Lake Okeechobee Watershed Restoration Project, Update on the Aquifer Storage and Recovery Program

September 1, 2022

Elizabeth Caneja
Lead Project Manager
South Florida Water Management District, West Palm Beach, FL

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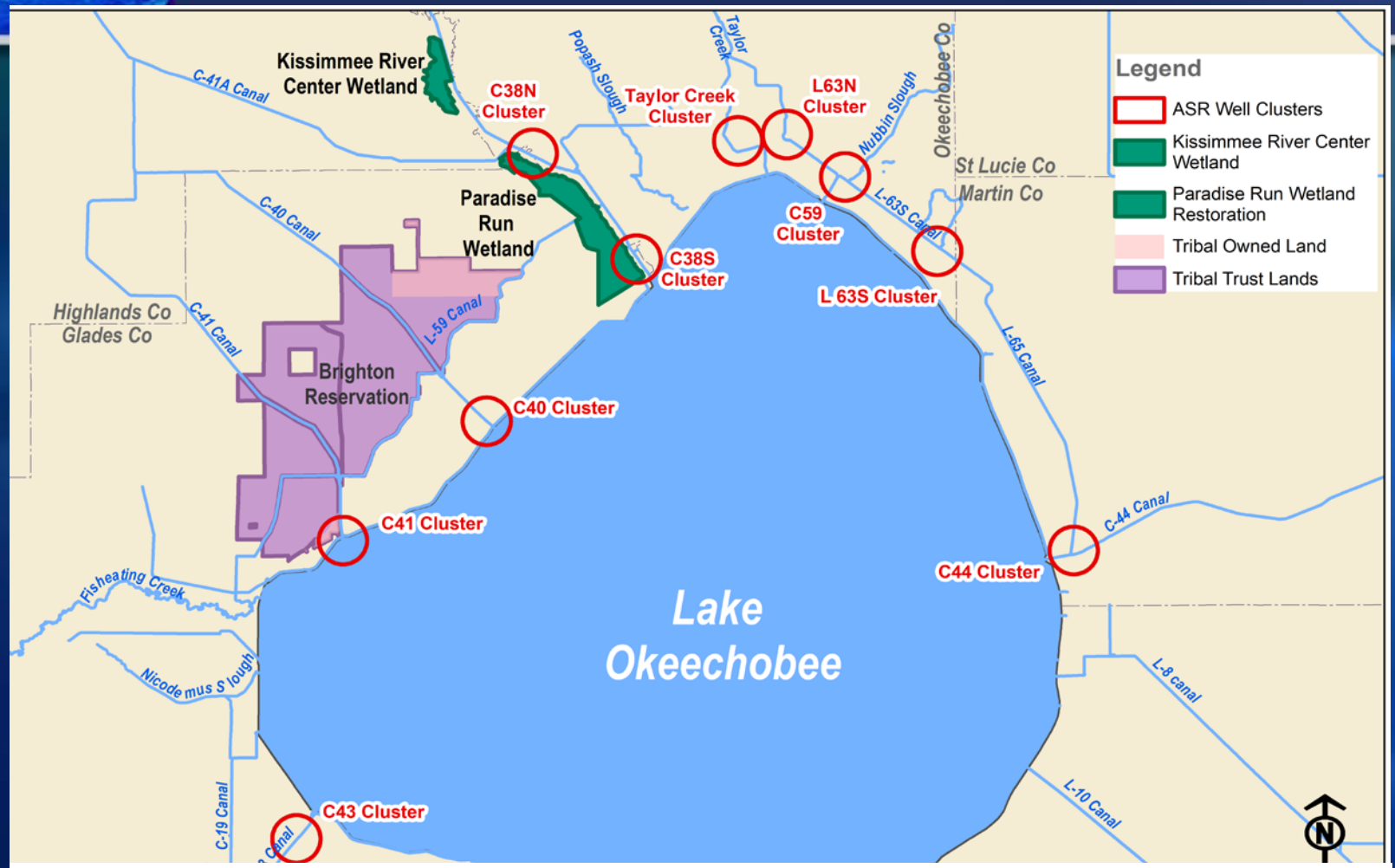
LOWRP Revised Recommended Plan (Alt ASR)



Aquifer Storage and Recovery (ASR)

- 55 ASR wells
- 308,000 acre-feet of storage per year

Wetland Restoration

- Kissimmee River Center: ~1,200 acres
- Paradise Run: ~4,700 acres

Project Objectives

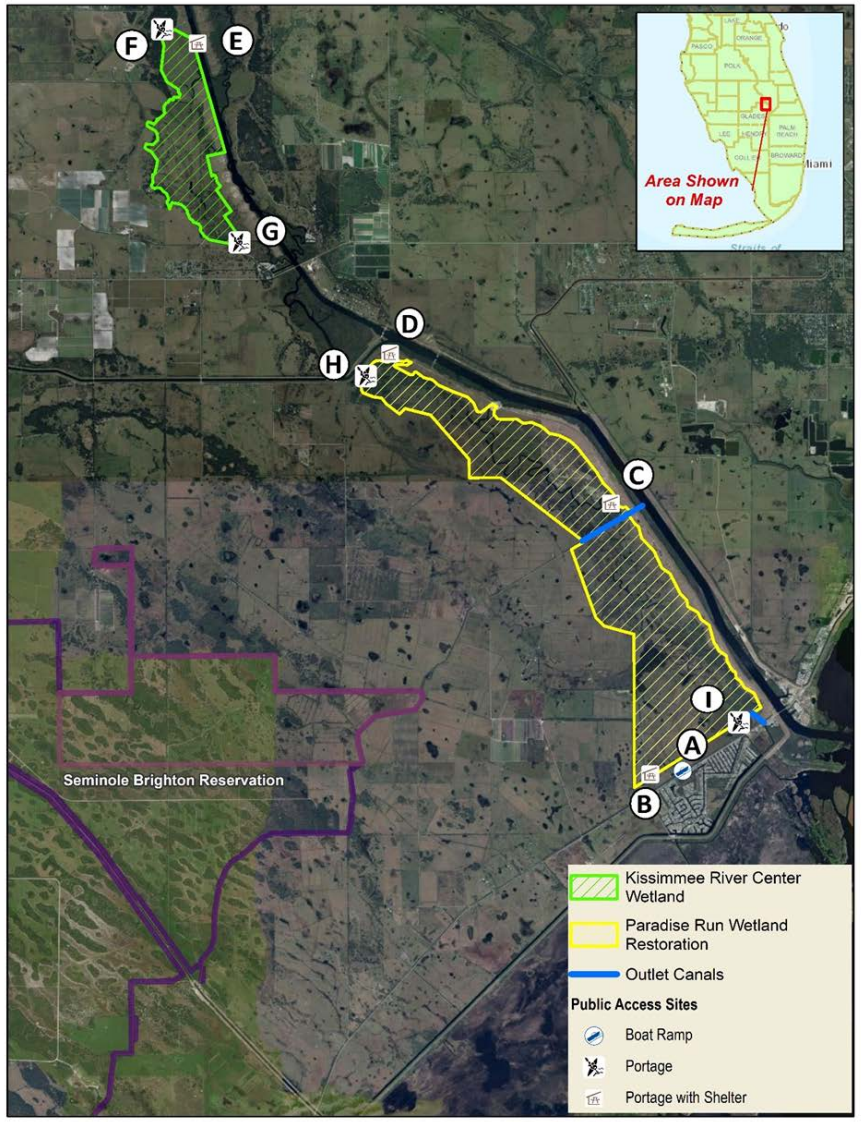
- Increasing water storage capacity in the watershed, resulting in improved Lake Okeechobee water levels
- Improving the quantity and timing of discharges to the St. Lucie and Caloosahatchee estuaries
- Restoring wetlands
- Improving water supply for existing legal users

LOWRP State Implementation

- **State Appropriations 1642A & Senate Bill 2516**
  - **FY19/20, First Year: Received $50M**
  - **FY20/21, Second Year: Received ~$49.9M**
  - **FY21/22, Third Year: Received ~$49.2M**
  - **FY22/23, Fourth Year: Received $100M**
  - **Additional $50M each year**
- **Incremental, phased approach being implemented in the Program and the specific watershed ASR projects prioritized for these State Appropriations**

LOWRP Wetland Restoration

- **Kissimmee River Center Wetland**
  - ~1,200 acres in size
- **Paradise Run Wetland**
  - ~4,700 acres in size
- **Land Acquisition**
  - Landowners within the project footprint have been notified
  - Initiated appraisals
- **Provides recreational opportunities**



ASR Cluster Implementation: Phased Approach

ASR Phased Implementation as Recommended by the National Research Council

Continuous Cores (2021-2023)
- APPZ attributes (local scale)
- Injection pressures for fracture potential
- P removal mechanisms
- Pathogen inactivation

Reactivation of Existing ASR Systems (2021-2023)
- APPZ attributes (local scale)
- P removal mechanisms
- Chronic toxicity testing
- Arsenic transport within aquifer
- Buffer zone to reduce sulfate concentrations
- Fate of sulfate in recovered water to form methylmercury
- Pathogen inactivation
- Groundwater travel times

Test/Exploratory Multi-Wells (2021-2023)
- APPZ attributes (local scale)
- Local scale model for heterogeneity, anisotropy, fracturing, travel times
- Anisotropy analysis for orienting wells
- Tracer studies for flow directions
- Cross-well tomography and geophysics
- Well spacing and optimal recovery efficiency
- Injection pressures for fracture potential
- Pretreatment technologies to remove arsenic
- Pathogen inactivation

Wellfield Design, Permitting, and Construction (2021-2026)
- Local scale model for heterogeneity, anisotropy, fracturing, travel times
- Anisotropy analysis for orienting wells
- Tracer studies for flow directions
- Well spacing and optimal recovery efficiency
- Injection pressures for fracture potential
- Technologies to meet regulatory requirements
- Pretreatment technologies to remove arsenic
- Pathogen inactivation
- Groundwater travel times
- Locate clusters near large water bodies

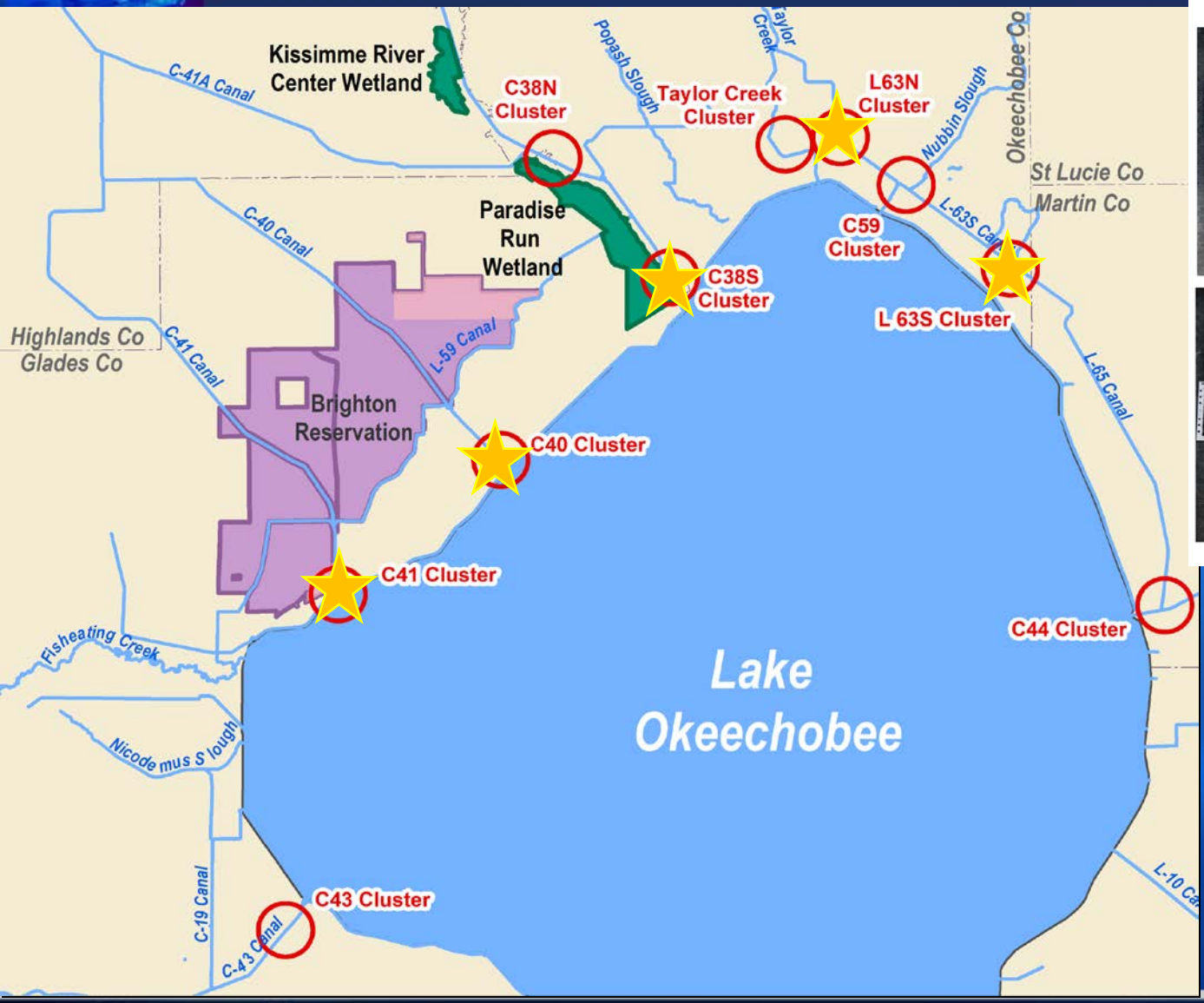
Initial Cycle Testing (2025-2027)
- Well spacing and optimal recovery efficiency
- Injection pressures for fracture potential
- P removal mechanisms
- Improve/extend cycle tests
- Establish buffer zone
- Operate multi-well pairs and clusters
- Locate clusters near large water bodies
- Pretreatment technologies to remove arsenic
- Chronic toxicity testing
- Multi-cluster chronic toxicity testing
- Community-level effects and bioaccumulation
- Prolonged bioconcentration studies
- Probabilistic, quantitative risk assessment
- Source water effects on redox evolution of aquifer
- Arsenic transport within aquifer using buffer zone
- Buffer zone usage to reduce sulfate concentrations
- Fate of sulfate in recovered water to form methylmercury
- Variability of gross alpha and radium in recovered water

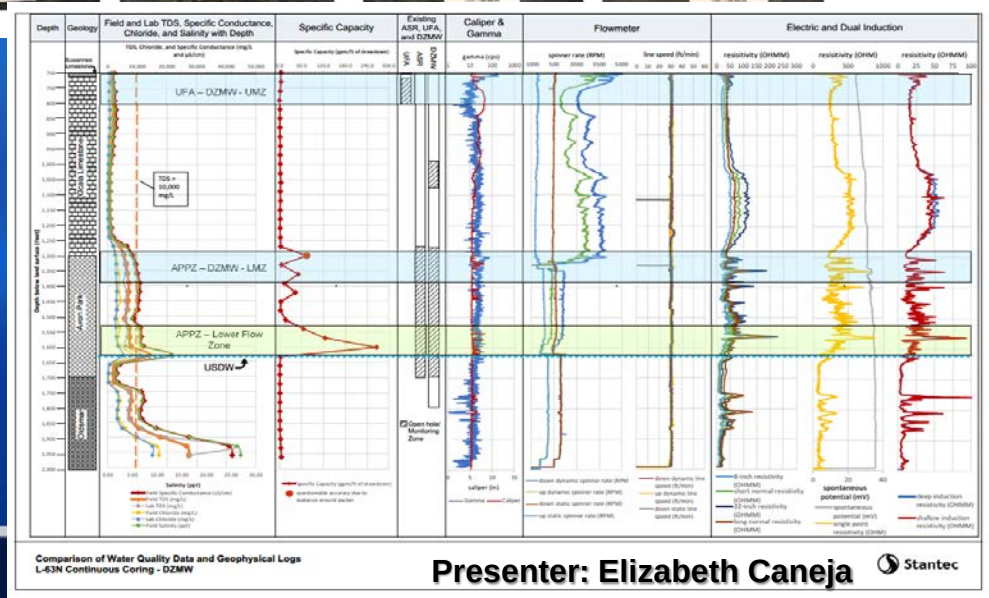
Extended Testing and Wellfield Expansion (2026-2030)
- Improve/extend cycle tests
- Establish buffer zone
- Operate multi-well pairs and clusters
- Multi-cluster chronic toxicity testing
- Community-level effects and bioaccumulation
- Prolonged bioconcentration studies
- Probabilistic, quantitative risk assessment
- Source water effects on redox evolution of aquifer
- Arsenic transport within aquifer using buffer zone
- Buffer zone usage to reduce sulfate concentrations
- Fate of sulfate in recovered water to form methylmercury
- Variability of gross alpha and radium in recovered water

Expansion of L63N Cluster

Reactivate KRASR Well

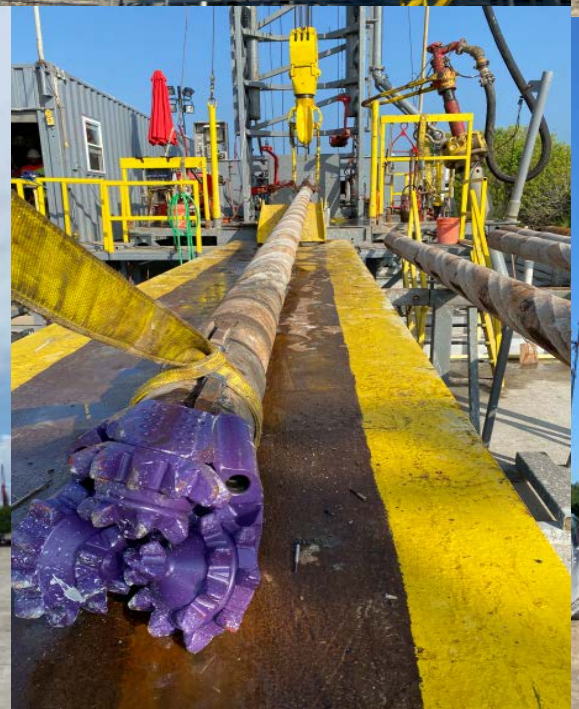
Continuous Coring and Monitoring Well Program





Presenter: Elizabeth Caneja

Test/Exploratory Wells at C38N and C38S



Presenter: Elizabeth Caneja

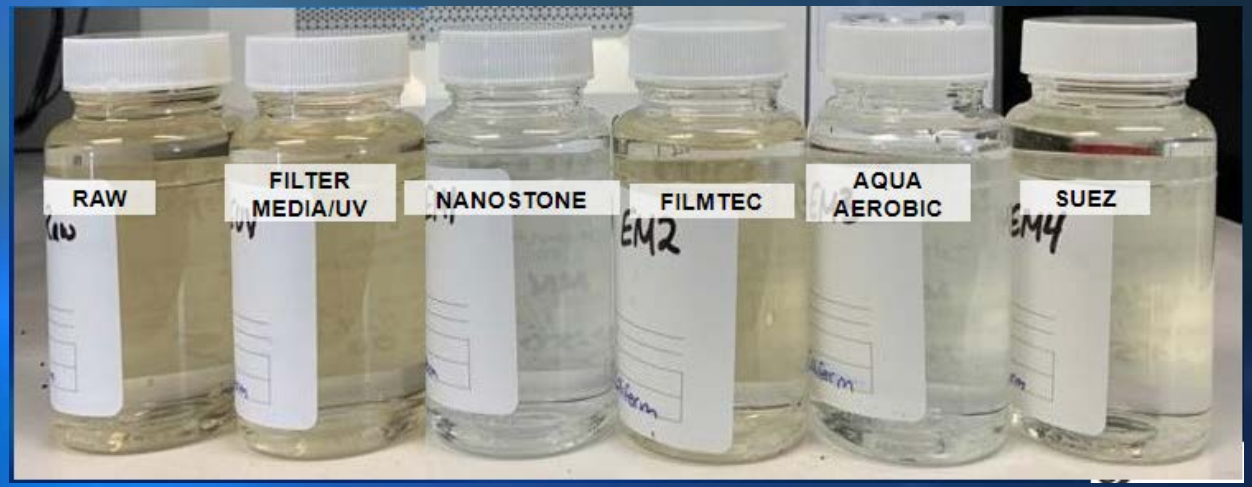
Treatment Technology Evaluation

Proof of Concept Testing

Water Samples - Raw and Treated

Treatment Technology Performance Summary

- **Membranes (Ceramic):**
  - Microfiltration/ultrafiltration removed coliform bacteria by size exclusion and removed significant amounts of color with the aid of a coagulant.
  - Used a greater amount of coagulant than polymeric membranes; would produce a greater volume of solids for management.
  - Ceramic membranes demonstrated the ability to reduce color by 93-95% to approximately 7.5-5 PCU. **Ceramic membranes would meet drinking water standard for color (15 PCU).**
- **Membranes (Polymeric):**
  - Polymeric membranes reduced color by 50-53% to approximately 50 PCU, which would **not meet the drinking water standard for color**.



- **Media Filtration + UV :**
  - Media filtration prior to UV helps with solids and turbidity reduction, but was **unable to reduce color to meet drinking water standards.**
  - UV treatment does not rely on chemicals for disinfection. However, high color surface water requires significant doses UV light to remove coliform bacteria.

Near-Term Next Steps

- **Near-Term Next Steps:**
  - **Complete Corrected Final Proof-of-Concept Report (Pending Consensus Sheet) – Sept/Oct 2022**
  - **Initiate Well Design and Permitting at L63S and C59 well cluster sites – Oct 2022**
  - **Initiate Continuous Core at C41 well cluster site (or another location) – Oct/Nov 2022**
  - **Initiate drilling of first set of Test Wells at L63N (permit anticipated ~Oct. 2022) – To be awarded in Nov 2022**
  - **Complete Construction of first set of Test Wells at C38S and C38N sites – Nov 2022**
  - **Signed Chief of Engineers Report for the LOWRP Planning Effort – Anticipated for Nov/Dec 2022**
  - **Initiate Siting Evaluation and Hydrogeological Assessment at C44 well cluster site – Nov/Dec 2022**
  - **Aquifer Pump Tests at C38S and C38N sites – Dec 2022/Jan 2023**
  - **Complete Continuous Core at the L63S site – Dec 2022**
  - **Initiate Treatment Design of a Demonstration Facility at either C38S, C38N, L63N or C44 well cluster sites – Feb 2023**
  - **Local-Scale Groundwater Model for C38S and C38N (under development and pending APT data) – March 2023**

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Update on the 2022 ASR Science Plan, Peer-Review Panel Report, and Ecological Risk Assessment Studies

Dr. Anna Wachnicka

Lead Scientist / ASR Science Plan Project Manager

South Florida Water Management District, West Palm Beach, FL

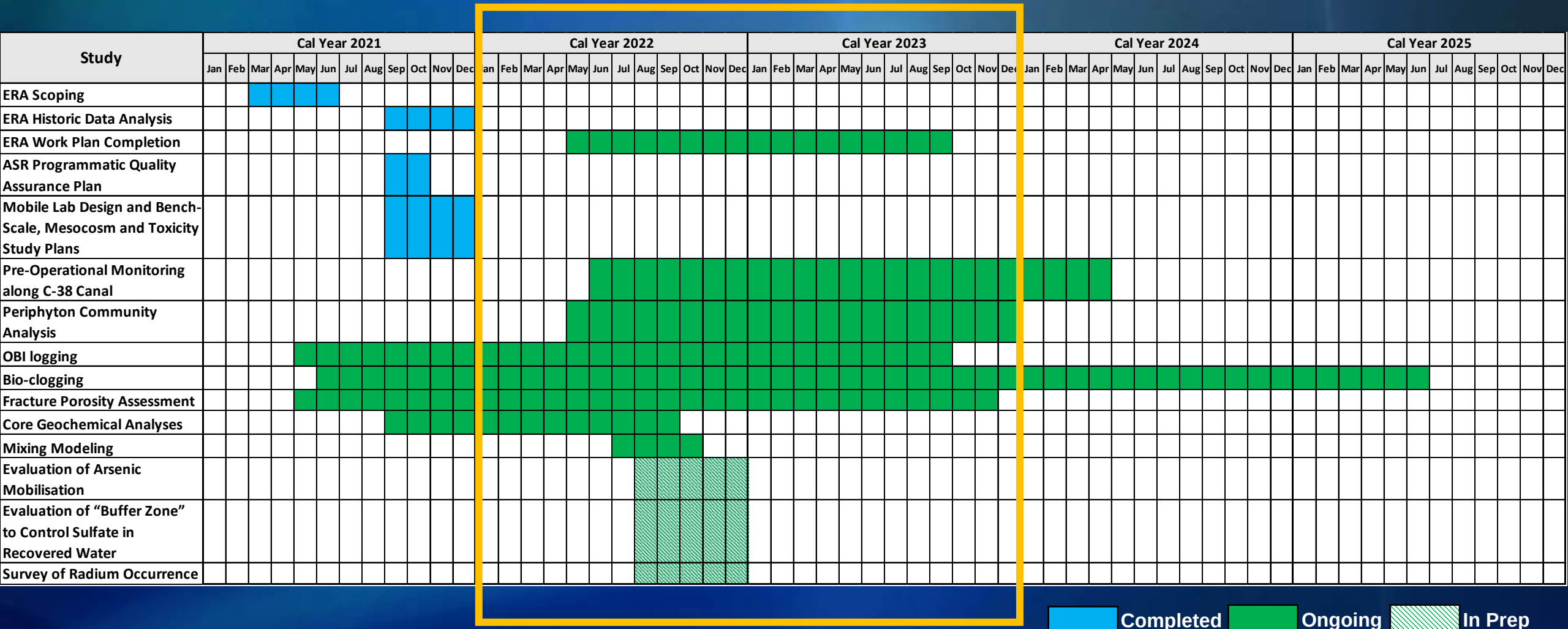
sfwmd.gov

ASR Science Plan
Phased Implementation

ASR Phased Implementation as Recommended by the National Research Council

Uncertainties Identified by the National Research Council	2021-2023 Continuous Cores	2021 -2023 Reactivation of Existing Wells	2021 -2023 Test/Exploratory Multiple Wells	2021-2026 Design, Permitting, and Construction	2025-2027 Initial Cycle Testing	2026-2030 Extended Testing and Wellfield Expansion
Local scale information on APPZ attributes	■	■	■			
P removal mechanisms	■	■	■		■	
Pathogen inactivation	■	■	■	■		
Injection pressures for fracture potential	■		■	■	■	
Chronic toxicity testing		■			■	
Arsenic transport within aquifer using buffer zone		■	■	■	■	■
Buffer zone usage to reduce sulfate concentrations		■	■	■	■	■
Fate of sulfate in recovered water to form methylmercury		■	■	■	■	■
Groundwater travel times		■	■	■		
Local scale model for heterogeneity, anisotropy, fracturing, travel times		■	■	■		
Pretreatment technologies to remove arsenic		■		■	■	
Well spacing and optimal recovery efficiency			■	■	■	
Anisotropy analysis used for orienting wells			■	■		
Tracer studies for flow directions			■	■		
Cross-well tomography and geophysics			■	■		
Locate clusters near large water bodies				■	■	
Technologies to meet regulatory requirements				■		
Multi-cluster chronic toxicity testing					■	■
Community-level effects and bioaccumulation					■	■
Prolonged bioconcentration studies					■	■
Probabilistic, quantitative risk assessment					■	■
Variability of gross alpha and radium in recovered water					■	■
Source water effects on redox evolution of aquifer					■	■
Improve/extend cycle tests					■	■
Establish buffer zone					■	■
Operate multi-well pairs and clusters					■	■

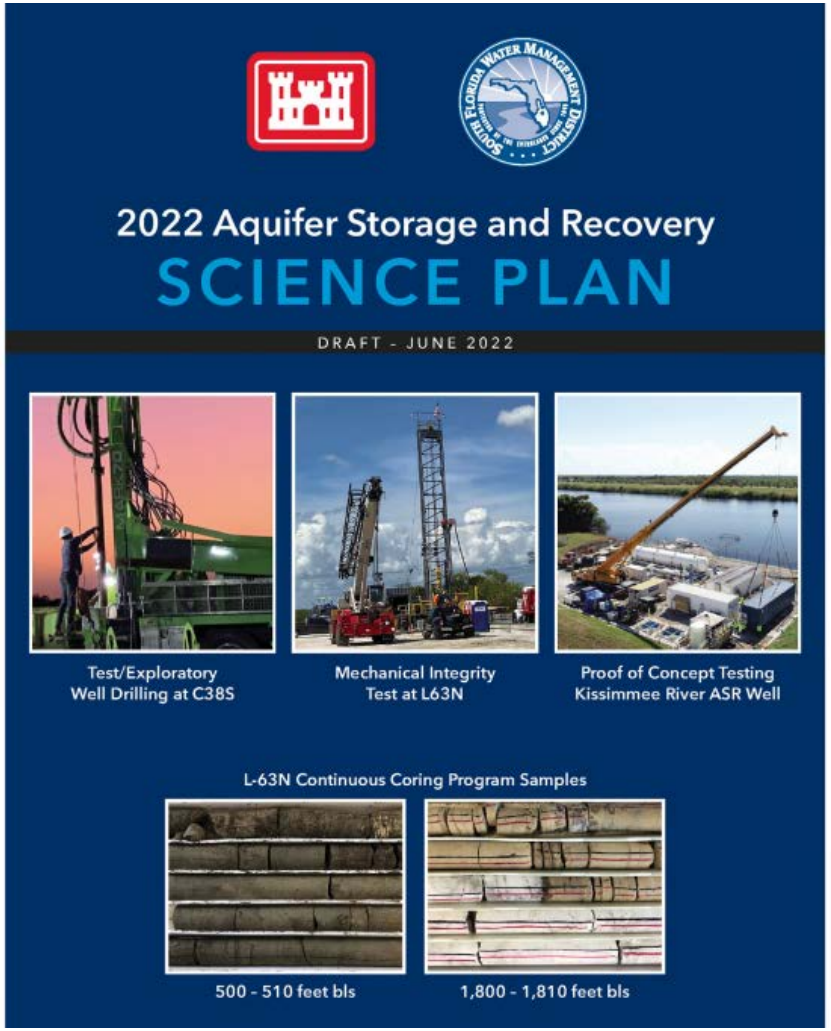
ASR Science Plan
Expected Progress Over the Next Year



2022 ASR Science Plan

2022 ASR Science Plan - Development Plan																								
Task #	SubTasks #	Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
1	Interagency (Dr. Checks) and Management Review of the Draft 2022 ASR Science Plan																						
2	Peer Panel Review of the Draft 2022 ASR Science Plan																						
3	Peer Review Panel Workshop																						
4	Peer Review Panel Report on Current Progress																						
5	Workshop with Peer Panel Members & Final version of Peer Review Panel Report delivered to SFWMD																						
6	Revisions of Draft 2022 ASR Science Plan + Management Review																						
7	30-day Public Review of 2022 ASR Science Plan																						
8	Responding to Public Comments																						
9	Final Revisions of the 2022 ASR Science Plan + Final Management Review																						
10	2022 ASR Science Plan Published online																						

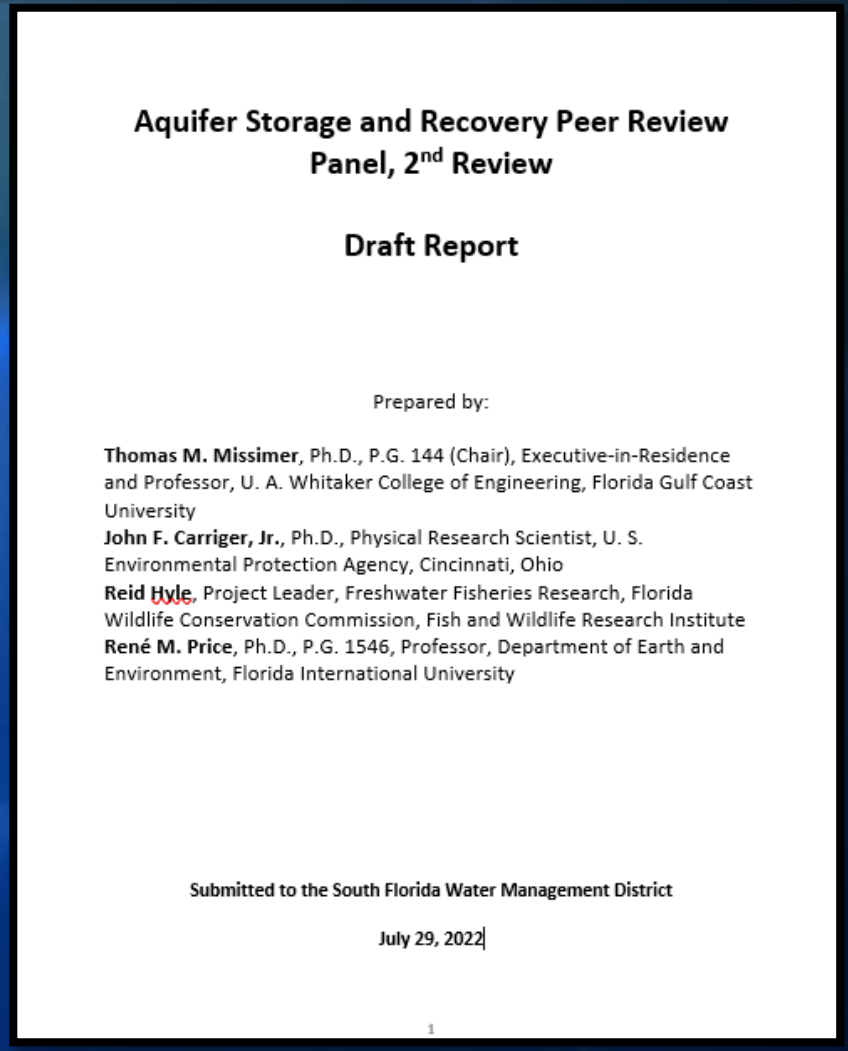
- **Public workshop with Peer Review Panel – June 15th**
- **Reconvene with the Peer Review Panel – August 26th**
- **Revise the Draft 2022 ASR Science Plan – September 18th**
- **Release Draft Report for 30-day public review - September 24th**
- **Publish 2022 ASR Science Plan - by December 20th**



2022 Peer Review Panel Workshop and Report

"The ASR Review Panel is pleased with the progress made on the completion of various portions of the science plan…"

- Continue with geological characterization and geochemical assessment of the aquifer system to aid with design of the ASR wells
- Take incremental approach to the design, construction and operation of a single low-capacity water treatment plant to evaluate the actual costs involved in meeting water quality requirements at the wellhead
- Add water treatment expert to the Peer Review Panel
- Continue with studies on the survival of bacteria and viruses in the storage aquifers
- Continue with ecological studies involving the quality of the recovered water and its potential impacts on the fauna and flora in the canal and lake systems
- Continue with ecological risk assessment modeling as described in the science plan



Aquifer Storage and Recovery Peer Review Panel, 2nd Review

Draft Report

Prepared by:

Thomas M. Missimer, Ph.D., P.G. 144 (Chair), Executive-in-Residence and Professor, U. A. Whitaker College of Engineering, Florida Gulf Coast University
John F. Carriger, Jr., Ph.D., Physical Research Scientist, U. S. Environmental Protection Agency, Cincinnati, Ohio
Reid Hyle, Project Leader, Freshwater Fisheries Research, Florida Wildlife Conservation Commission, Fish and Wildlife Research Institute
René M. Price, Ph.D., P.G. 1546, Professor, Department of Earth and Environment, Florida International University

Submitted to the South Florida Water Management District

July 29, 2022

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ASR Ecological Risk Assessment

Phase 1: Planning & Scoping

- **Goal:** Development of scoping document outlining planning and implementation of ERA & formulating Subject Matter Expert Working Group

Phase 2: Problem Formulation

- **Goal:** Identify data gaps (what and where is at risk? What is the hazard of concern?) & develop a **Work Plan** for completion of the Quantitative ASR ERA

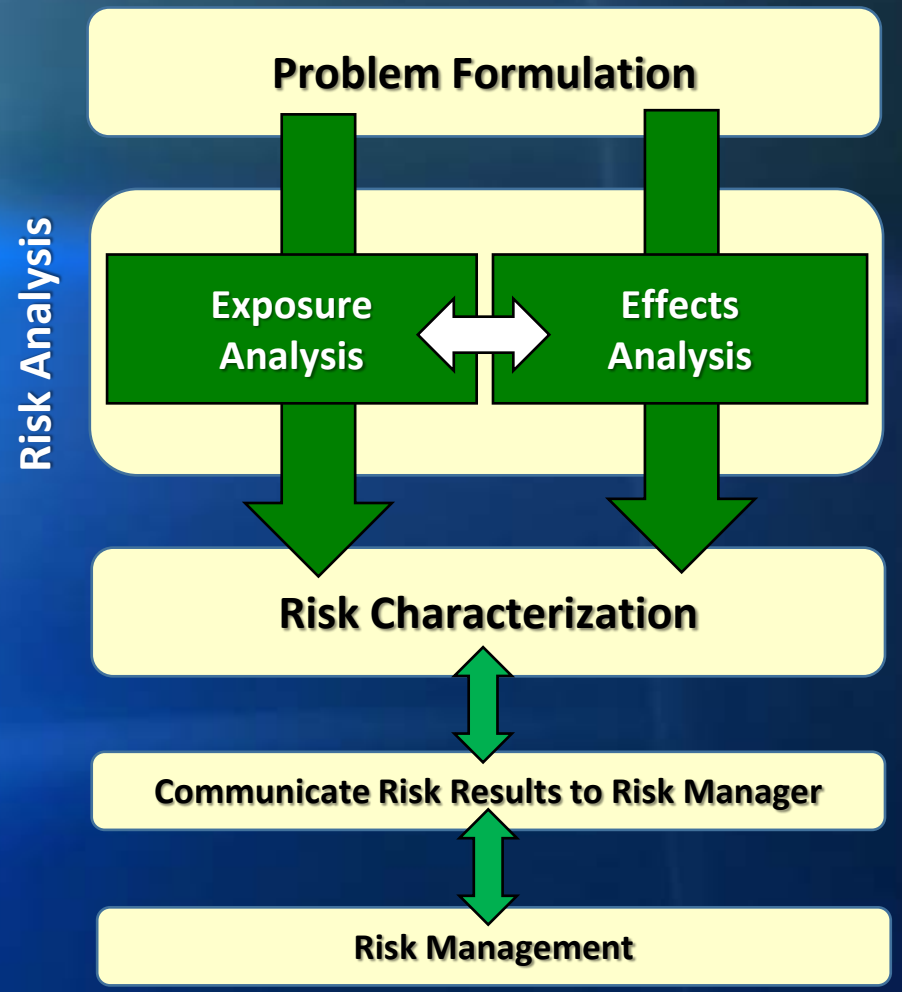
Phase 3: Data Collection

- **Goal:** Collect data identified in the ERA Work Plan to complete Quantitative ASR ERA

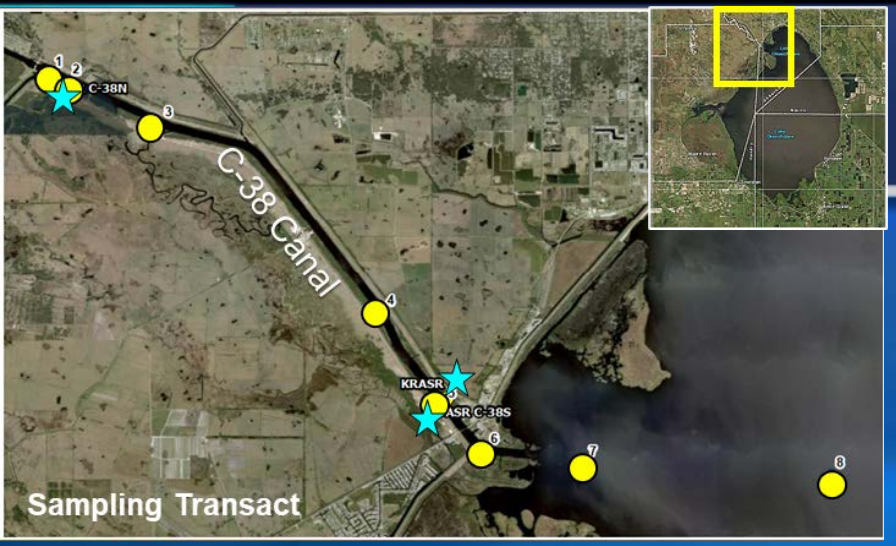
Phase 4: Quantitative Ecological Risk Assessment

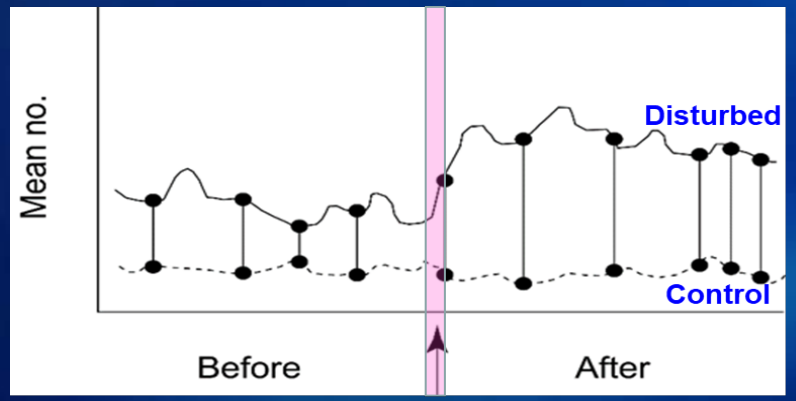
- **Goal:** Provide a technically defensible assessment of ecological risks (local and regional) from the operation of the planned ASR wells

U.S. EPA Ecological Risk Assessment Framework



Pre- and Post-Operational Monitoring Along the C-38 Canal





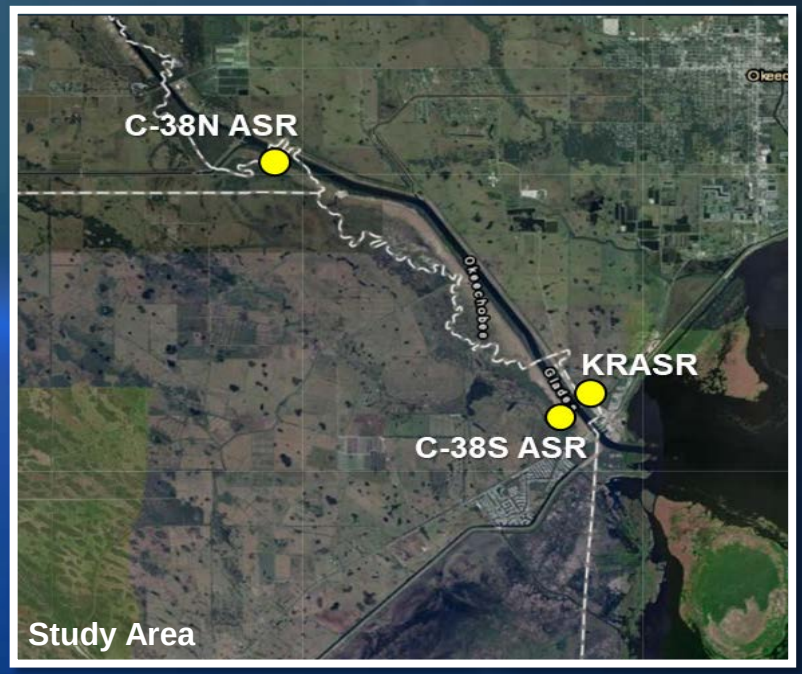
- **Evaluation of long-term bioaccumulation and community-level responses at different temporal and spatial scales**
- **Before-After-Control-Impact (BACI) study designs under low flow conditions and during different recovery periods**
  - **1-year Pre-Operational monitoring (2022 - 2023)**
  - **2 – 3 years Post-Operational monitoring once cycling begins (2023 - 2026)**

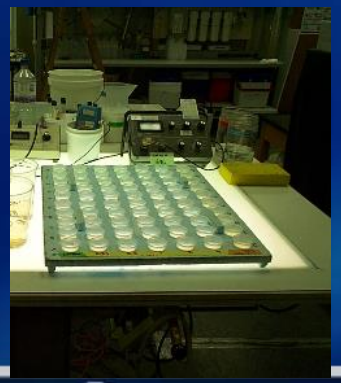
Pre-Operational Monitoring Schedule (2022-2023)

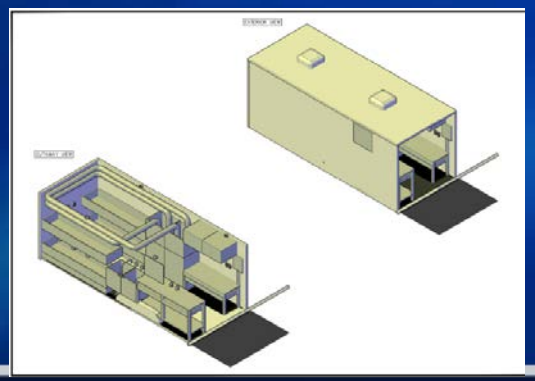
Study Components	July	August	September	October	November	December	January	February	March	April	May	June
Water quality												
Periphyton												
SAV												
Benthic Macros												
Sediment												
Apple Snails												
Mussels												
Fish Population												
Fish tissue												
Ichthyoplankton												

Bench-Scale Acute and Chronic Toxicity Tests and Bioconcentration Studies

- **Bioconcentration studies in mobile, flow-through, temperature-controlled laboratory in 2022-2024**
  - At multiple ASR locations (starting at C-38 S & N in 2023 – 2024)
  - Accumulation of contaminants within tissue of selected organisms
  - Experiments conducted under variety of conditions using source, recovered and 50/50 mixed water
- **Acute and Chronic Toxicological studies in laboratory-controlled setting (as required by NPDES and CERP permits)**
  - Survival, Growth, Reproduction tests
  - Conducted during cycles of varying durations (recharge & recovery phases)







Main ASR Peer Review Panel Recommendations Ecological Risk Assessment and Eco Studies

- Establish a system to implement and update the ERA with new information, conclusions, and information gaps annually.
- Use decision-making framework approach to determine future study types (included in ERA Work Plan).
- Use the weight of evidence approach to guide the information used for judging adverse effect and be tied into recommendations for management decisions (included in ERA Work Plan).
- Use Bayesian networks in a risk assessment framework if useful and appropriate to the quantitative work.
- Use separate but interconnected conceptual models that include information from impacted ecosystems and stressor types, and hypothesized exposure scenarios and interactions within the systems. Update models over time after more information become available (included in ERA Work Plan).
- Incorporate measurement endpoints into conceptual models and align and delineate measures of exposure to clarify how the assessment endpoints will be examined (developed for ERA Work Plan)
- Use native species for experimental work for better evaluation of ASR impacts (future work).

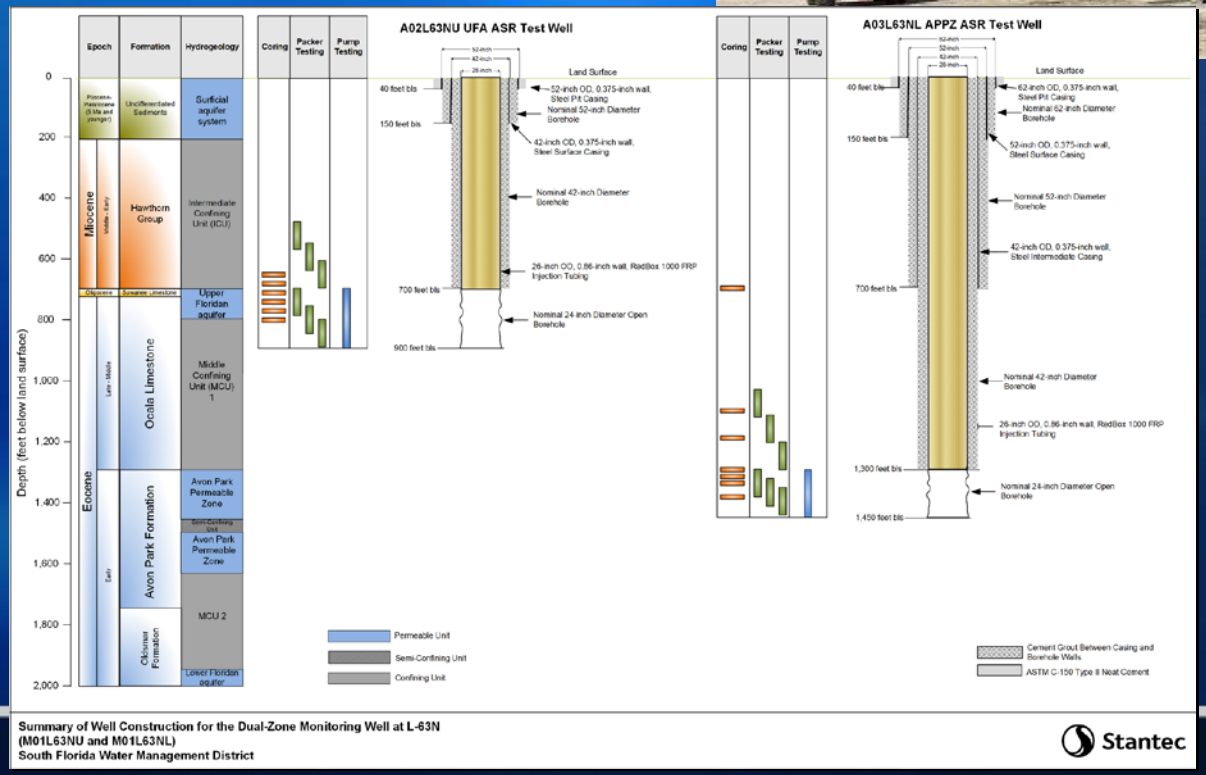
Aquifer Storage and Recovery Program Hydrogeologic Investigations

Bob Verrastro, P.G.
Principal Hydrogeologist
South Florida Water Management District, West Palm Beach, FL

Hydrogeologic Investigations

Test wells

- Aquifer hydraulic properties
  - Evaluate "vertically stacked" storage zones
  - Confinement
  - Leakance
  - Pumping pressures
  - fracture potential
  - Groundwater Model
  - Water quality



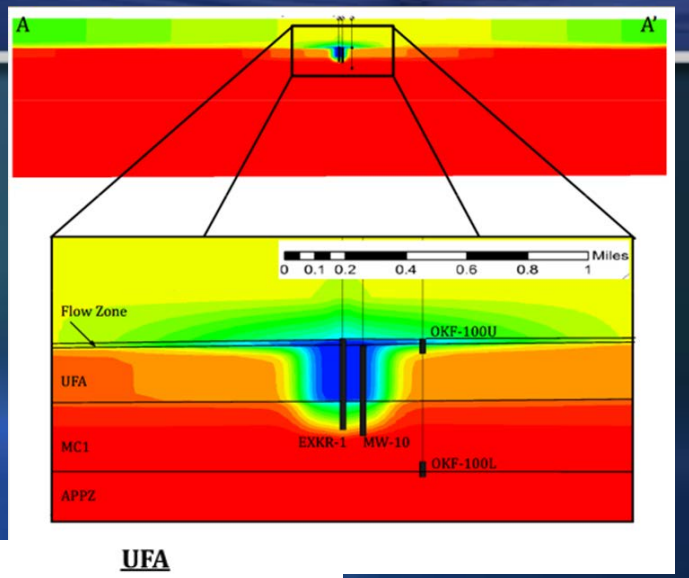
Summary of Well Construction for the Dual-Zone Monitoring Well at L-63N
(M01L63NU and M01L63NL)
South Florida Water Management District

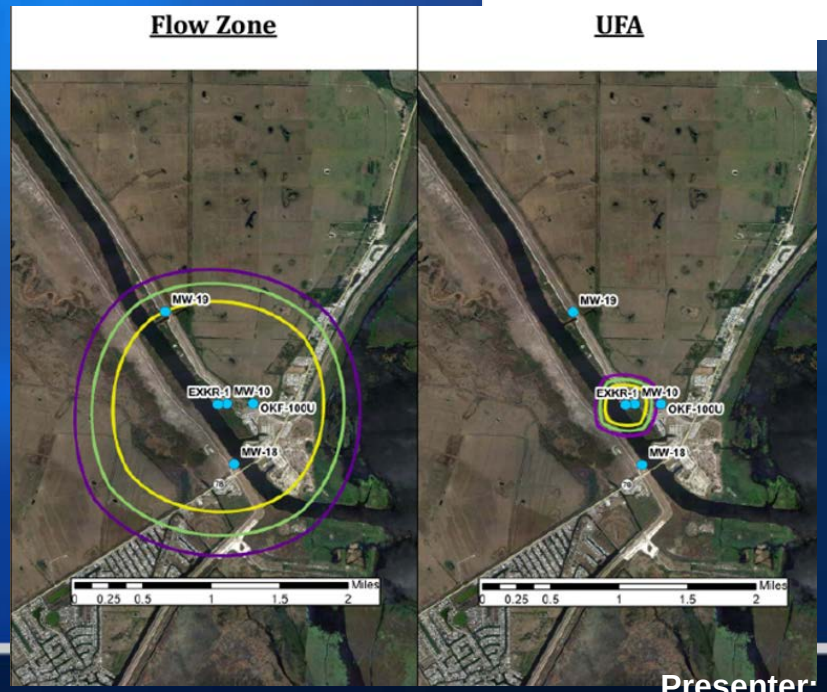
Stantec

Hydrogeologic Investigations (cont.)

Groundwater modeling

- Using models developed during the ASR Regional Study
- Radius of influence (impacts to existing users)
- Wellfield design (how many wells at each cluster)
- Fracture potential (injection pressure)
- Buffer zone evaluation (recovery efficiency)
- Permitting
- Cycle testing plan formulation

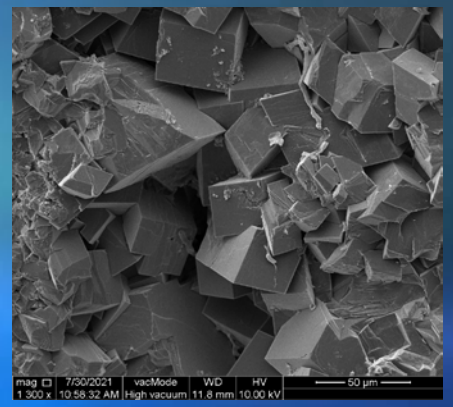


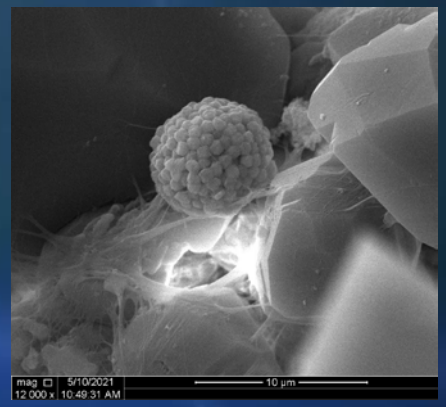


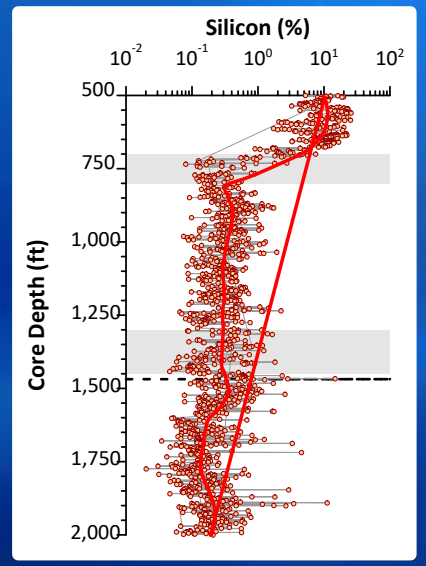
Hydrogeologic Investigations (cont.)

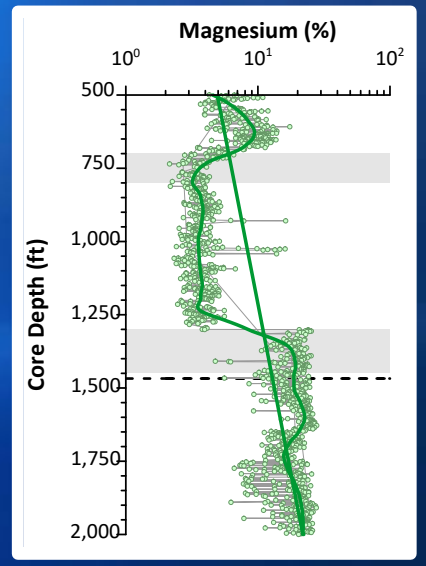
Continuous Cores

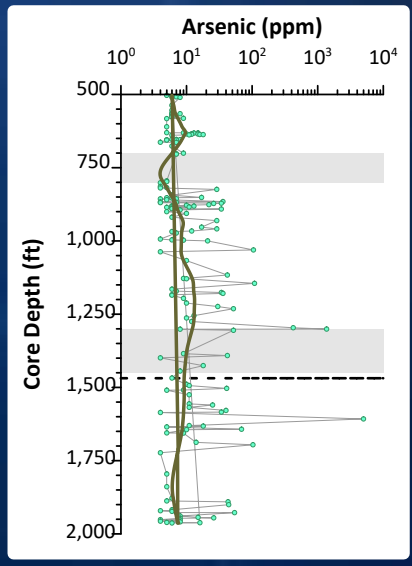
- Mineralogy, Inc.
- Florida Gulf Coast University
  - Portable X-ray fluorescence
  - Determination of mineralized zones
  - Whole-rock composition
  - "Ash" layer







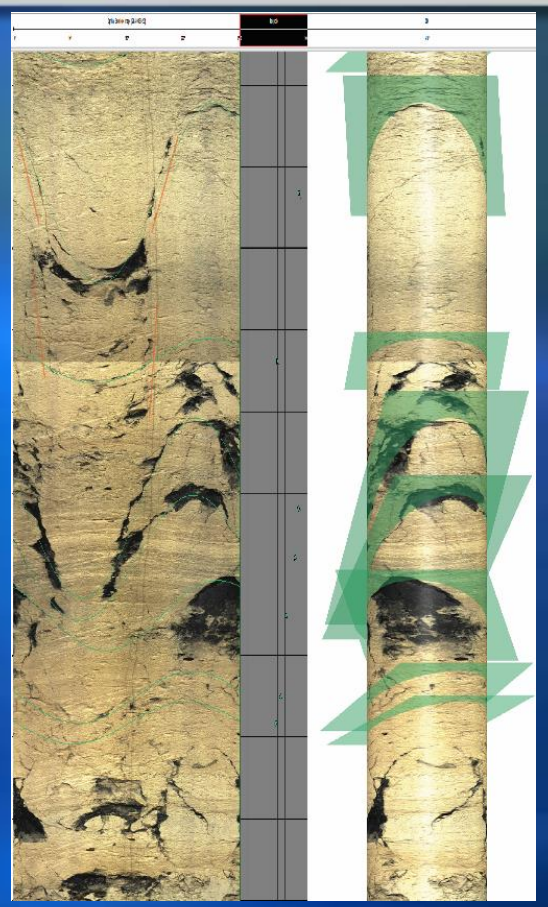




Hydrogeological Studies (cont.)

USGS Studies

- Davie
  - Lithology and stratigraphy
  - Secondary features (porosity, fractures)
- St. Pete
  - Pathogen inactivation
  - Nutrient reduction
  - Clogging potential



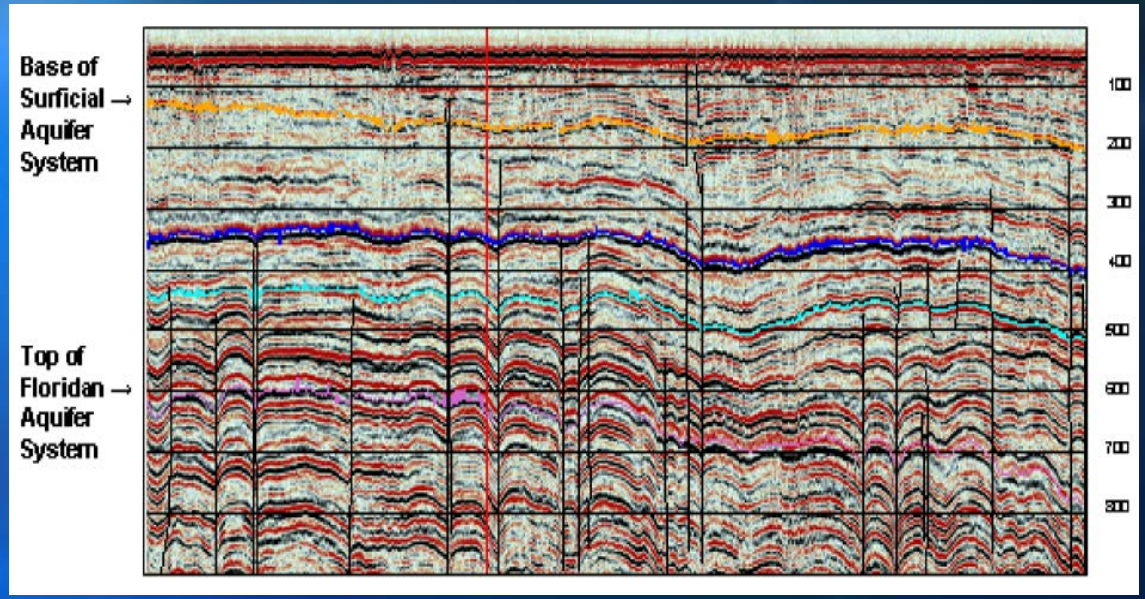
Hydrogeologic Investigations (cont.)

Reflection seismic surveys

- Recon locations where little is known
- Comparative evaluation to assess risks
- Data without having to drill a well

Geochemistry

- Radium/gross alpha
- Benchtop geochemical "mixing" model
  - Probability of arsenic mobilization



Hydrogeological Investigations (cont.)

2022 Peer Review Panel Comments

- Archive all rocks at the FGS for future researchers
- Continue studies on mineralogy, XRF to assist in storage zone selection
- Develop a logarithmic-type testing plan for recovered water
  - Arsenic and other metals
  - Sulfate
  - Gross alpha and radium
- Integrate regional fracture, faulting and anisotropy into groundwater model
  - Preferential flow patterns
  - Influence on subsurface water storage, migration and recovery

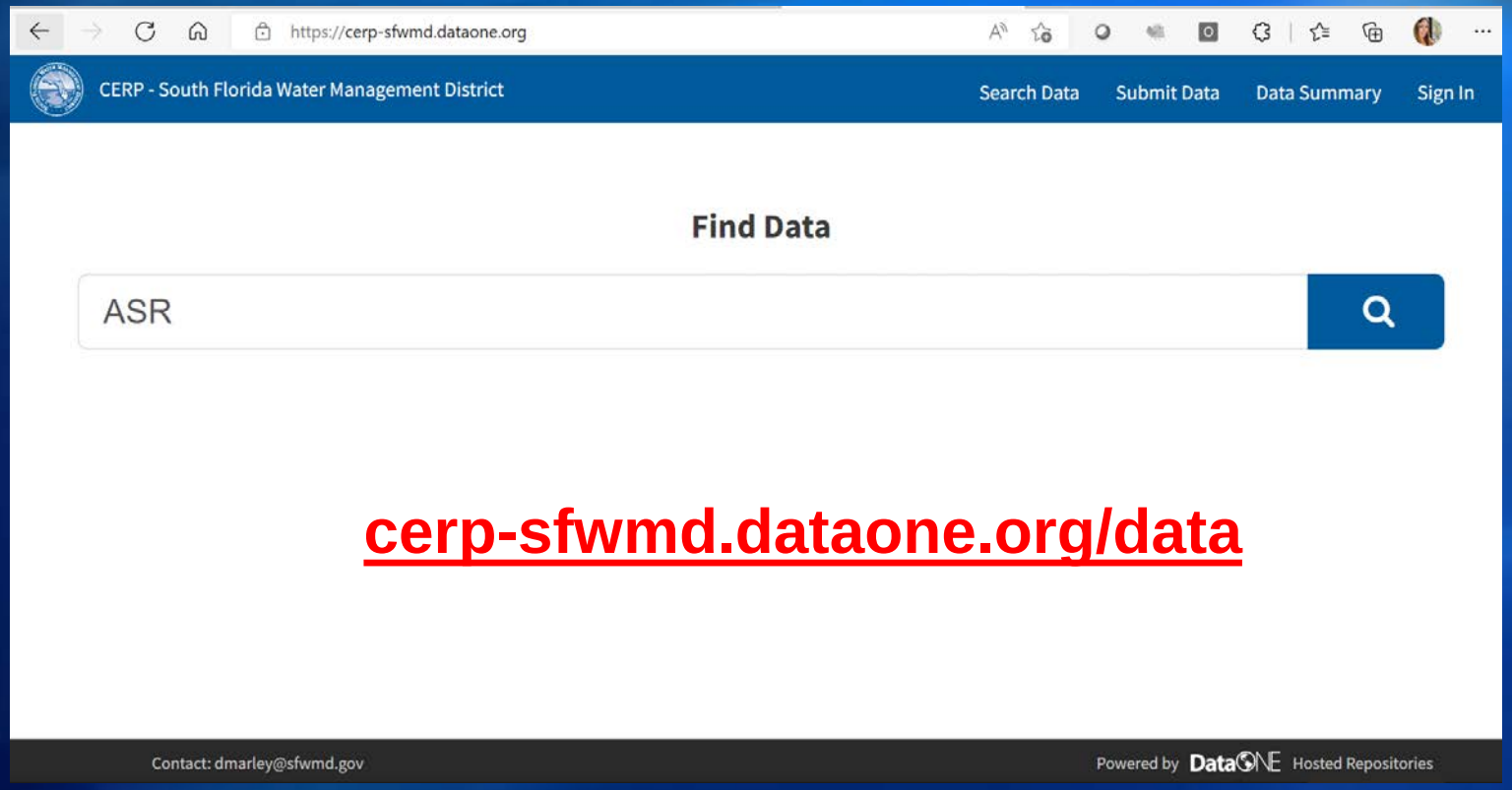
Draft 2022 ASR Report Card

2022 ASR Science Plan Report Card

National Research Council Uncertainties and ASR Peer Review Panel Recommendations	% Progress Towards Adressing the Topic									
	10	20	30	40	50	60	70	80	90	100
2015 National Research Council Uncertainties										
Local scale information on atributes of APPZ										
Research Phosphorus removal mechanisms										
Reseach pathogen inactivation in the aquifer										
Couple pathogen inactivation with groundwater travel times	•									
Analysis of injection pressures for fracture potential	•									
Establish buffer zone										
Arsenic transport within aquifer using buffer zone										
Buffer zone usage to reduce sulfate concentrations										
Fate of sulftate in recovered water to form methylmercury										
Local scale model for heterogeneity/anisotropy/fracturing/travel times	•									
Pretreatment technologies to remove arsenic										
Analysis of wellfield cluster for spacing and optimal recovery efficiency										
Anisotropy analysis used for orienting wells										
Tracer studies for flow directions										
Cross-well tomography and geophysics										
Locate clusters near large water bodies										
Examine technologies to meet regulatory requirements										
Variability of gross alpha and radium in recovered water										
Examine source water effects on redox evolution of aquifer										
Improve/extend cycle tests										
Operate multi-well pairs and clusters										
Continue chronic toxicity testing at multiple ASR locations										
Long-Term ecological monitoring and bioconcentration studies, including examining community-level effects										
Probabilistic, quantitative ecological risk assessment										
2021 ASR Peer Review Panel Recommendations										
Develop ASR Programmatic Quality Assurance Plan										
Data Storage, Management, and Public Access										

ASR Data Storage and Public Access

- Reports pertaining to LOWRP or the ASR studies can be found on DBHYDRO or DataOne
- Information pertaining to ASR Science Plan can be found on SFWMD website



cerp-sfwmd.dataone.org/data

www.sfwmd.gov/asr

Questions?

www.sfwmd.gov/lowrp or www.sfwmd.gov/asr