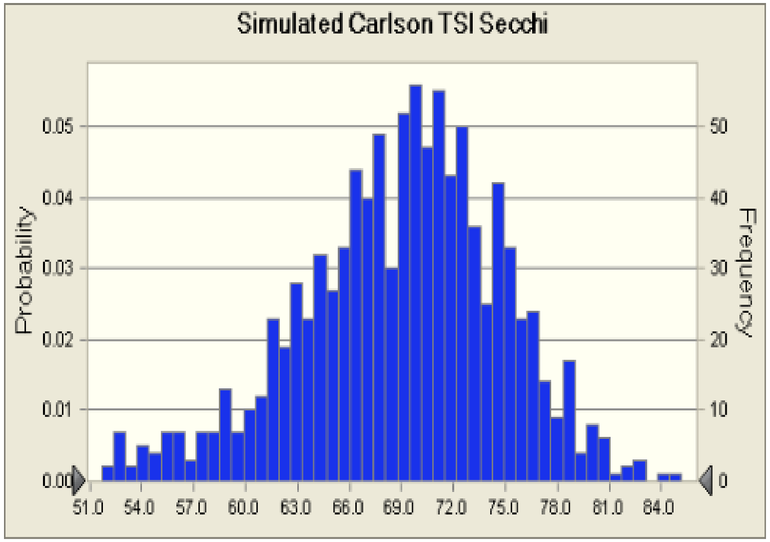
<u>Secchi Depth vs. Chl-a and Non-Algal Turbidity:</u>

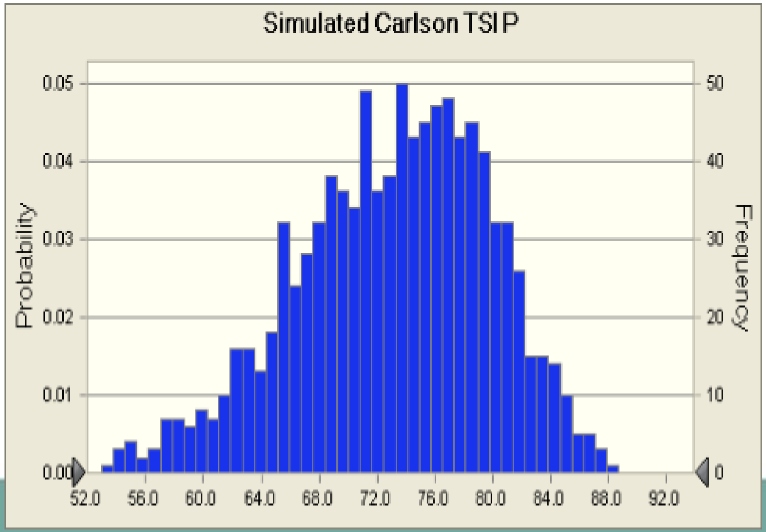
Secchi (m) = [CS] / (a + 0.025 * Chl-a)

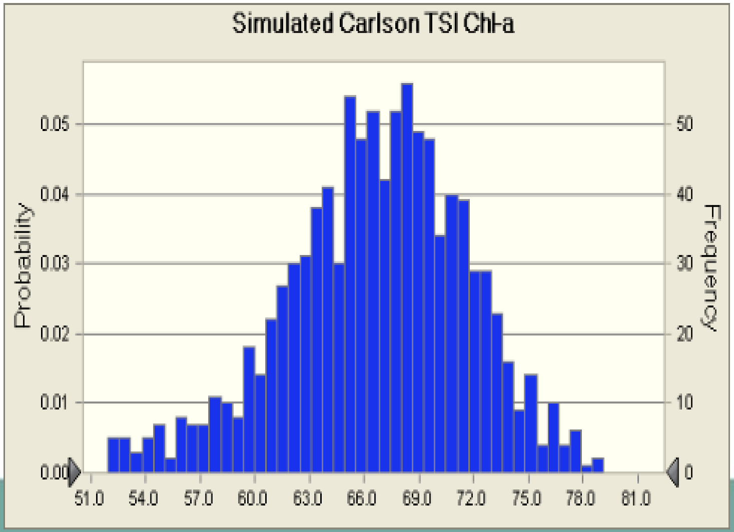
<u>Secchi Depth vs. Combined Nutrient:</u>

Secchi (m) = [CS] * 16.2 * $X_{pn}^{-0.79}$

Trophic States



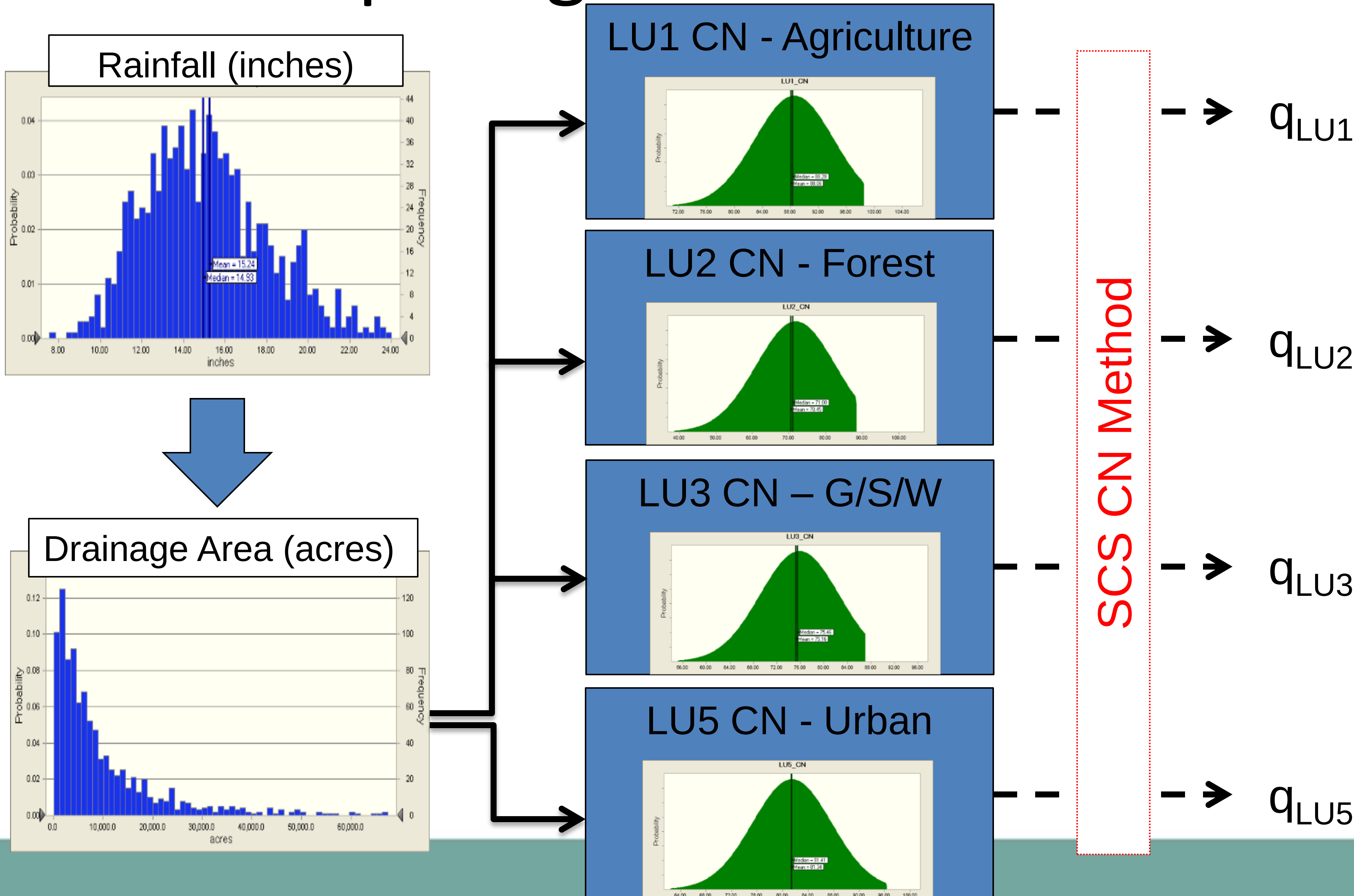




Loading Model

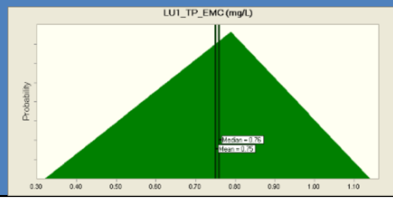
- Simple loading model based on SCS CN Method for computing runoff
- Use land use EMCs for pollutant loading
- Compute values on a daily timestep
- Sum to an annual open water (March 1 – Nov 30) season value
- Results:
  Open Water Season Overland Runoff, $Q_{overland}$
  Open Water Season TP Load, L_{TP}
  Open Water Season TN Load, L_{TN}

Computing Overland Runoff

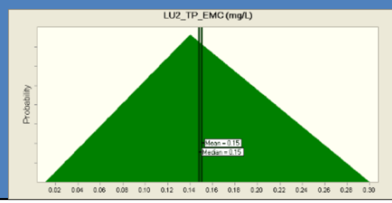


Computing Overland Nutrient Load

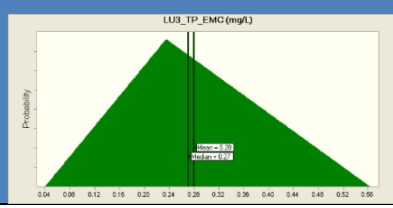
q_{LU1} * LU1 EMC - Ag = l_{LU1}



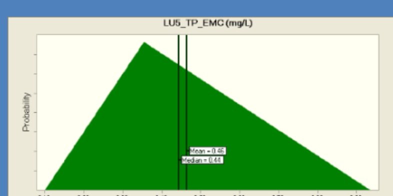
q_{LU2} * LU2 EMC - Forest = l_{LU2}



q_{LU3} * LU3 EMC – G/S/W = l_{LU3}



q_{LU5} * LU5 EMC - Urban = l_{LU5}



Total
<u>Overland Nutrient Load</u>

$$L_{TP} = \sum l_{LU_{n,TP}}$$

$$L_{TN} = \sum l_{LU_{n,TN}}$$

<u>Total Overland Flow</u>

$$Q_{overland} = \sum q_{LU_n}$$

Receiving Water Model

- CNET – spreadsheet version of BATHTUB (Walker, 1996)
- Empirically-based eutrophication model
  - Computes TP, TN, Chl-a, secchi depth, organic N, non-ortho-P, hypolimnetic oxygen depletion
  - Function of TP, TN, non-algal turbidity, hydraulic residence time

Receiving Model Inputs