Adapting Assessment Tools and Water Quality Criteria for a Changing Climate

UF Water Symposium
Session: Impacts of Climate Change and Climate Variability on Water Resources

Beck Frydenborg
Frydenborg EcoLogic, L.L.C.
Overview

• Projected climate change effects in Florida
• Regulatory Implications for selected programs:
  • Total Daily Maximum Loads (TMDLs)
  • Municipal Separate Storm Sewer System (MS4)
  • Minimum Flows and Levels (MFLs)
  • Groundwater/Drinking Water program
  • Water Quality Criteria
  • Biological Assessment
What is likely for Florida?

- Drivers: Increasing greenhouse gases, air temperature, ambient water temperature, sea level rise
- Predicted changes include:
  - Ocean acidification
  - Greater evapotranspiration
  - Increased heavy rains, increased or decreased precipitation
  - Saltwater intrusion, estuary community shifts
  - Fewer freezes, warmer long-term weather
  - Warmer ambient water
  - Coral bleaching/disease
  - Changes in nutrient supply/cycling/food webs
  - Changes in distribution of native and invasive species
Total Maximum Daily Load (TMDL)

- TMDL is a mandatory program for restoring impaired waters
- TMDL identifies the maximum amount of a pollutant that a body of water can receive and still achieve water quality standards
- Point source and non-point source discharges subject to pollutant reductions
TMDL Example: Alachua Sink

• Alachua Sink determined to be impaired (excessive chlorophyll) due to nitrogen enrichment
• TMDL for total nitrogen of 40,380 lb/yr and 623 lb/yr, for MSWRF and KGS respectively. MS4 must reduce TN by 45%
• Upgrades to MSWRF
• 125 acre wetland created to achieve TMDL
• If loading increases, wetland treatment must increase
MS4 Permits

- **MS4 permits** authorize cities, counties, or other governmental entities to discharge storm-water collected by their storm systems to waters of the United States.

- MS4 permits based on structural and non-structural best management practices demonstrated to reduce pollutants from **historic rainfall/loading rates**.

- BMP effectiveness must be re-evaluated at new rain/loading patterns.
Gainesville MS4s

• 125 acre wetland created to reduce nutrients, any increase in MS4 loading would require additional treatment
Minimum Flows and Levels (MFLs)

- Designed to protect aquatic systems from excessive water consumption by humans
  - Increasing demand from population growth, and likely less recharge (more runoff, less rainfall depending on season/location)

- Each MFL represents a long-term water level and/or flow statistic that climate change influences, composed of:
  - Water level or flow (how much / high)
  - Duration (how long)
  - Frequency (how often)
What is a Minimum Flow?

Normal Flow

Low Flow Causing Harm?
Variety of Goals for MFLs

• Climate change will affect ability to meet management goal differently

• Management goals include:
  • Recreation in and on the water;
  • Fish and wildlife habitats and the passage of fish;
  • Estuarine resources;
  • Transfer of detrital material;
  • Maintenance of freshwater storage and supply;
  • Aesthetic and scenic attributes;
  • Filtration and absorption of nutrients and other pollutants;
  • Sediment loads;
  • Water quality; and
  • Navigation.
Volusia Blue

• MFL endpoint is manatee protection from cold temperatures
• Easier to achieve if warm
• ~80% of Florida’s drinking water is groundwater
• The Groundwater/Drinking Water program is designed to assure the water Floridians consume meets critical drinking water criteria
• Primary Standards (e.g., many contaminants, carcinogens)
• Secondary Standards (e.g., chloride, 250 mg/L)
Florida’s Hydrogeology (USGS)

Florida’s extremely porous karst geology makes installing barriers to rising sea levels impossible.
Chloride Levels Getting Higher

- Chloride is rising significantly in Florida’s aquifers, which will be exacerbated by increased sea level rise.
- Implications for surface water consumption, inter-basin transfers (surface instead of ground).

Rick Copeland, FDEP
Water Quality Criteria

• Narrative or numeric standards designed to maintain waterbody designated uses, generally supporting healthy, well balanced aquatic communities and recreation in and on the water

• Most criteria are derived in laboratory toxicity tests, but some are based on “background” conditions:
  • Specific conductance
  • pH
  • Transparency
  • Turbidity
  • Chloride
Chloride Example

• Shall not be increased more than 10% above normal background. Normal daily and seasonal fluctuations shall be maintained.

• If Everglades chloride begins to increase by >10% due to sea level rise, how can this be mitigated?

• Mangrove forest develop – new background condition?
Biological Assessment

• FDEP has developed biological assessment tools for Stream Condition Index, BioRecon, Lake Vegetation Index, Linear Vegetation Survey, and Rapid Periphyton Survey

• Biological expectations separated by regional reference conditions

• When reference conditions change, tools must be adapted
2016 Algal Bloom in St. Lucie Estuary

Microcystis, A Freshwater Alga That Can Produce Toxins, Thrives in Warm Water
• Based on “**maintain healthy existing conditions**”, BUT:

• Increased flows to estuaries likely to increase nutrient delivery and eutrophication  
  (Easterling et al 2000; Alber 2002; Peterson et al 2008)

• Major spatial shifts in wetland communities, including invasions of exotic species, likely  
  (Dahdouh-Guebas et al 2005)

• More wet years than baseline, more NNC failures
Climate change will significantly affect regulatory program effectiveness, will stress municipalities/dischargers seeking to comply with law. Must plan now.
• Development of assessment tools, particularly for assessments of biological community status and trends, for rapid assessments of natural resources, and for evaluation of management efforts
Springs and Water Quality

- Nitrate water quality criterion of 0.35 mg/L required for spring vents

Weeki Wachee, 1950s; Nitrate < 0.1 mg/L, Eel grass

Weeki Wachee, 2001: Nitrate ~ 0.7 mg/L, Lyngbya mats
Dr. Skip Livingston (FSU) has concluded that global climate change, leading to excessive drought, has caused Apalachicola water shortage issues.
Atlantic Multi-Decadal Oscillation and Flows
(SFWMD)
Excess vs. Deficit Rainfall and Lake Levels (USGS)
Ecological Regions/Geography

All categories influenced by geographic region (ecoregion or physiographic province):

- Terrestrial
- Wetland
- Aquatic Freshwater
- Marine

Southeastern Plains Ecoregion (#65)
- 65f – Southern Pine Plains and Hills
- 65g – Dougherty/Marianna Plains
- 65h – Tifton Upland/Tallahassee Hills

Southern Coastal Plains Ecoregion (#75)
- 75a – Gulf Coast Flatwoods
- 75b – Southwestern Florida Flatwoods
- 75c – Central Florida Ridges and Uplands
- 75d – Eastern Florida Flatwoods
- 75e – Okefenokee Swamps and Plains
- 75f – Sea Island Flatwoods

Southern Florida Coastal Plains Ecoregion (#76)
- 76a – Everglades
- 76b – Big Cypress
- 76c – Miami Ridge/Atlantic Coastal Strip
- 76d – Southern Coast and Islands
Aquatic Eco-systems

Morphology: Physical Configuration

Aquatic Habitat Structure: System Dependent

Organism Recruitment: Food Webs

Hydrology: Timing, Frequency, Duration of Freshwater Inputs

Water Quality: Transparency, Nutrients, etc.

Littoral/Riparian Buffer: Plant Community Type
Factors Affecting Biological Communities

Biota

Producers: Algae, macrophytes, terrestrial plant leaf litter, bacteria/detritus

1° Consumers: Benthic invertebrates, zooplankton, some fish

2° Consumers: Fish, wildlife, humans

Physical factors
- Hydrology/flow
- Dessication
- Habitat structure
- Fire frequency
- Sediment/substrate
- Light penetration
- Rainfall
- Storms/Wind-throw
- Temperature

Water quality factors
- Conductivity/Salinity
- pH
- Major ions
- Dissolved Oxygen
- Organic carbon
- Nutrients

Human factors
- Introduction of exotics
- Harvesting game species
- Fire suppression
- Hydrological modifications
  - Consumptive use
  - Impounding
  - Ditching/draining
- Habitat disruption:
  - Physical destruction
  - Siltation/Sedimentation
- Degradation of water quality:
  - Toxic substances
  - Organic enrichment
  - Nutrient enrichment
- Hydrological modifications
- Fire frequency
- Rainfall
- Storms/Wind-throw

Degradation of water quality:
- Nutrient enrichment
Average Monthly Rainfall

Typical Hydroperiods (FNAI, 1990):

<table>
<thead>
<tr>
<th>System</th>
<th>Inundation Days Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet flatwoods</td>
<td>30-90 days/yr</td>
</tr>
<tr>
<td>Wetland hardwood forests</td>
<td>60 days/yr</td>
</tr>
<tr>
<td>Wet prairie</td>
<td>50-100 days/yr</td>
</tr>
<tr>
<td>Basin marshes</td>
<td>200 days/yr</td>
</tr>
<tr>
<td>Isolated cypress domes</td>
<td>200-300 days/yr</td>
</tr>
<tr>
<td>Floodplain swamps</td>
<td>300 days/yr</td>
</tr>
</tbody>
</table>
Expected Wetland Levels

Central Region Depressional Herbaceous Wetland

Central Region Depressional Forested Wetland

Data from SWFWMD 1994-2003.

Data from SWFWMD 1981-2003.
Moss collars and lichen lines on a cypress trunk. (KCR)

Moss collars, lichen lines, and water marks on cypress trees during low water levels. (KCR)
River Hydrographs: Panhandle vs Peninsula (SWFWMD)