Nutrient TMDLS for Algae-related Impairments to Lakes
TMDLs with Large Lakes or Reservoirs

1. Wisconsin River Basin - Castle Rock, Petenwell, and Lake Wisconsin

2. Upper Fox-Wolf Basin – Lake Winnebago and the pool lakes
Castle Rock
Lake Wisconsin
Lake DuBay
Petenwell
Water Quality Standards

* **Designated Uses:**
  - Fish & Aquatic Life
  - **Public Health** (Lake Winnebago)
  - Recreation

* **Water Quality Criteria:**
  - Numeric: dissolved oxygen, pH, bacteria, toxic substances, phosphorus, etc.
  - Narrative: “no objectionable deposits,” “substances in concentrations or combinations shall not be harmful to humans, fish, plants, or other aquatic life.”

* Per Wis. Stat. s. 281.15 water quality standards must be adopted by rule.
Recreational Use

Allowable phosphorus concentrations calculated to support recreational use by preventing excessive algae blooms.

(Chlorophyll a shall not exceed 20 µg/L more than 30% of days during July 15 – Sept 15).
Statewide Phosphorus Criteria

Rivers
100 µg/L

Streams
75 µg/L

Reservoirs
- Not Stratified = 40 µg/L
- Stratified = 30 µg/L

Inland Lakes
- Ranges from 15-30 µg/L

Great Lakes
- Lake Michigan = 7 µg/L
- Lake Superior = 5 µg/L

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1All unidirectional flowing waters not in NR 102.06(3)(a). Excludes Ephemeral Streams.
2Excludes wetlands and lakes less than 5 acres
Chlorophyll geomean target = 30% > 20 µg/L
TMDL Development Process

- Determine loading capacity
- Calculate baseline load contributions
- Allocate loads to sources
- Calculate receiving water concentrations

* For river/stream reaches:
  * Loading capacity = Water Quality Target (criteria) * Flow

* For lakes and reservoirs a response model is needed to simulate loads based on waterbody characteristics to determine pollutant response (algal growth vs TP)
Lake Modeling

* Use the least complicated model that represents the answers the questions that need to be addressed

* What’s going on in the reservoir system?
  • Size, shape, depth, volume
  • Hydrologic budget (rain, evaporation, inflow, outflow)
  • Pollutant concentration
  • Chemical conditions
### Site-Specific Total Phosphorus Criteria for Petenwell Flowage, Castle Rock Flowage, and Lake Wisconsin Reservoir

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Existing TP Criterion (µg/L)</th>
<th>Recommended Site-Specific TP Criterion (µg/L)</th>
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</thead>
<tbody>
<tr>
<td>Petenwell Flowage</td>
<td>40</td>
<td>53</td>
</tr>
<tr>
<td>Castle Rock Flowage</td>
<td>40</td>
<td>55</td>
</tr>
<tr>
<td>Lake Wisconsin</td>
<td>100</td>
<td>47</td>
</tr>
</tbody>
</table>

*Calculated to support recreational use by preventing excessive algae (Chlorophyll a shall not exceed 20 µg/L more than 30% of days during July 15 – Sept 15)*
Percent Reduction Maps

Current Criteria

Percent Reduction
- 0%
- 1 - 25%
- 25.1 - 50%
- 50.1 - 60%
- 60.1 - 70%
- 70.1 - 80%
- 80.1 - 90%
- 90.1 - 93%

Outfalls •

SSC
Cores were collected at two sampling sites and dated with sedimentation rates determined.

Diatoms were collected from the cores at the top and bottom of the cores to evaluate current and historic phosphorus concentrations (μg/L).

<table>
<thead>
<tr>
<th></th>
<th>Top</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Basin</td>
<td>108</td>
<td>40</td>
</tr>
<tr>
<td>South Basin</td>
<td>94</td>
<td>47</td>
</tr>
</tbody>
</table>
Schematic for the Eutrophication Model Bathtub (Simulations of Winnebago Pools)

- **Stream Gage**
- **Direct Tributary Input**
- **Ungaged Input**
- **Internal Loading**
- **Groundwater Loading**
- **Point Sources**
Simulation of a 75% Reduction in all external loading to the Upper Fox/Wolf Basin

The BATHTUB model shows that a 73% reduction in external load is needed to meet 0.04mg/L.

Upper Pools need about a 70% Reduction in Loading & 40 yrs to Reach 0.04 mg/L
Winnebago needs about a 75% Reduction in Loading & 75 yrs to Reach 0.04 mg/L
Historical Comparison of Butte des Morts

 Estimated internal load during the growing season accounts for 56% of the total growing season phosphorus load to Lake Winnebago (2009-2011) compared to 15% for Lake Poygan, 14% for Lake Butte des Morts, and 3% for Lake Winneconne.
Restoration of Aquatic Plants