Evidence of Inlet Leading to Eutrophication (2012-2018 data)

Inlet Water Quality Means
- DO = 7.0 mg/L
- Conductivity = 397 mS/cm
- TP = 0.245 mg/L
- TNH = 1.7 mg/L
- TSS = 57

Lake Water Quality Means
- DO = 8.8 mg/L
- Conductivity = 285 mS/cm
- TP = 0.018 mg/L
- TNH = 0.8 mg/L
- TSS = < 10

Bottom Hardness Maps

2014

2018

Sediment Bottom Hardness Trends

<table>
<thead>
<tr>
<th>Relative Bottom Hardness</th>
<th>May 2014 % Cover</th>
<th>August 2014 % Cover</th>
<th>June 2014 % Cover</th>
<th>June 2017 % Cover</th>
<th>September 2017 % Cover</th>
<th>% Loss (or Gain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>15-30</td>
<td>12.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>30-50</td>
<td>12.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>50-60</td>
<td>12.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>&gt;60</td>
<td>12.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-</td>
</tr>
</tbody>
</table>
Austin Lake Basin & Watershed Data
- Lake Area = 1,090 acres
  (South Basin = 245 acres)
- Lake Volume = 4,408 acre-feet
- Mean Depth = 4.0 feet
- Max Depth = 14.0 feet
- Watershed: Lake Ratio = 16.8

Austin Lake South Basin & Mandigo Marsh
- Road was constructed between Mandigo Marsh and South Basin resulting in low outflow of sediments/nutrients
- Steep slopes around most of shoreline, impaired soils
- Sediment accumulations up to 17 meters in Basin
- Pre-aeration sediments were highly anoxic, high in H₂S, impeding navigation
Austin Lake South Basin Impairments

- Unconsolidated, silty
- Intense H2S odor
- High ammonia concentrations (toxic to aquatic life)
- Anoxic sediments (low ability to break down)
- High in organic matter
- Black, jelly-like in some areas (inability to use lake bottom)
- Impediment to recreation and navigation

Why not Dredging?

- In order to remove approximately 1,666,666 cubic yards (yd³) of sediment from the South Basin of Austin Lake, (assuming a dredging cost of $17 per cubic yard), to a depth of 5 feet, the cost of a dredging project would be approximately $28,333,322 dollars.
- A study by Straw et al., 1978 determined that 28 of the 50 sediment samples analyzed were lead-contaminated with concentrations up to 224.9 ppm.

Austin Lake South Basin System

- 27 micro-porous ceramic diffusers
- 28,500 feet of self-sinking airline
- Bacteria and enzyme treatments which consist of 50 gallons of bacteria for nitrogen reduction, 200 gallons of enzyme as a catalyst for mud reduction, and 200 lbs of bacteria for mud reduction.
- On-land components consist of 3 locally-sourced sheds and 5 4HP rotary claw compressors along with cooling fans and ventilation.
Sediment Muck Loss Measurement Methods

- Measurements taken at n=45 "control" and n=19 diffuser sites in SB
- Measurement "instruments" included metered plate and Lowrance® GPS transducer (accurate to 1 inch)
- All measurements taken on calm days
- Lake level data recorded via USGS online website and sediment loss calculated between sampling periods accounting for changes in lake level and depth measurements
Changes in Muck Loss w/Time

<table>
<thead>
<tr>
<th>Year</th>
<th>Diffuser</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>-10.8°</td>
<td>-6.0°</td>
</tr>
<tr>
<td>2013</td>
<td>-1.9°</td>
<td>-1.9°</td>
</tr>
<tr>
<td>2014</td>
<td>-6.0°</td>
<td>-11.6°</td>
</tr>
<tr>
<td>2015</td>
<td>+16.9°</td>
<td>+15.5°</td>
</tr>
<tr>
<td>2016</td>
<td>-5.4°</td>
<td>-4.8°</td>
</tr>
<tr>
<td>NET</td>
<td>-17.2°</td>
<td>-8.8°</td>
</tr>
</tbody>
</table>

Conclusions/Recommendations

- To date, a net loss of 17.2" muck in diffuser sampling areas and 6.6" muck loss in "control" areas (system only operational Apr 1-Nov 30 each year per MDEQ)
- Significant differences in both sediment ammonia and nitrate/nitrite (both decreased)
- Observed changes in sediments may also explain reduction in ammonia-loving aquatic vegetation (i.e., milfoil)
- Recommendation: Keep aeration system in SB and bioaugmentation with enzymes/bacteria/measurements/re-evaluate
- Conduct surveys of entire lake and recommend EWM treatment in areas outside of SB

Case Study #3 Sherman Lake, Kalamazoo County, MI
Sherman Lake Issues:

PRE-AERATION
- Excessive aquatic plant growth (ex. Elodea and Egeria Pontederia)
- Excessive algae
- Excessive mud accumulation
- Invasive aquatic plants dominating littoral zone
- Decline in DO with depth during stratification

POST-AERATION
- Some algae
- Invasive aquatic plants present but controlled
Sherman Lake Post-Aeration

BioBlast Treatments:
- BioBlast begins in 2018 to reduce cyanobacteria
- Increase proportion of good algae
- Done at least 2x per season on lake
- Uses ONLY natural components
- Reduces dependency on algaecides
Trends in Blue-Green Algae with Time:

<table>
<thead>
<tr>
<th>PIC and/or Location</th>
<th>Lake/pond</th>
<th>Date</th>
<th>Cyanobacteria (Xmg/L)</th>
<th>Chlorophyll A (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinehurst</td>
<td>Pine</td>
<td>5/27/19</td>
<td>275</td>
<td>900</td>
</tr>
<tr>
<td>Pinehurst</td>
<td>Pine</td>
<td>5/27/19</td>
<td>500</td>
<td>75</td>
</tr>
<tr>
<td>Pinehurst</td>
<td>Pine</td>
<td>5/27/19</td>
<td>200</td>
<td>75</td>
</tr>
<tr>
<td>Pinehurst</td>
<td>Pine</td>
<td>5/27/19</td>
<td>313</td>
<td>60</td>
</tr>
</tbody>
</table>

Management Recommendations

- Maintain LFA system with bioaugmentation
- Reduce P, N, and TSS loads from drains through mitigation buffers and re-routes
- Continue monitoring lake and drain water quality
- Use aquatic herbicides sparingly only where critical (scan of lake in early July to determine if any is needed)
- If needed, use harvesting or DASH for other nuisance growth (NOTE: this may be costly)