Northern Everglades
Water Quality Monitoring
Network Expansion

Blue-Green Algae Task Force Meeting
December 8, 2021

Lawrence Glenn, Division Director, Water Resources
Governor’s Executive Order 19-12

Expanded Monitoring Implemented to:

1. Expedite nutrient reductions in the Northern Everglades
2. Facilitate Blue-Green Algae Task Force initiatives
3. Facilitate DEP’s efforts to achieve Total Maximum Daily Loads under the Basin Management Action Plans
4. Augment data-driven scientific approaches
Northern Everglades Water Quality Monitoring Networks

Receiving Waterbody Monitoring

Watershed Monitoring
Lake Okeechobee, St. Lucie, Caloosahatchee, and C-51
Lake Okeechobee Previous Monitoring

- Sampling at Inflows/Outflows
  - Sampled Weekly or Bi-weekly. Also sampled for algae and toxin at FDEP request or when bloom is observed

Sampled Monthly

- [Green Circle] In-Lake Sampling
- [Yellow Triangle] Marsh Sampling (>13.5 ft Stg)
- [White Circle] Toxin and Algal Communities
Uses of In-Lake Data

- Assess long-term trends in water quality standards for FDEP
- Measure downstream effects of watershed restoration projects
- Monitor effects of lake stage on distribution of nutrients and sediment
- Calibrate and ground truth satellite monitoring data
- General predictions of potential magnitude of summer algal blooms
- Respond to regional water quality concerns
Lake Okeechobee Expanded Monitoring

- Existing Monitoring Locations
- Sample 2 Fisheating Bay sites regardless of stage (no longer restricted to stages >13.5 ft NGVD)
- 13 New monitoring stations focused on bloom gradients
- Sample all 32 locations monthly (Nov – Apr) and 2x/month May - Oct

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Lake Okeechobee Expanded Monitoring Details

- Expanded toxin, comprehensive algal ID from 6 to 9 stations
- May – Oct: Monitor toxins and simple algal ID (dominant species) at all 23 other stations
- Sample all 32 locations monthly Nov – Apr, Twice/month May - Oct
- Automated sondes @ 6 locations. 2 buoys: DO, pH, SCOND, Temp, Chl, phycocyanin (BGA), ammonia, nitrate, and turbidity at surface and DO, Chl, phycocyanin (BGA), ammonia, nitrate, and turbidity at bottom. 4 platforms: DO, pH, SCOND, Temp, Chl, phycocyanin (BGA), ammonia, nitrate, and turbidity at both the surface and bottom.
- Light sensors deployed @ 3 locations in SAV areas
Lake Okeechobee Algae Bloom Monitoring & Expansion

<table>
<thead>
<tr>
<th>Elements</th>
<th>Existing</th>
<th>Expanded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored sites</td>
<td>17-19</td>
<td>32 (plus sondes)</td>
</tr>
<tr>
<td>Primary Collection Method and Frequency</td>
<td>Monthly grabs</td>
<td>Biweekly grabs in Bloom Season (May thru Oct)</td>
</tr>
<tr>
<td>Monitored parameters of interest</td>
<td>TP, OPO4, TN, NH4, NOx, Chla, Turb (all sites)</td>
<td>Same WQ parameters (32 sites). Toxin, Algae ID/cnets 9 sites (3 new). Toxin, dominant algae during bloom season (all 32 sites)</td>
</tr>
</tbody>
</table>

**Result:** Spatial increase in sampling (red), doubled intensity during algal bloom season. Toxin and dominant species ID at 32 locations, 2x/mo May-Oct. Toxin and algae community ID at 9 sites year-round. Seven locations with automated meters for bloom predictions (Turb, Chla, Temp, pH, and/or light)

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Lake Okeechobee Expanded Monitoring

Will ensure data exists for:

1. More robust statistical analysis of trends
2. Better monitoring, documentation of ephemeral bloom conditions and associated toxins
3. Building predictive models for algal blooms
4. Building better predictive models for SAV (a factor in bloom formation, intensity)
5. Gradient analyses between distinct water quality regions, effects of stage on those gradients

West Lake Okeechobee, July 2018
Lake Okeechobee Expanded Monitoring – Cost & Effort

- Annual cost for In-Lake Expanded Monitoring is $572k
- SFWMD conducts 13 sampling trips per month (10 hours/trip) for In-Lake Expanded Monitoring.
- SFWMD laboratory tests increased from 11,848 to 21,225 tests per year following implementation of In-Lake Expanded Monitoring (9,377 additional tests per year).
In April 2015, SFWMD and the FDEP entered into a verbal agreement to collect surface water BGA samples at stations where algal blooms were reported.

As the lead agency coordinating the State’s response to algal blooms, the FDEP provides sampling supplies, identifies sampling locations, analyzes samples, manages data, and disseminates results to the public.

SFWMD supports this effort by collecting samples at routine SFWMD monitoring stations and from other locations, when requested by the FDEP, and as resources allow.

The primary goal of this agreement is to maximize State resources and minimize duplication of effort.
Watershed Monitoring – Basins

- **Basin Monitoring Sites**
  - Represents large regional hydrologic areas
  - Sampled at SFWMD structures or USACE
  - Long-term robust data sets
  - Flow volume, total phosphorus (TP), total nitrogen (TN), physical parameters (pH, Temperature, Dissolved Oxygen, Conductivity)

- **Uses of Data**
  - Determine relative contributions
  - Establish benchmarks/metrics (FDEP)
  - Measure progress
  - Calibrate & ground-truth models
  - Select, design, & optimize watershed protection plan projects

Lake Okeechobee Watershed TP Load (%)

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Watershed Monitoring – Upstream

- Upstream Monitoring Sites
  - Represents localized areas within Basins
  - Less robust data sets
  - Typically only TP & TN concentration

Uses of Data
- Identify target source areas within priority basins
- Address site specific drivers of nutrient loads
- Identify appropriate nutrient reduction activities
- Select Alternative Nutrient Technologies
- Measure progress of specific remedial activities
Lake Okeechobee Watershed Expanded Upstream Monitoring

<table>
<thead>
<tr>
<th>Elements</th>
<th>Existing</th>
<th>Expanded</th>
</tr>
</thead>
<tbody>
<tr>
<td># of sites</td>
<td>113</td>
<td>37 new</td>
</tr>
<tr>
<td>Primary Collection Method &amp; Frequency</td>
<td>Monthly grabs</td>
<td>Biweekly grabs</td>
</tr>
<tr>
<td>Monitored parameters</td>
<td>TP – all sites (37 new)</td>
<td>TN – all sites (110 new)</td>
</tr>
<tr>
<td></td>
<td>OPO4, NH4, NOx, pH, Temperature, Dissolved Oxygen, Conductivity – all sites (150 new)</td>
<td></td>
</tr>
</tbody>
</table>

Result: 150 sites over 3.5 million acres, 37 sites added to improve representation of priority areas.
### St Lucie Watershed Expanded Upstream Monitoring

<table>
<thead>
<tr>
<th>Elements</th>
<th>Existing</th>
<th>Expanded</th>
</tr>
</thead>
<tbody>
<tr>
<td># of sites</td>
<td>31</td>
<td>15 new</td>
</tr>
<tr>
<td>Primary Collection Method &amp; Frequency</td>
<td>Biweekly grabs</td>
<td>Biweekly grabs</td>
</tr>
<tr>
<td>Monitored parameters</td>
<td>TP, OPO4, TN, NH4, NOx, Conductivity</td>
<td>TP, OPO4, TN, NH4, NOx, Conductivity - (15 new) pH, Temperature, Dissolved Oxygen - all sites (46 new)</td>
</tr>
</tbody>
</table>

**Result:** 46 sites over 640,000 acres, 11 of 15 new sites in the freshwater basins (C-23, C-24, C-44) not previously represented & which represent a substantial portion of nutrient load.

Presenter: Lawrence Glenn
Caloosahatchee Watershed Expanded Upstream Monitoring

<table>
<thead>
<tr>
<th>Elements</th>
<th>Existing</th>
<th>Expanded</th>
</tr>
</thead>
<tbody>
<tr>
<td># of sites</td>
<td>- No SFWMD sites</td>
<td>15 new</td>
</tr>
<tr>
<td></td>
<td>- Local Entities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sample coastal &amp; tidal basins</td>
<td></td>
</tr>
<tr>
<td>Primary Collection Method &amp; Frequency</td>
<td>Not applicable</td>
<td>Biweekly grabs</td>
</tr>
<tr>
<td>Monitored parameters</td>
<td>Not applicable</td>
<td>TP, OPO4, TN, NH4, NOx, pH, Temperature, Dissolved Oxygen, Conductivity (15 new)</td>
</tr>
</tbody>
</table>

Result: 15 sites over 1 million acres to represent the freshwater basins (East and West Caloosahatchee Basins), a substantial portion of nutrient load.

Presenter: Lawrence Glenn
# C-51 Basin Expanded Monitoring

<table>
<thead>
<tr>
<th>Elements</th>
<th>Existing</th>
<th>Expanded</th>
</tr>
</thead>
<tbody>
<tr>
<td># of sites</td>
<td>0</td>
<td>21 new</td>
</tr>
<tr>
<td>Primary Collection Method &amp; Frequency</td>
<td>Not Applicable</td>
<td>Biweekly if flowing grabs</td>
</tr>
<tr>
<td>Monitored parameters</td>
<td>Not Applicable</td>
<td>TP, OPO4, TN, NH4, NOx, TSS, pH, Temperature, Dissolved Oxygen, Conductivity (21 new)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MBAS (surfactants) (8 new)</td>
</tr>
</tbody>
</table>

**Result:** 21 sites over 60,000 acres to represent the freshwater basin (C-51 Basin) not previously represented.

Presenter: Lawrence Glenn
## Northern Everglades Watershed Monitoring

<table>
<thead>
<tr>
<th>Elements</th>
<th>Basin Level</th>
<th>Upstream Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># of sites</strong></td>
<td>47</td>
<td>211</td>
</tr>
<tr>
<td></td>
<td>32 LOW, 8 CRW</td>
<td>150 LOW, 15 CRW</td>
</tr>
<tr>
<td></td>
<td>7 SLRW</td>
<td>46 SLRW</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Biweekly or Weekly</td>
<td>Biweekly</td>
</tr>
<tr>
<td><strong>Monitored parameters</strong></td>
<td>TP, OPO4, TN, NH4, NOx, pH, Temperature, Dissolved Oxygen, Conductivity</td>
<td>TP, OPO4, TN, NH4, NOx, pH, Temperature, Dissolved Oxygen, Conductivity</td>
</tr>
</tbody>
</table>

**Result:** 258 SFWMD monitored sites across over 5 million acres
Watershed Expanded Monitoring – Cost & Effort

- Annual cost for Watershed Expanded Monitoring is $1.2M:
  - Lake Okeechobee Watershed (Upstream) $753K
  - St. Lucie Watershed $94K
  - Caloosahatchee Watershed $144K
  - C-51 Basin $205K
- SFWMD conducts 33 sampling trips per month (10 hrs./trip) for Watershed Expanded Monitoring:
  - Lake Okeechobee Watershed (Upstream) - 18 trips
  - St. Lucie Watershed - 7 trips
  - Caloosahatchee Watershed - 4 trips
  - C-51 Basin - 4 trips
- SFWMD laboratory tests increased from 12,316 to 25,120 tests per year following implementation of Watershed Expanded Monitoring (12,804 additional tests per year).
Data Storage and Accessibility

- All Expanded Monitoring data are available in DBHYDRO and publicly accessible.
- BGA Response samples (both SFWMD and FDEP results) are available in DBHYDRO but not publicly accessible (coded as NRD).
- Current turnaround time is 26 days from collection->analysis->validation->uploaded to DBHYDRO.
- Uploads to WIN are performed monthly. Current turnaround is approximately 45 days from collection to load to WIN.
Bloom Events

Total Number of Bloom Events Per Site

- Number of bloom events (chl a > 40 µg/L) decreased by ~25% since May
- The highest number of blooms (7 out of 12 events total) was recorded at LZ2, NES191 and POLESOUT stations in northern and northwestern parts of the Lake
- The highest bloom concentrations were recorded at FEBIN (187 µg/L), POLESOUT1 (142 µg/L) and LZ25A (140 µg/L) in W, NW and N part of the Lake

Percentage of Bloom Events Per Sampling Event

- % Contribution to the Wet Season Total

Presenter: Lawrence Glenn
Spatial And Temporal Differences In Phytoplankton Biomass

% of Samples in Different Chlorophyll a (µg/L) Categories

- Not Sampled
- ≤ 40
- > 40

Presenter: Lawrence Glenn
Microcystin Concentrations (EPA Recreational Standard)

Number of Samples Per Site with Concentrations Above EPA Recreational Standard (> 8 µg/L)

% Contribution to Wet Season Total

May-June

July-August

September-October

% of Samples in Different Toxin Concentration Categories

Presenter: Lawrence Glenn
Microcystin Concentrations (Detection Limit)

Number of Samples Per Site with Concentrations Above Detection Limit (> 0.25 µg/L)

% Contribution to We Season Total

% of Samples in Different Toxin Concentration Categories

Presenter: Lawrence Glenn
- **Microcystis aeruginosa** was a dominant taxa in 55.5% of the samples collected.
- The highest abundance of *M. aeruginosa* was recorded in May (84 - 91%), and then decreased over time. The lowest abundance was recorded in late July and early August.
- Mixed communities and communities dominated by diazotrophic species were most abundant in nearshore areas, while communities dominated by *M. aeruginosa* were most commonly recorded in central and eastern parts of the Lake.
**Spatial And Temporal Differences In Dominant Taxa**

May-June, July-August, September-October

% of Samples with Different Dominant Taxa

- **Legend**
  - Not Sampled
  - Mixed
  - *Microcystis aeruginosa*
  - *Cylindrospermopsis raciborskii*
  - *C. raciborskii*
  - *Dolichospermum circinale*
  - *Planktothrix limnetica*
  - *P. limnetica/C. raciborskii*

Presenter: Lawrence Glenn
NOAA Satellite-Based Monitoring of Cyanobacterial Bloom Potential
Temporal Differences In Dissolved Inorganic Nitrogen And Phytoplankton Biomass

### Temporal Differences In Dissolved Inorganic Nitrogen

- **Nearshore**
- **Pelagic**

### Phytoplankton Biomass

- **Chlorophyll a (mg/L)**

#### Table: Temporal Differences In Nutrient Concentrations

<table>
<thead>
<tr>
<th>September</th>
<th>Year</th>
<th>Chl-A (mg/L)</th>
<th>TN (mg/L)</th>
<th>DIN (mg/L)</th>
<th>TP (mg/L)</th>
<th>SRP (mg/L)</th>
<th>Turbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearshore</td>
<td>2017</td>
<td>18.4</td>
<td>0.22</td>
<td>0.347</td>
<td>0.270</td>
<td>0.035</td>
<td>66.2</td>
</tr>
<tr>
<td></td>
<td>2018</td>
<td>13.7</td>
<td>0.24</td>
<td>0.162</td>
<td>0.123</td>
<td>0.065</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>22.2</td>
<td>0.13</td>
<td>0.044</td>
<td>0.076</td>
<td>0.019</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>23.1</td>
<td>0.24</td>
<td>0.117</td>
<td>0.087</td>
<td>0.032</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>2021</td>
<td>23.5</td>
<td>0.14</td>
<td>0.039</td>
<td>0.062</td>
<td>0.010</td>
<td>5.7</td>
</tr>
<tr>
<td>Pelagic</td>
<td>2017</td>
<td>2.7</td>
<td>0.23</td>
<td>0.25</td>
<td>0.141</td>
<td>0.025</td>
<td>18.6</td>
</tr>
<tr>
<td></td>
<td>2018</td>
<td>10.2</td>
<td>0.23</td>
<td>0.008</td>
<td>0.131</td>
<td>0.019</td>
<td>32.5</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>13.0</td>
<td>0.23</td>
<td>0.121</td>
<td>0.131</td>
<td>0.025</td>
<td>25.9</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>11.3</td>
<td>0.23</td>
<td>0.133</td>
<td>0.124</td>
<td>0.042</td>
<td>25.9</td>
</tr>
<tr>
<td></td>
<td>2021</td>
<td>14.0</td>
<td>0.23</td>
<td>0.045</td>
<td>0.133</td>
<td>0.040</td>
<td>15.0</td>
</tr>
</tbody>
</table>

East Shoreline of Lake Okeechobee

Presenter: Lawrence Glenn
Next Steps

- Full analysis of 2021 wet season data.
- Development of predictive tools/forecast modeling using large-scale analytics and machine learning.
- Collaborating with NOAA and USACE on development of forecasting/modeling tool for Lake Okeechobee.
Questions