WATER AND CLIMATE RESILIENCE METRICS

Public Workshop
December 17, 2021
Welcome

Moderator: Yvette Bonilla
Q&A Session

If you’re participating in person – please fill out a question card and give to a meeting attendant.

If you’re participating via Zoom – use the chat function to submit a written question.

Public Comments

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If you’re participating via Zoom – use the Raise Hand feature.

If you’re participating via Phone – *9 Raises Hand
*6 Mutes/Unmutes

Moderator: Yvette Bonilla
Opening Remarks

Drew Bartlett
Executive Director
South Florida Water Management District
Opening Remarks

Adam Blalock
Deputy Secretary for Ecosystems Restoration
Florida Department of Environmental Protection
Opening Remarks

Dr. Wesley Brooks
Chief Resilience Officer for the State of Florida
Introduction and Background

Carolina Maran, Ph.D., P.E.
District Resiliency Officer
South Florida Water Management District
2021 Extreme Events in South Florida

• Less Intense King Tide Season, with no significant tropical cyclones contributing to swells along the Atlantic Ocean, near Florida

• 2021 Atlantic Hurricane Season – third most active (exhausted the names, two consecutive years)

• Impacts from Extreme Rainfall Flood, i.e. Downtown Miami (in November) and King Tide Flood, i.e. Palm Beach (in October)

Source: The Palm Beach Post, King Tide Flooding (November 2021)

Presenter: Carolina Maran
2020 Extreme Events

- Tropical Storm Eta
- 2020 King Tide Season
- Hurricane Isaias
- Memorial Day Rainfall

Presenter: Carolina Maran
How significant was 2020, 2021 compared to the record?

What impacts are we observing in South Florida?

How can we associate these impacts with Climate Change?

Are these recent events part of a long-term trend?

Presenter: Carolina Maran
Water and Climate Resilience Metrics

OBJECTIVES

1. Track and document long term trends and shifts in observed data owned/managed by SFWMD

2. Advance the understanding of the climate change impacts over the District’s mission

3. Report and Communicate the water and climate resilience aspects, and the associated science

4. Support the assessment of future conditions, and propose uniform guidelines.

Presenter: Carolina Maran
## Water and Climate Resilience Metrics

### Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
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<tbody>
<tr>
<td>Stronger SFWMD planning capacity</td>
<td>by documenting and publishing observed trends districtwide, based on best available data analysis and science-based approaches</td>
</tr>
<tr>
<td>Better substantiated modeling assumptions and risk informed decisions</td>
<td></td>
</tr>
<tr>
<td>Smarter infrastructure investment decisions</td>
<td>supported by robust assessment of current and anticipated future climate conditions</td>
</tr>
<tr>
<td>More educated and engaged stakeholders and partner agencies</td>
<td></td>
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<tr>
<td>Enhanced resilience of District’s projects</td>
<td>regarding observed or expected changes in climate</td>
</tr>
</tbody>
</table>

Presenter: Carolina Maran
Main Drivers

- Water Quality Impacts
- Flood Protection
- Wet Season Increase in Ground Water
- Flooding
- Evapotranspiration Changes
- Estuary / Wetland Migration
- Soil Subsidence
- Increasing Salinity in Estuaries
- Increasing Tidal Elevations
- Saltwater Intrusion
- Changing Rainfall Patterns

Primary drivers of change:
- Climate Metrics
- Resilience Metrics

Consequences of change, cascading drivers:
- Water Supply
- Ecosystem Restoration

Presenter: Carolina Maran
Stakeholder Comment (USGS): “the report represents a comprehensive and insightful review of available data that will help guide the South Florida Water Management District in their many critical directives in water-resources management over the long term. Pulling all of this information together and providing the data analysis will make this document invaluable not just for the SFWMD, but also many of the stakeholders and other resource-managers within the district boundaries. It may also serve as a template for the other WMDs in pointing to data and analysis needed for long-term planning under changing conditions.”
Bringing Water and Climate Resilience Metrics to the South Florida Environmental Report (SFER), and the District Resilience Metrics Hub

Nicole A. Cortez
District Resiliency Coordinator
South Florida Water Management District
Resilience Metrics Hub

South Florida Environmental Report (SFER)

Water and Climate Resilience Metrics
PHASE 1: LONG-TERM OBSERVED TRENDS
Final Report and December 17, 2021

Presenter: Nicole Cortez
SFER ANNUAL REPORTING

• Home for scientific discussions

• Provides the public with the science and data used to drive decisions at the SFWMD.

• Documents restoration, water quality, scientific and engineering accomplishments in South Florida each Water Year (May 1 – April 30).
Resilience Metrics Content:

Chapter 2A
- Same content previously featured in Chapter 2
- With the addition extreme hydrological event summaries

Chapter 2B – Water and Climate Resilience Metrics
- Rainfall
- Evapotranspiration
- Tidal Elevations at Coastal Structures
- Water Quality

Important dates:
- **Monday January 17** – Draft opens for public review
- **Tuesday March 1** – Final 2022 SFER Published
RESILIENCE METRICS HUB: SFWMD Resiliency (arcgis.com)

- Living data hub
  - Offers the flexibility to bring new and different types of data
  - Will be regularly updated

- A tool to support our region
  - Making data readily available
  - Advance additional scientific analysis

- Full implementation and automation in 2022
RESILIENCE METRICS HUB: SFWMD Resiliency (arcgis.com)

- Story Maps for:
  - Estuarine Inland Migration in the Everglades
  - Salinity in the Everglades
  - Soil Subsidence
  - Saltwater Interface

- Under development:
  - Rainfall
  - *Tidal Elevations at Coastal Structures and SLR*

- Future plans
Observed Trends in Groundwater:
Groundwater Stages and Saltwater Intrusion

Karin Smith, P.G.
Principal Scientist
Water Supply Bureau

Technical Lead: Karin Smith
Groundwater Stages and Saltwater Intrusion

Sea level rise causes denser saltwater further inland and freshwater floating atop it to rise.

Impacts

• Saline water further inland, reduced freshwater gradient
• Inland flooding from higher groundwater, reduced storm water storage capacity
Saltwater Intrusion Monitoring – Induction Logs
Saltwater intrusion monitoring of multiple aquifers
Collier County - Lower West Coast

Technical Lead: Karin Smith

Saltwater Intrusion

BACKWARD LOOKING:
Utility Wellfield                       # of wells abandoned
Deerfield Beach PWS                   2
Dania Beach PWS                       1
Broward County 3A/3B Wellfields       9
Broward County 2a Wellfield           3
Hollywood – North & Plant wellfields  10
Lake Worth Utilities – East Wells     7
Manalapan PWS                         3

FORWARD LOOKING
Utilities Identified in Most Recent Water Supply Plan

<table>
<thead>
<tr>
<th>Water Supply Planning Region</th>
<th>Total Utilities</th>
<th>More Vulnerable (no alternative)</th>
<th>Vulnerable (but has alternative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower East Coast</td>
<td>52</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Lower West Coast</td>
<td>22</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Upper East Coast</td>
<td>17</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Technical Lead: Karin Smith
Groundwater Stages

Technical Lead: Karin Smith
Biscayne Aquifer Minimum Flow and Minimum Water Level Prevention Strategy

Biscayne Aquifer MFL Prevention Strategy
Snapper Creek (C-2) Canal
Salinity Control Structure S-22

Mean Daily Stage in Feet NGVD


S22 Headwater
S22 Tailwater
S22 Minimum Operation Level (2.5' NGVD)

Technical Lead: Karin Smith
Saltwater Intrusion in Coastal Aquifers

The inland migration of saltwater poses a threat to water supply and critical freshwater habitats.

Karin Smith, Principal Scientist, Water Supply Bureau, SFWMD
December 16, 2021
Observed Trends in Evapotranspiration

Kevin Zhu, PE
Staff Engineer
Hydrology & Hydraulics Bureau
Evapotranspiration (ET)

\[
evapotranspiration = \text{transpiration} + \text{evaporation}
\]

- Pan Evaporation: (popular most)
- Lysimeter: (direct measure of ETp)

(Data of Rainfall & ET: District-wide Average over the Past 25 Years.)
Evapotranspiration (ET)

**Selection Criteria:**

1. Period of Records $\geq 25$ Years.
2. Still in Operation (for future trend watch).

**Three Selected Stations/Sets:**

EVAP (2): S7 (SFWMD), WPB.EEDD (City of WPB)

ET (1): District (USGS or Univ of Alabama)

Technical Lead: Kevin Zhu
Evapotranspiration (ET)

Driving Factors:

1. Solar Radiation
2. Relative Humidity (or Vapor Pressure Deficit)
3. Air Temperature
4. Wind Speed
Evapotranspiration (ET)

SolarRAD vs. ETp @ SFWMD

AirTemp vs. ETp @ SFWMD

RelHumd vs. ETp @ SFWMD

WindSpd vs. ETp @ SFWMD

Period of Records: 1995 - 2020

Technical Lead: Kevin Zhu
Evapotranspiration (ET)

Summary

# Upward Trend starting back to 60 years ago (↑ ET);
# The averaged Change Rate: +0.25 in/yr (+6.35 mm/yr);
# Major Driving Variables: Solar Radiation (↑), Relative Humidity (↓).
Water Quality

Nenad Iricanin, Ph.D.
Principal Scientist
Water Quality Bureau
Water Quality

- List of water quality parameters
  - Temperature, dissolved oxygen, pH, specific conductance
- Water quality data used for six in-lake stations
  - L001, L004, L005, L006, L007, and L008
  - Stations have longest data records
- 48-year period of record retrieved
  - November 1972 – June 2020
  - Data retrieved from District corporate database, DBHYDRO
  - Data aggregated as monthly means
  - Identified climatic events (droughts, tropical storms)
- Analyses performed
  - Seasonal Mann-Kendall trend analyses
  - Potential interpretation of observed trend for specific conductance

Technical Lead: Nenad Iricanin
Temperature, Diss. Oxygen, pH – Trend Analysis

Water temperature and water pH data do not show statistically significant trends ($p\text{-value} \geq 0.05$). Diss. oxygen data exhibited a statistically significant decreasing trend. The annual rates of change for all three parameters (Sen-slopes) are not measurable over the period of record.
Specific Conductance – Trend Analysis

- A measurable and significant decrease was observed for specific conductance
- Over 48-year period, specific conductance decreased significantly by 40% (~660 µS/cm in 1973 to ~400 µS/cm in 2020)
- Seasonal variations in specific conductance are caused by evaporation (increase in specific conductance during droughts and dry season months) and precipitation (decrease in specific conductance during tropical events and wet season months)
- Typical specific conductance for Florida lakes is 385 µS/cm (Hand 2004)

Seasonal Mann-Kendall
Sen-Slope = -5.4; Kτ = -0.523; p-value <0.01

Statistical Significance at p-value <0.05

Major Ions in Lake Okeechobee

- Period of record major ions were retrieved from DBHYDRO for the in-lake stations (Na⁺, K⁺, Ca²⁺, Mg²⁺, Cl⁻, HCO₃⁻, SO₄²⁻)
- Ions were summarized by decade and graphically presented using Schoeller plots and Stiff diagrams

**Schoeller Plots**
- Plots are used to present major ion concentration groups (cations and anions) and demonstrate different hydro-chemical water types
- Plots can also be used to show changes in ionic composition by identifying dominant ion pairs (cations and anions)

**Stiff Diagrams**
- Resulting polygon shape extends from either side of the zero axis with cations presented on the left side and anions presented on the right side. All ions are plotted in units of meq/L.
- Stiff patterns are a useful method for making rapid visual comparisons between waters from different sources/types.

Technical Lead: Nenad Iricanin
Changes in Lake Okeechobee Ionic Composition

Schoeller Plots

- Decadal median concentrations were calculated for each ion
- These median values were used to generate Schoeller plots and Stiff diagrams
- Results show a decadal change in the ionic composition of lake water
  - 1973–1992: More Na-Cl dominated during higher specific conductance
  - 2003–2020: More Ca-HCO₃ dominated with lower specific conductance
- Shift in ionic composition appears to mirror the observed change/decrease in specific conductance as shown on the next slide

Stiff Diagrams
Changes in Lake Okeechobee Ionic Composition

- Decadal shift in ion composition follows the changes to specific conductance
- Na:K and Na:Ca ratios were analyzed to explore potential sources
  - 1973–1982 period Na:K ratios were higher and approached a mean seawater ratio of 46 suggesting a potentially more marine-like source (e.g., connate seawater)
  - 1973–1993 period Na:Ca ratios were greater than 1 supporting the finding that this period was more Na-Cl dominated
  - After 1994, both Na:K and Na:Ca ratios decreased
  - Na:K ratios more representative of freshwater and Na:Ca ratios suggesting a more Ca-HCO₃ dominant source

Ratios and Stiff diagrams based on ion concentrations in meq/L
Decadal values presented as averages ± st. deviations
Water Quality Trend Analysis Summary

• Results from trend analyses performed for 48-year period:
  ▪ Water temperature and pH had increasing trend; trends were not statistically significant
  ▪ Dissolved oxygen had a statistically significant decreasing trend; the observed change not measurable over the period
  ▪ Specific conductance had a measurable significant decreasing trend over the period
• Lake’s ionic composition over the period of record exhibited a shift from a more Na-Cl source to more a Ca-HCO₃ source
• Na:K ratios suggest that the higher specific conductance levels observed may have been affected by a more marine-like source, possibly upwelling of connate seawater
• The observed change in ionic composition appears to have occurred after 1994 (based on Na:K and Na:Ca) and coincides with observed decrease in specific conductance
• This evaluation shows that changes in water quality are affected multiple factors that can exert a more complex influence on water quality that hinder the ability to detect potential influence of climate change factors

Technical Lead: Nenad Iricanin
Observed Trends in Ecosystem: Soil Subsidence and Estuarine Migration

Carlos Coronado, Ph.D.
Lead Scientist
Applied Sciences Bureau
Peat Collapse Concepts and Mechanisms of Soil Surface Elevation Loss

Conceptual framework detailing the potential pathways that a healthy wetland (panel a) that is exposed to various acute or chronic environmental stressors (panel b) can result in vegetation death (panel c), leading to four potential (non-exclusive) mechanisms of soil surface elevation loss (panel d) and ultimately conversion to an open water pond or mudflat (panel e). Figure by Chambers et al. 2019

Technical Lead: Carlos Coronado
Definition: Peat Collapse, a specific type of soil subsidence, is process in which **highly organic soils** experience loss of soil strength and structural integrity that contributes to a decline in vertical elevation below the lower limit for plant growth and natural recovery.

Technical Lead: Carlos Coronado
High Energy & Frequently Flooded Sites n=5

- Elevation Change: 3.9 mm yr\(^{-1}\)
- Vertical Accretion: 2.1 mm yr\(^{-1}\)
- Soil Expansion: 1.8 mm yr\(^{-1}\)

Low Energy & Permanent Flooded Sites n=7

- Elevation Change: 1.7 mm yr\(^{-1}\)
- Vertical Accretion: 1.9 mm yr\(^{-1}\)
- Soil Subsidence: -0.2 mm yr\(^{-1}\)

Technical Lead: Carlos Coronado
Habitat Transition with an Accretion Rate of 4.2 mm yr⁻¹ (0.211 m by 2070).

*Accretion Rate in Biscayne Mangroves
Importance of Soil Accretion to keep up with SLR

Habitat Transition

- No Accretion
  - Total Wetlands (sq km)
  - Transition of Wetland to Open Water (sq km)
- Accretion 0.211 m
  - Total Wetlands (sq km)
  - Transition of Wetland to Open Water (sq km)
- Accretion 0.55 m
  - Total Wetlands (sq km)
  - Transition of Wetland to Open Water (sq km)

Technical Lead: Carlos Coronado
Increases in SLR rate and saltwater intrusion have induced release of CO2 from marshes. The collapse of marsh peat soils, W/O sufficient freshwater input, will hinder landward migration of mangroves by reducing seedling establishment and belowground production, a key process for organic matter accumulation.

The current and future response of mangroves to SLR projection scenarios depends on the ability of mangroves to keep pace with rising sea level. Southern Everglades mangroves can keep pace with current SLR, but they will not be sustainable with SLR rates greater than 4-6 mm/yr.

Modeling indicates a transition to open water by 2070 if accretion rates are not enhanced.

Technical Lead: Carlos Coronado
Soil Subsidence in South Florida

Maintaining soil elevations within coastal and intertidal habitats, as sea level changes, is an indicator of long-term stability of coastal.

Dr. Carlos Carmona, Scientist Lead, Applied Sciences Bureau, SFWMD
July 19, 2021

Frequently Flooded Sites

Elev. Change 3.7 mm/yr
Accretion 1.4 mm/yr
Expansion 2.4 mm/yr
Average of Frequently Flooded Sites: TS-3, TS-4, TS-8, TS-10 and TS-14
Water and Climate Resilience Next Steps

• Bring full content respective to all the metrics to the Resilience Metrics Hub

• Complete Automation: real time access for datasets available in DBHYDRO

• Continue to publish technical analyses and scientific resources in SFER

• Review data monitoring needs
  • quality/spatial distribution/frequency to appropriately evaluate trends

• Incorporate New Metrics

• Phase II: Future projections

Presenter: Carolina Maran
From Observations to Projections

The Rainfall Case

Presenter: Carolina Maran
Regional Rainfall

Changes in rainfall patterns will impact people and ecosystems by altering the amount of water in our region throughout the year.

Alan A. Hydrolological and Environmental System Modeling, SFWMD
October 26, 2021
Regional Rainfall Trend Analysis - Observations

Monthly Rainfall Trend Analysis Results, illustrated by the month of August

Technical Lead: Alaa Ali

Wet Season Rainfall Trend Analysis Results

Presenter: Carolina Maran
Future Rainfall Data Release

https://doi.org/10.5066/P9KEM

- Internal review of the data by SFWMD teams
- Initial recommendations for planning purposes
- Partner / Stakeholder Review & Feedback Next

Presenter: Carolina Maran
Join us at the 2022 UF Water Institute Symposium

OVERVIEW
The UF Water Institute and Duke Energy invite you to participate in the 8th biennial UF Water Institute Symposium. The Symposium will bring together individuals from a broad range of disciplines and organizations to explore water issues from multiple perspectives.

WHERE
J. Wayne Reitz Union
University of Florida
Gainesville, FL

WHEN
Tuesday to Wednesday
February 22-23, 2022

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
Q&A Session

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Moderator: Yvette Bonilla
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South Florida Water Management District (govdelivery.com)

• You may also update your current preferences if you’re already signed-up
Thanks for Participating