SOUTH FLORIDA WATER MANAGEMENT DISTRICT

2022 Aquifer Storage and Recovery Science Plan Peer Review Panel Workshop

June 15, 2022

sfwmd.gov

Welcome and Progress Since the 2020 ASR Science Plan Workshop

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

Welcome/Workshop Logistics

- Welcome/Meeting Purpose and Objectives
- Introductions
  - Panel members
  - ASR team members
- Meeting Format
  - June 15th – 9am - 4pm (Public Meeting)
  - June 16th – 9am - 3pm (Panelists and Project Team Only)
  - Panel discussion throughout the day
  - Public comment period prior to lunch and prior to closing remarks

Workshop Agenda

2022 ASR Science Plan Peer Review Panel Meeting

June 15, 2022 at 9:00 am – 4:00 pm

1. **Welcome and Progress Since 2021** — 9:00 – 9:15 am
   Elizabeth Caneja, Lead Project Manager,
   SFWMD – Ecosystem Restoration and Capital Projects Division

2. **L63N Corehole Presentation** — 9:15 – 9:45 am
   Hannah Rahman, GIT, Stantec

3. **Geochemical Analysis of Cores** — 9:45 – 10:15 am
   Dr. Jamie MacDonald, Provost Faculty Fellow and Professor,
   Florida Gulf Coast University – Environmental Geology Program

Break 10:15 – 10:30 am

4. **Assessment of Fracture Porosity of the Floridan Aquifer System** — 10:30 – 11:00 am
   Dr. Kevin Cunningham and Victor Flores,
   USGS Caribbean–Florida Water Science Center

5. **Characterization of Microbial and Geochemical Processes that Contribute to Nutrient Reduction and Potential Clogging** — 11:00 – 11:30 am
   Dr. John Lisle, Research Microbiologist,
   USGS – St. Petersburg Coastal and Marine Science Center

6. **Panel Discussion** — 11:30 – 11:50 pm

7. **Public Comment** — 11:50 – 12:00 pm

Lunch Break 12:00 – 12:30 pm

8. **Water Treatment Technology Evaluation** — 12:30 – 1:00 pm
   Heath Wintz PE, Lead Environmental Engineer, Stantec

2022 ASR Science Plan Peer Review Panel Meeting

June 15, 2022 at 9:00 am – 4:00 pm

9. **Ecological Risk Assessment** — 1:00 – 1:30 pm
   Joseph Allen MS, Senior Wildlife Biologist / Risk Assessor,
   Formation Environmental

10. **Ecological Risk Assessment – Ecological Studies** — 1:30 – 2:00 pm
    Jennifer Mathia MMM, Senior Biologist,
    Environmental Consulting and Technology

Break 2:00 – 2:15 pm

11. **ASR Programmatic Quality Assurance Plan** — 2:15 – 2:35 pm
    Steven Elliott MS, Senior Chemist, Stantec

12. **ASR Projects in the Southwest Florida Water Management District** — 2:35 – 3:00 pm
    Samantha Smith, Hydrogeologist, SWFWMD

13. **Panel Discussion** — 3:00 – 3:30 pm

14. **Public Comment** — 3:30 – 3:40 pm

15. **Closing Remarks and Expected Progress Over the Next Year** — 3:40 – 4:00 pm
    Dr. Anna Wachnicka, Lead Scientist,
    SFWMD – Applied Sciences Bureau

16. **Adjourn**

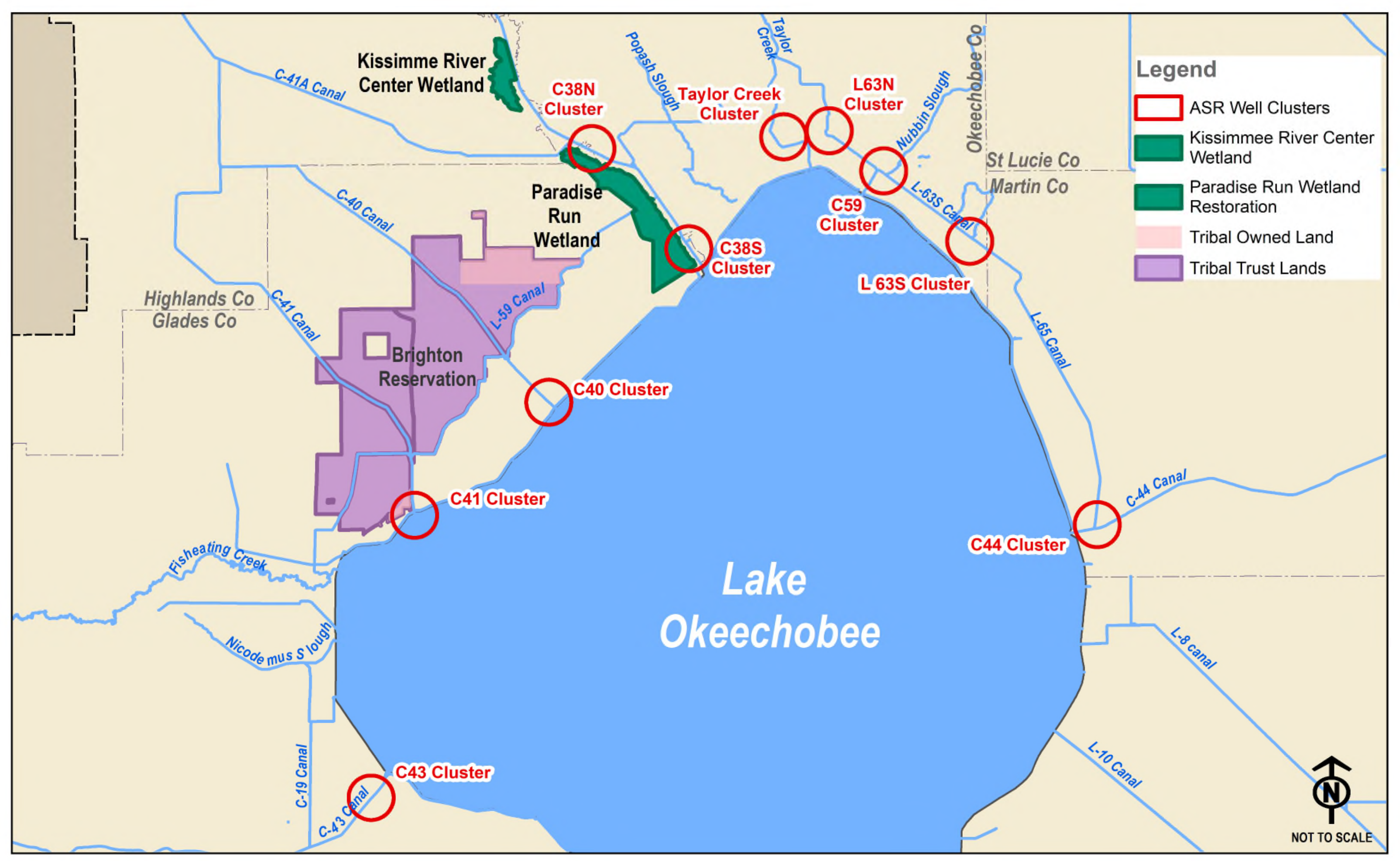
June 16, 2022

PRP Meeting at SFWMD Headquarters, West Palm Beach 9:00 am – 10:00 am

Optional PRP Tour of Kissimmee River ASR Facility 10:00 am – 3:00 pm

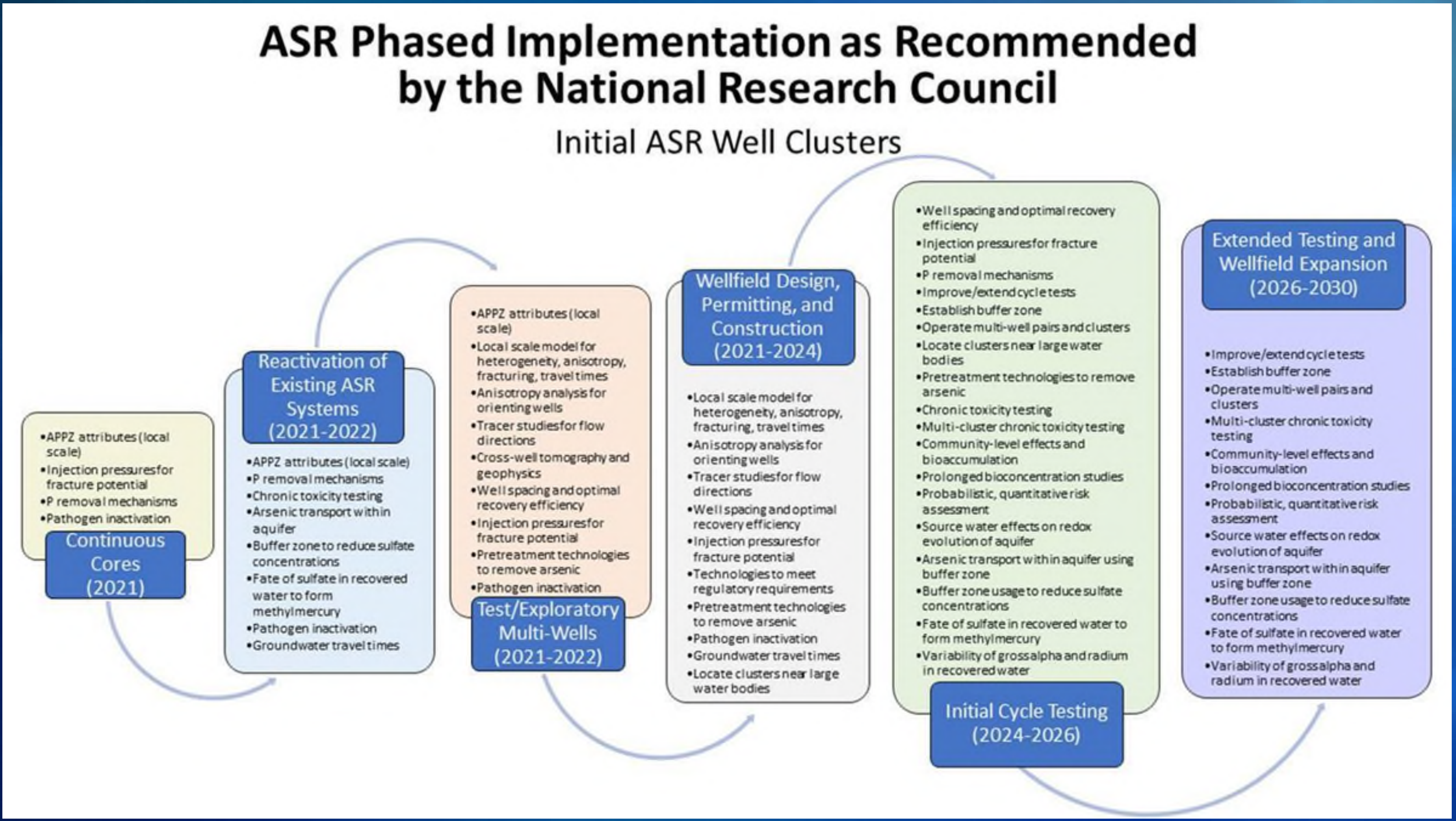
Second Zoom Workshop – September 2022

LOWRP Revised Recommended Plan (Alt ASR)



- **Aquifer storage and recovery**
  - 55 ASR wells
  - 308,000 ac-ft of storage per year
- **Wetland restoration**
  - Paradise Run ~ 4,700 acres
  - Kissimmee River Center ~ 1,200 acres

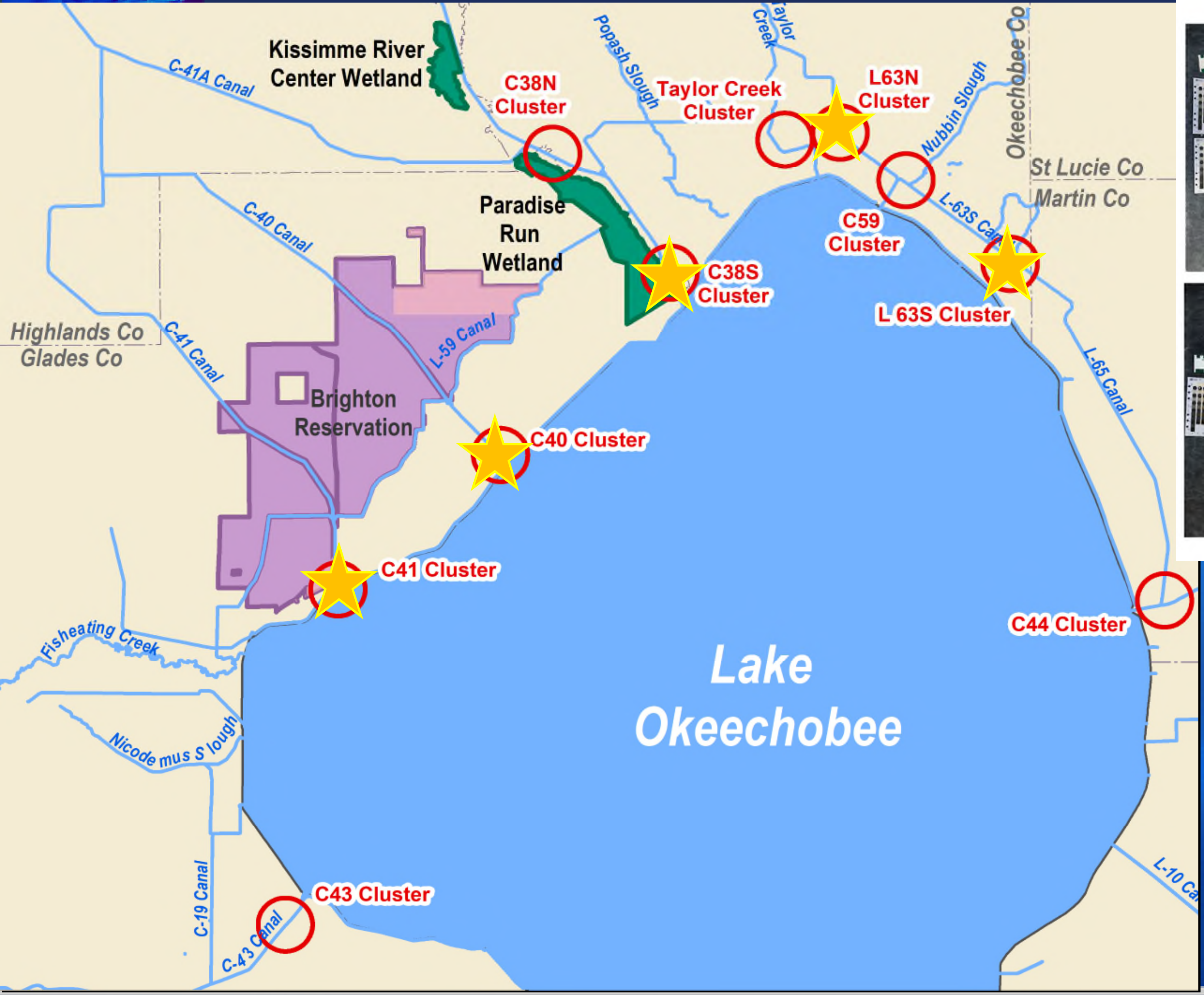
ASR Cluster Implementation: Phased Approach

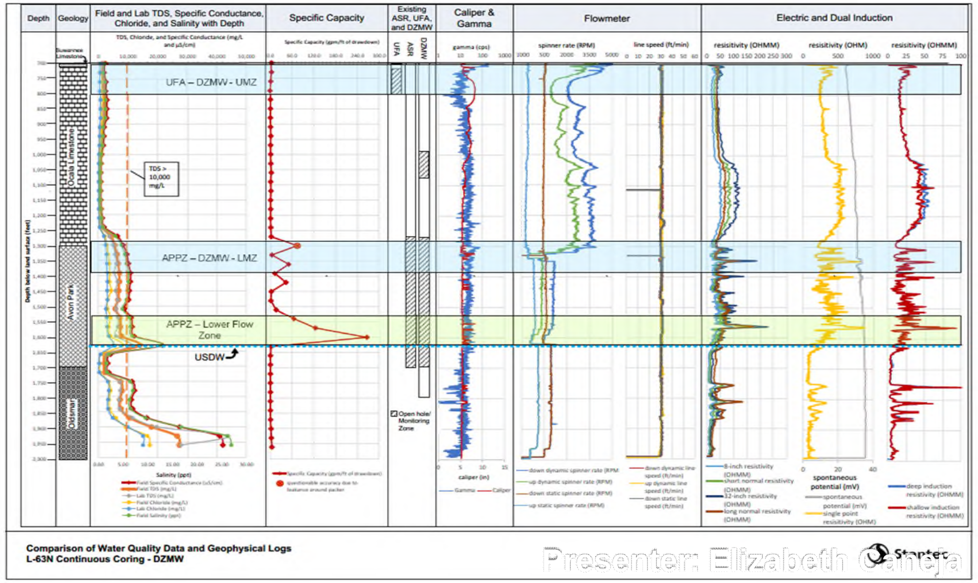


- Expansion of L63N Cluster

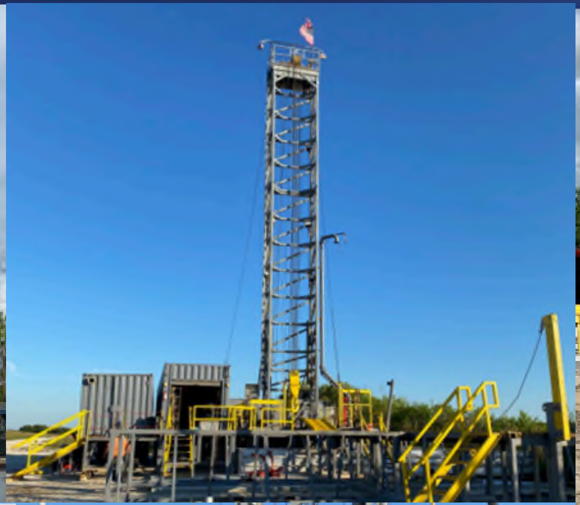
- Reactivate KRASR Well

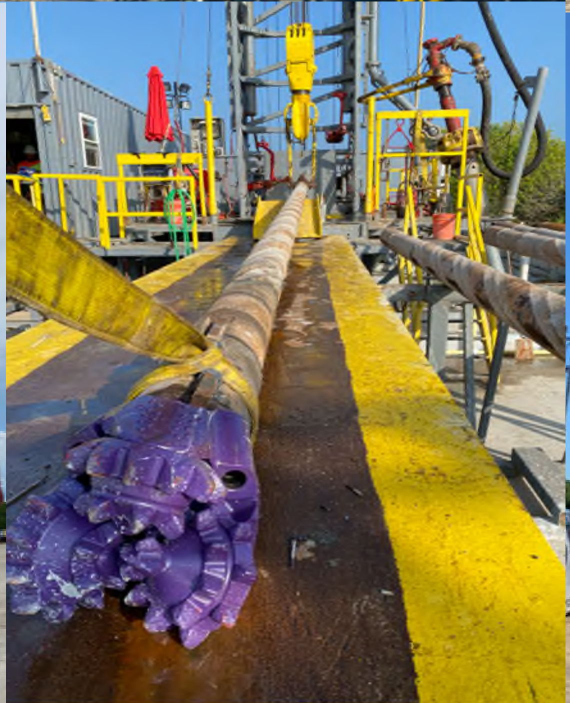
Continuous Coring and Monitoring Well Program





Test/Exploratory Wells at C-38N and C-38S

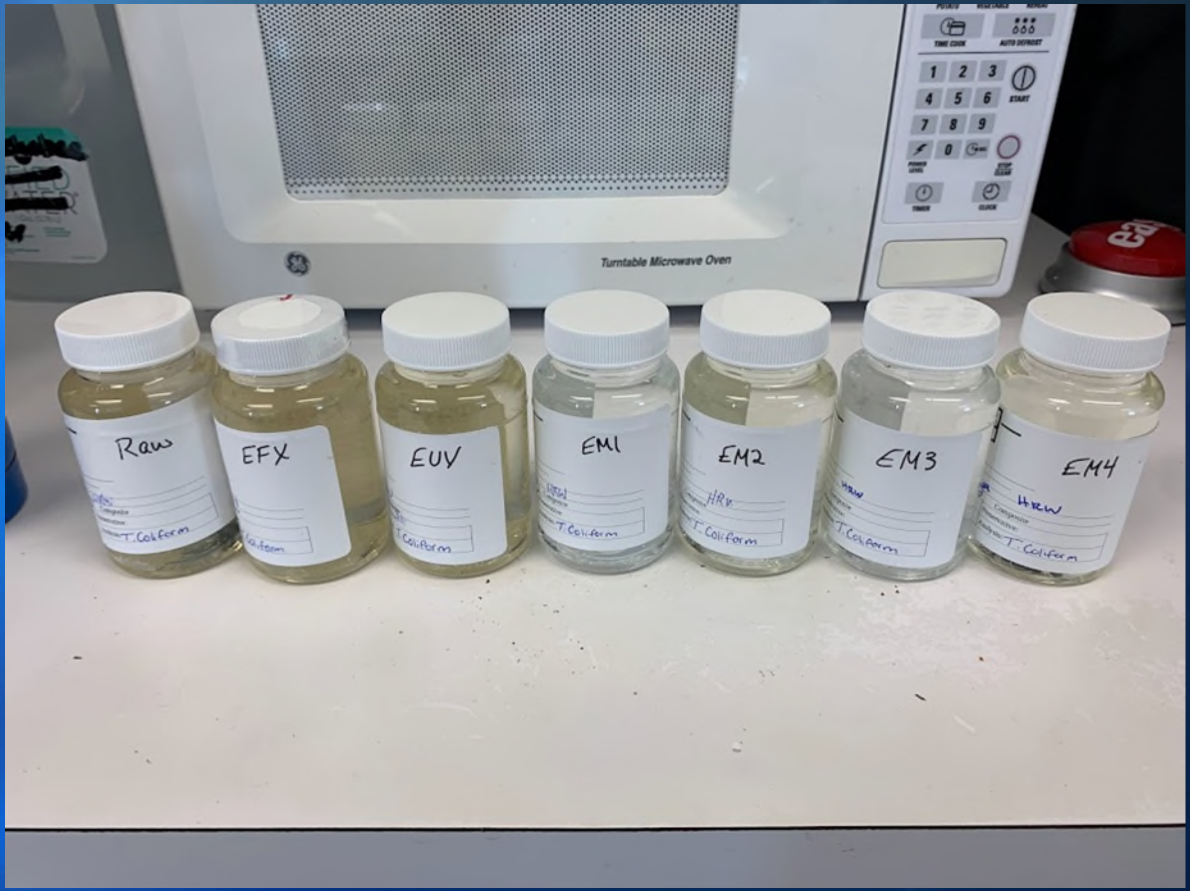




Presenter: Elizabeth Caneja

Treatment Technology Evaluation

Proof of Concept Testing



Water Samples - Raw and Treated

ASR Implementation Schedule and Near-Term Next Steps

LOWRP ASR Program Implementation	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
L63N Well Cluster Site											
Well Construction (5 wells + 1 existing APPZ well)	SITING	CORE/DATA	TEST WELLS 1&2	TEST WELLS 3&4	TEST WELLS 5						
Treatment Plant				DESIGN,PERMITTING & CONSTRUCTION							
Testing and Operations							CYCLE TESTING		O&M		
Science Plan Tasks		SCIENCE PLAN									
C38N Well Cluster Site											
Well Construction (10 wells)	SITING	TEST WELLS 1&2	TEST WELLS 3&4	TEST WELLS 5&6	TEST WELLS 7&8	TEST WELLS 9&10					
Treatment Plant			DESIGN,PERMITTING & CONSTRUCTION								
Testing and Operations							CYCLE TESTING		O&M		
Science Plan Tasks			SCIENCE PLAN								
C38S Well Cluster Site											
Continuous Core		CORE/DATA	CORE/DATA								
Well Construction (10 wells)	SITING	TEST WELLS 1&2	TEST WELLS 3&4	TEST WELLS 5&6	TEST WELLS 7&8	TEST WELLS 9&10					
Treatment Plant			DESIGN,PERMITTING & CONSTRUCTION								
Testing and Operations							CYCLE TESTING		O&M		
Science Plan Tasks		SCIENCE PLAN									
Existing KRASR Well Refurbishment		DESIGN & PERMITTING		CYCLE TESTING		O&M					
Science Plan Tasks for Existing KRASR		SCIENCE PLAN									
C59 Well Cluster Site											
Well Construction (4-10 wells)	SITING		DATA								
Science Plan Tasks			SCIENCE PLAN								
L63S Well Cluster Site											
Well Construction (4-10 wells)	SITING		CORE/DATA								
Science Plan Tasks			SCIENCE PLAN								
Taylor Creek Well Cluster Site											
Well Construction (4-10 wells)		SITING	DATA								
Science Plan Tasks			SCIENCE PLAN								
C40 Well Cluster Site											
Well Construction (4-10 wells)		SITING	CORE/DATA								
Science Plan Tasks			SCIENCE PLAN								
C41 Well Cluster Site											
Well Construction (4-10 wells)		SITING	CORE/DATA								
Science Plan Tasks			SCIENCE PLAN								
C43 Well Cluster Site											
Well Construction (4-10 wells)			DATA								
Science Plan Tasks											
C44 Well Cluster Site											
Well Cluster (4-10 wells)			DATA								
Science Plan Tasks											
Estimated Costs:	$2,111,128	$24,479,328	$97,628,122	$115,445,738	$94,675,944	$93,365,000	$42,760,000	$6,450,000	$5,400,000	$5,400,000	$5,400,000

TOTAL: $493,115,260

- SITING EVALUATION
- CORE & DATA COLLECTION
- TEST/EXPLORATORY WELLS
- DESIGN, PERMITTING & CONSTRUCTION
- CYCLE TESTING
- OPERATION & MAINTENANCE (O&M)
- SCIENCE PLAN

TBD/Blank - Will be scheduled when additional funding becomes available

- Near-Term Next Steps:
  - Complete Proof-of-Concept Draft Report – May 2022 (Final Report in July 2022)
  - Complete Continuous Core at the C38S site – Dec 2022
  - Initiate Treatment Design of C38S and C38N well cluster sites – Aug 2022
  - Initiate first set of Test Wells at L63N – To be awarded in Aug 2022
  - Complete Construction of first set of Test Wells at C38S and C38N sites – Aug and Nov 2022
  - Aquifer Pump Tests at C38S and C38N sites – Sept and Dec 2022
  - Request for Proposal for Drilling Contractors – To be awarded in Oct 2022
  - Request for Proposal for Treatment Technology Vendors – To be awarded in Dec 2022

ASR Science Plan Progress

Progress towards addressing uncertainties:

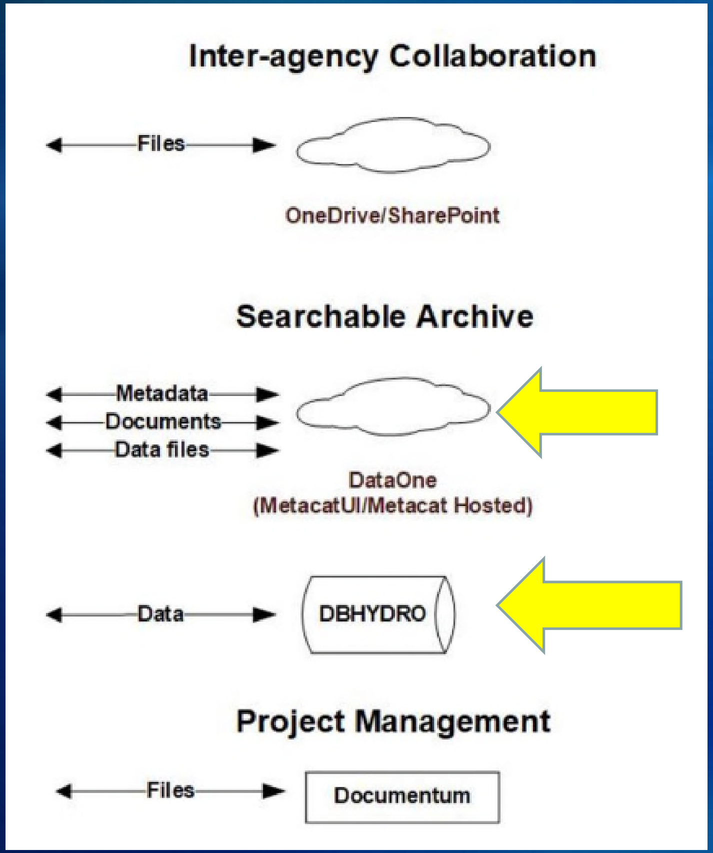
- USGS Contracts – Bioclogging Analysis of the Aquifer, Multi-well Assessment Fracture Porosity, and Optical Borehole Logging
- Florida Gulf Coast University – Core analysis of L63N
- Stantec – Site Feasibility Analysis, Treatment Technology Evaluation, Proof-of-Concept Testing for Treatment Technology (water stored in the aquifer), DEP Permitting (UIC and CERPRA), Monitoring Plans and Programmatic Quality Assurance Plan
- Hazen & Sawyer – Treatment Technology Evaluation and Proof-of-Concept Testing (3^{rd} Party Review)
- Huss Drilling – Continuous Core Program
- Florida Design Drilling – Exploratory/Test Well Drilling at C38N and C38S, Aquifer Pump Test, DEP NPDES Permitting
- ECT, PSI, Formation – Ecological Risk Studies (bench-scale bioconcentration and ecotoxicity studies, long-term ecological monitoring)

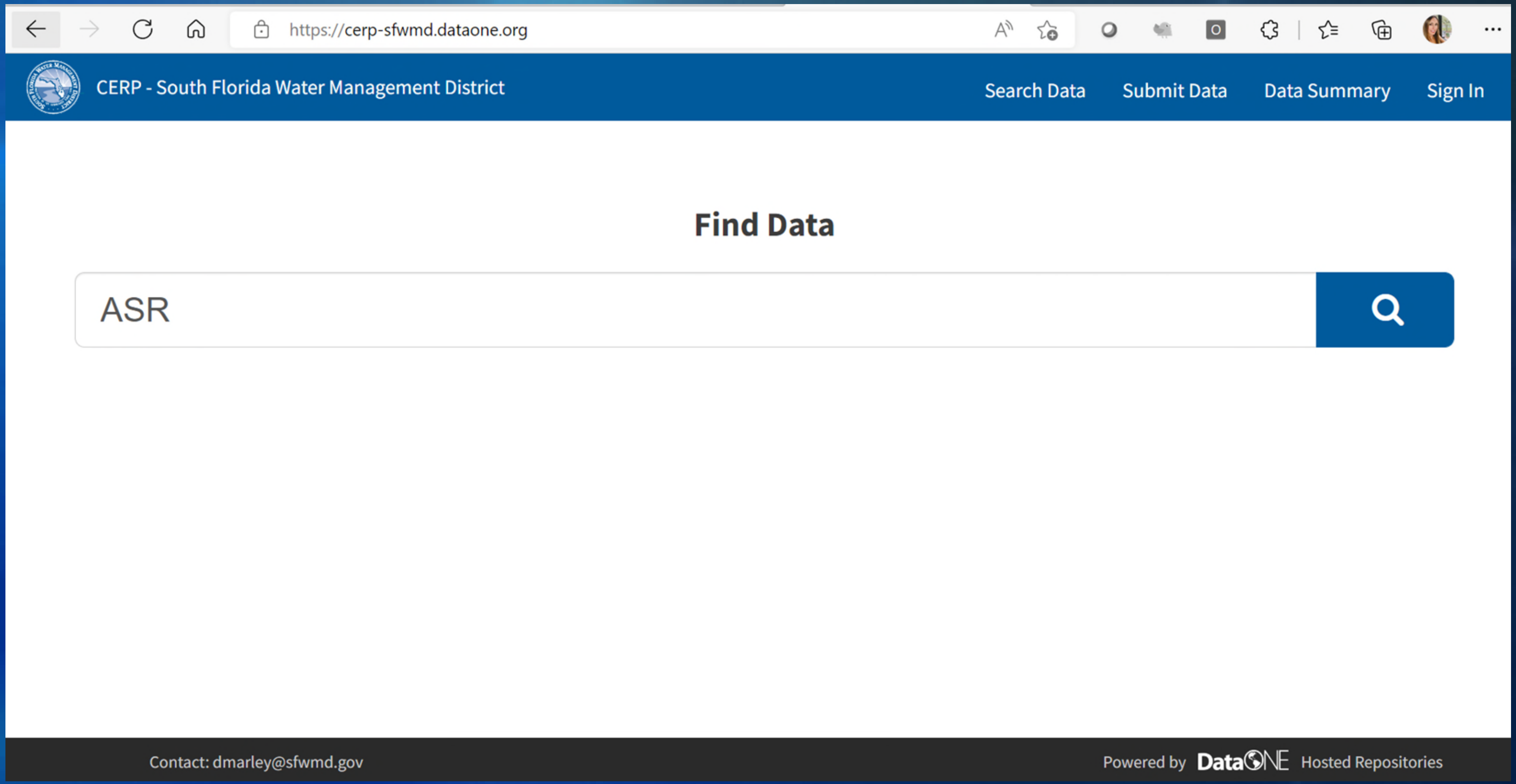
Draft 2022 ASR Report Card

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										

Data Storage, Management, and Public Access





Panel Discussion (5 min.)

Stantec

Lake Okeechobee Watershed Restoration Project (LOWRP) Aquifer Storage and Recovery Wells Continuous Coring Program

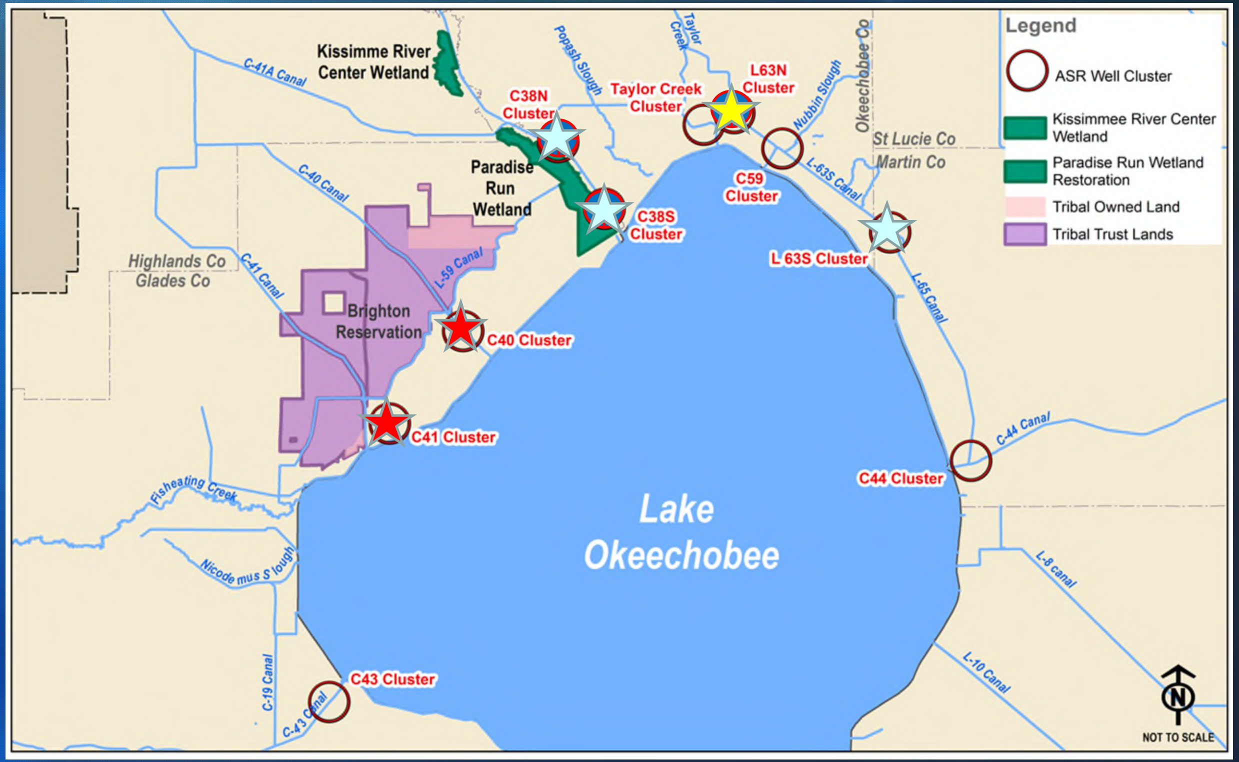
Presenter: Hannah Rahman, GIT

Contributor: Rick Cowles, PG

Stantec Inc.

Lake Okeechobee Watershed Restoration Project (LOWRP) and ASR Well Sites

- **Aquifer Storage and Recovery (ASR) Wells**
  - ASR refers to the process of recharge, storage, and recovery of water in the aquifer
  - Surface water is collected during times when water is plentiful, treated to meet applicable water standards, and then pumped into an aquifer through a well
- **Surface water level stabilization**
- **Wetland restoration**



Ongoing and Completed Work Over the Past 2.5 Years

- L-63N ASR MIT
- Hydrogeologic Assessment – C-38N, C-38S, L-63N, L-63S, C-59, C-40, and C-41
- Continuous Core Holes – three sites
- Treatment Evaluation
- Proof of Concept Treatment Technologies Evaluation
- Kissimmee ASR System Assessment
- FDEP UIC Permitting
- C-38N and C-38S ASR Test Well Design and Construction
- L-63N ASR Test Well Design and Construction Summery
- Upcoming Groundwater Modeling

ASR Test Well Construction

- Four drill rigs construction two UFA and two APPZ ASR Test Wells simultaneously – ASR well pairs
- Currently permitting the second set of wells
- Construction anticipated to start in late summer 2022
- Construction 50 MGD wellfields at C-38N and C-38S sites

SFWMD Continuous Core Program

Continuous Coring Program L-63N Site

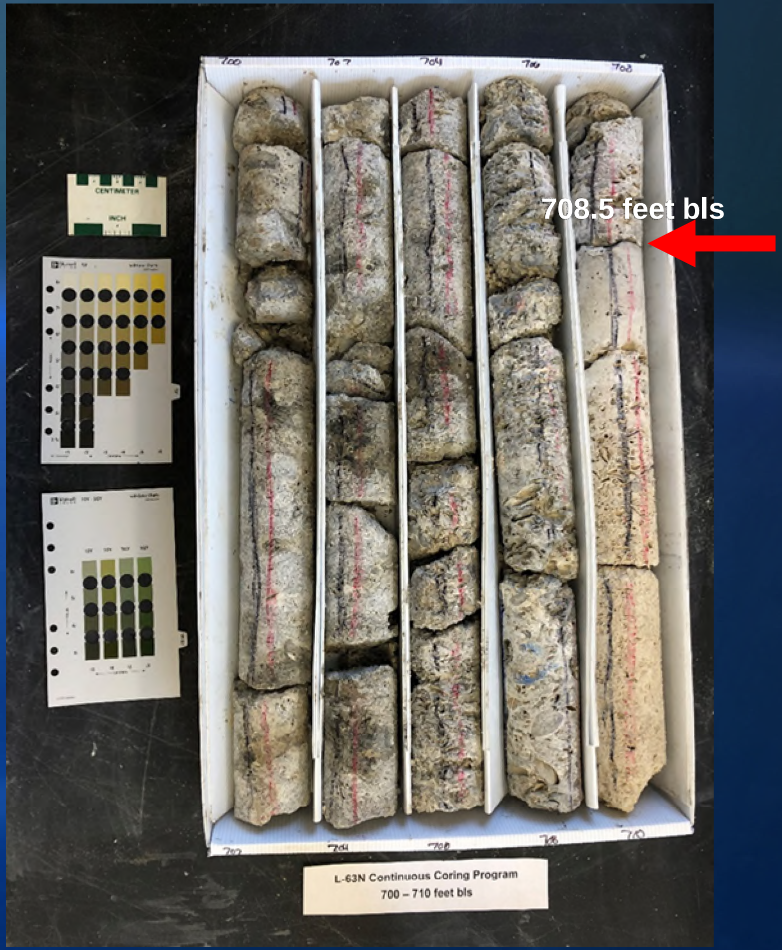
Continuous Coring Process

- Cuttings from 0 feet to 500 feet bls
- 10-foot cores from 500 feet to 2,000 feet bls
  - RQD and Recovery
- Off-bottom packer tests every 30 feet bls starting at 700 feet bls
  - Water quality
  - Isotope
  - Specific Capacity
- Geophysical Logging including OBI

Cores


L-63N Continuous Coring Program
500 – 510 feet bls


697 feet bls
L-63N Continuous Coring Program
690 – 700 feet bls


708.5 feet bls
L-63N Continuous Coring Program
700 – 710 feet bls

Cores


L-63N Continuous Coring Program
840 – 850 feet bls


1,300.5 feet bls
L-63N Continuous Coring Program
1,300 – 1,310 feet bls


L-63N Continuous Coring Program
1,800 – 1,810 feet bls

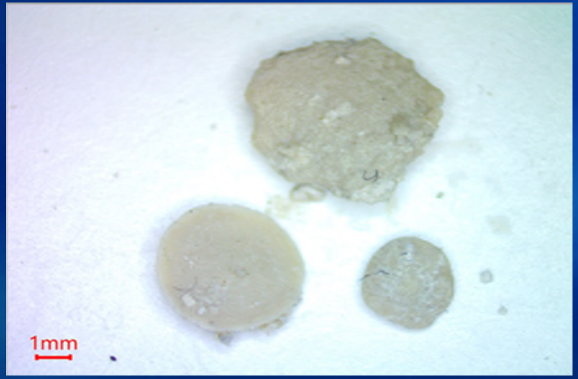
Fossils and Features

Lemon Shark Tooth – 535 feet

Phosphate Nodule - 565 feet bls

Sponge spicules – 705 feet bls

Lepidocyclina ocalana - 715 feet bls

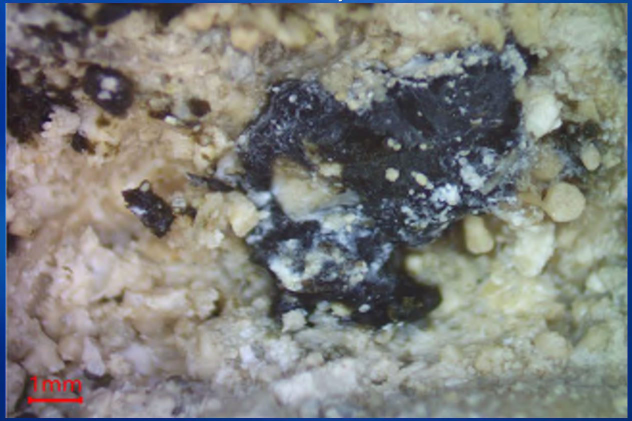


Pyrite - 925 feet bls

Fossils and Features

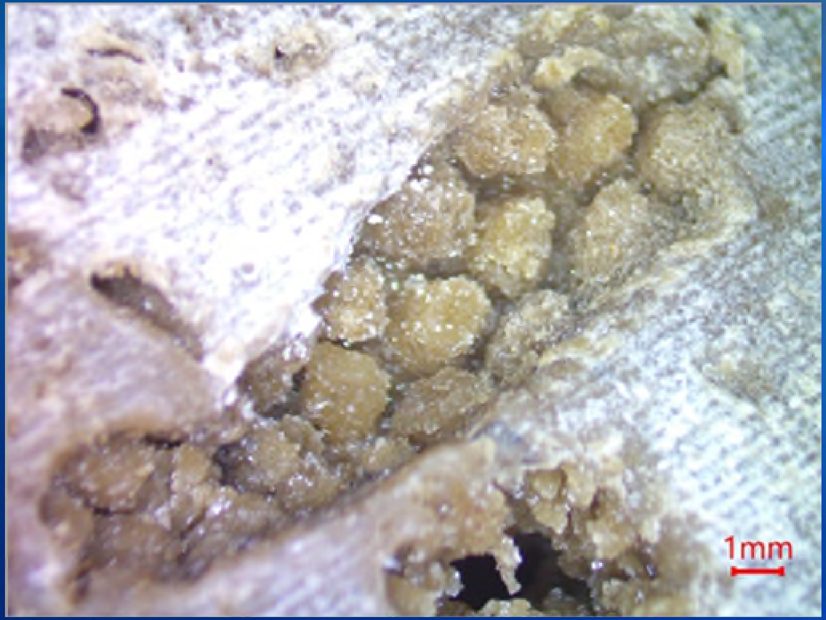
Limestone with grains comprised of mudstone rip up clasts – 1,078.5 feet bls

Glauconite - 1,118 feet bls

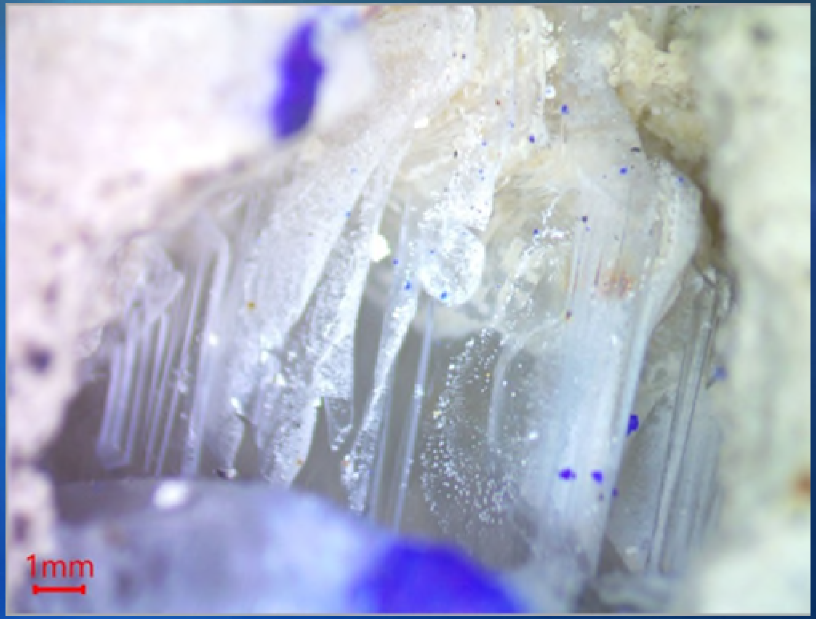


Fossils and Features

Bryozoan Fossil - 1,522.5 feet bls

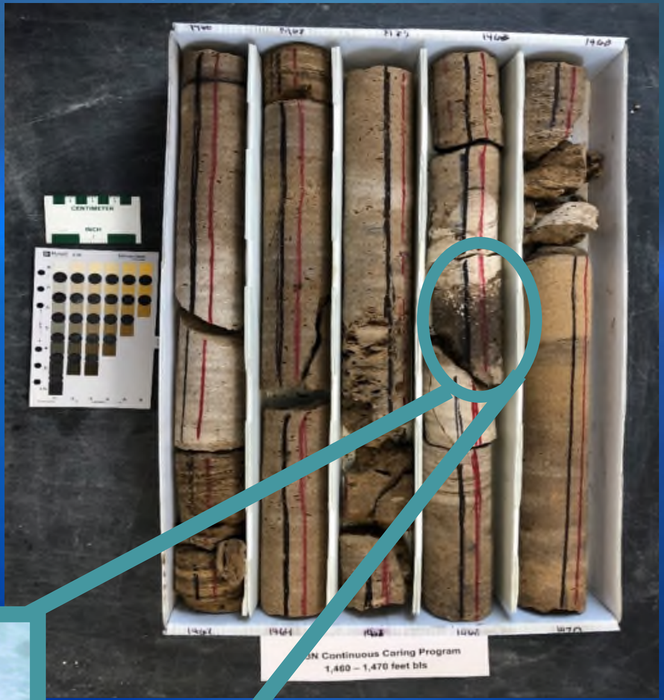


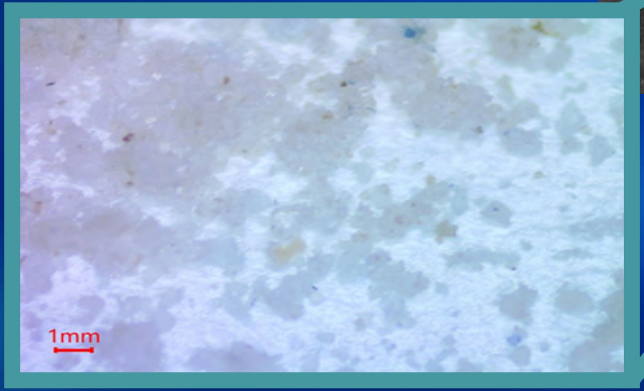
Gypsum crystal - 1,745 feet bls

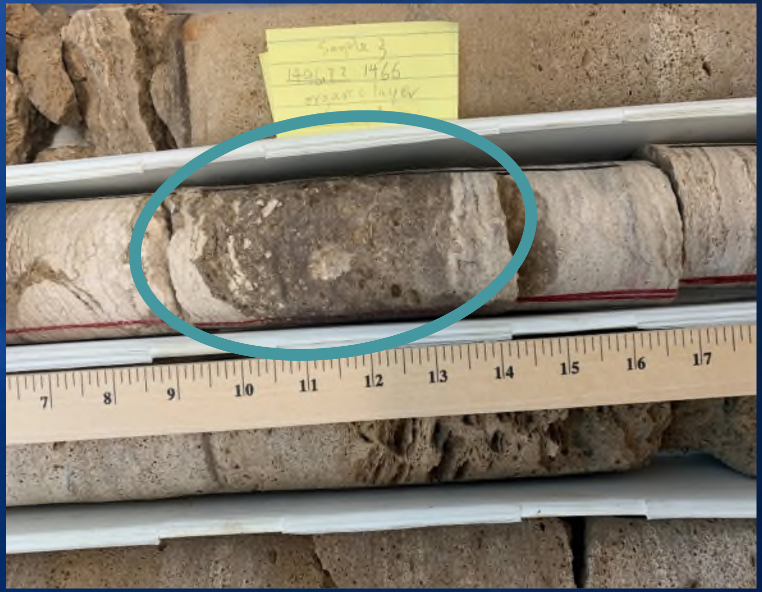


Ash Layer

Ash Layer at 1,466.20 feet bls

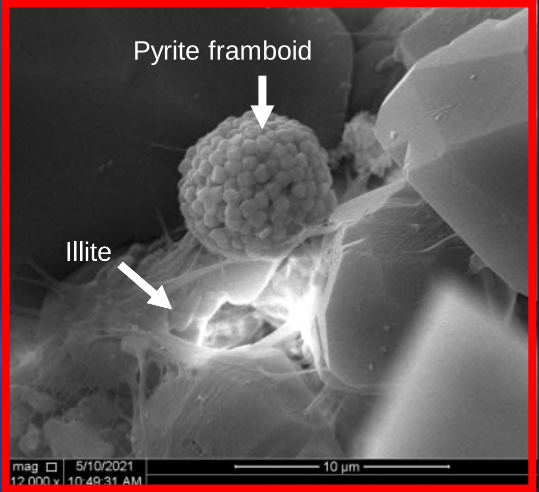


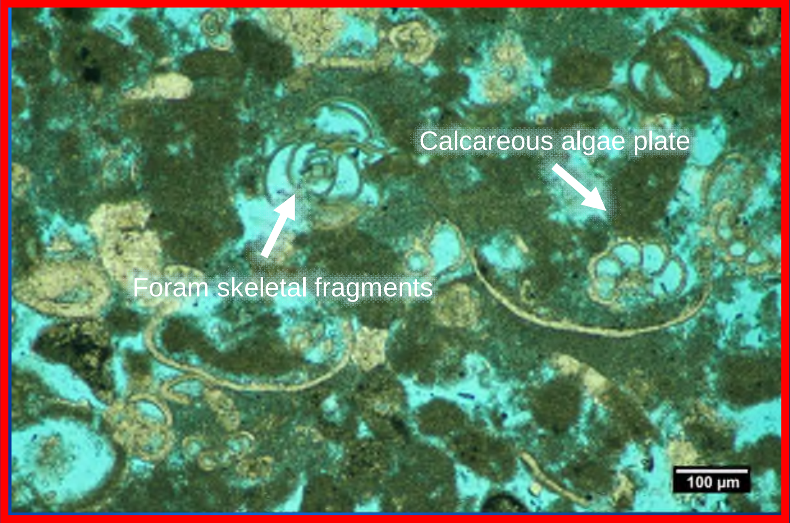


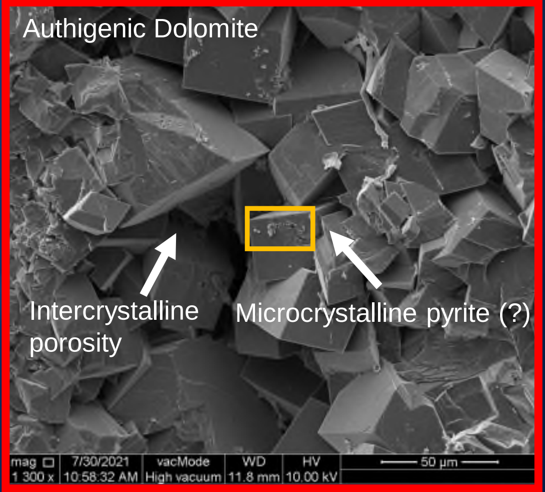


Mineralogy, Inc.

- Scanning electron microscope
- X-ray diffraction
- Thin section analysis

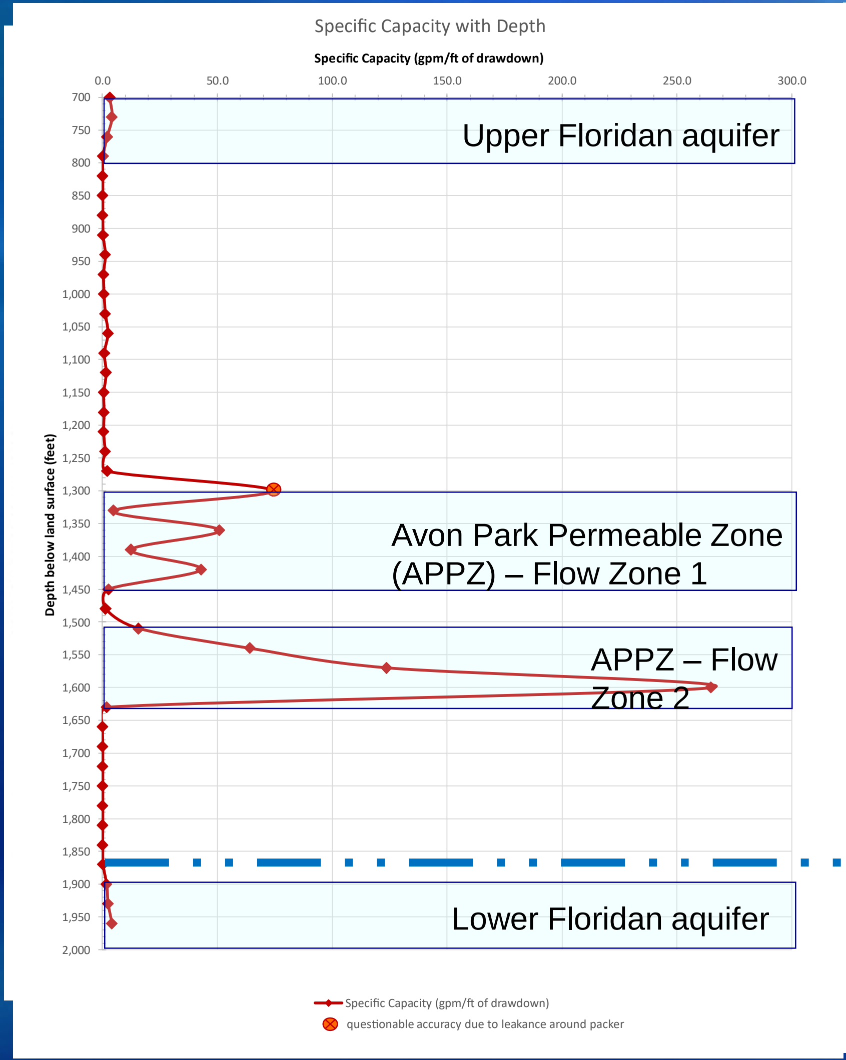


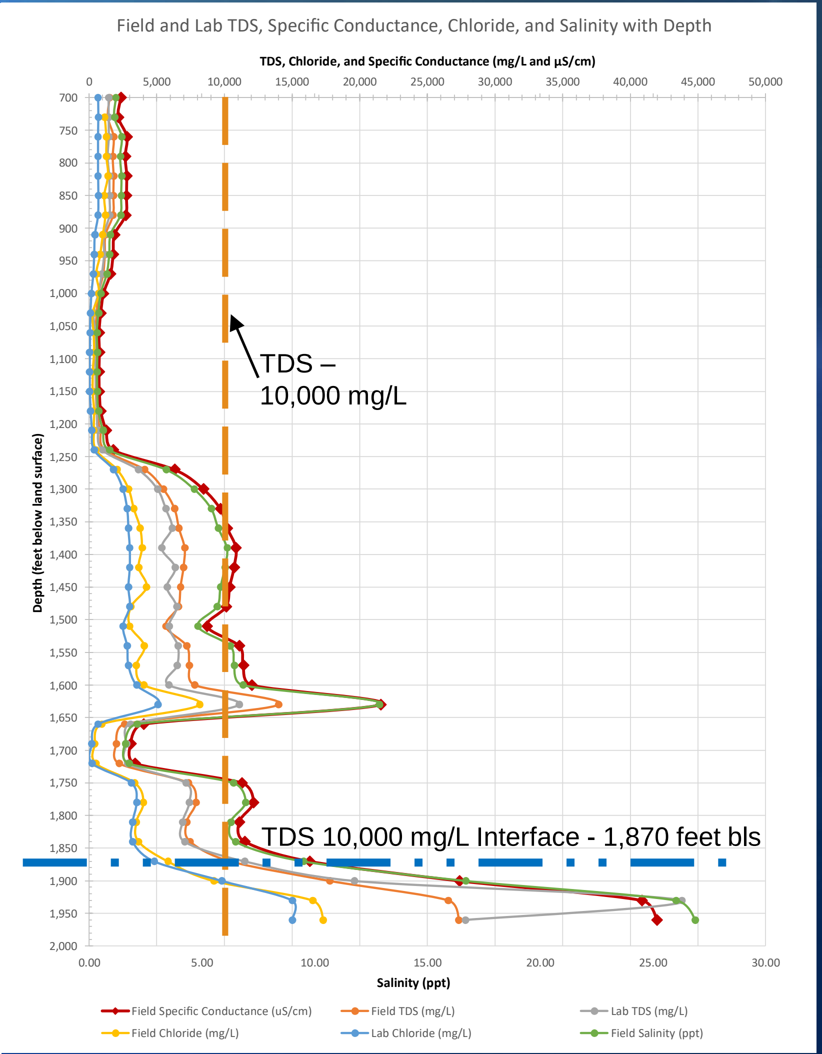




- 8 Core Intervals chosen:
  - 697.4 – 697.5 feet bls
  - 755.5 – 755.7 feet bls
  - 950.4 – 950.5 feet bls
  - 1,154 – 1,155 feet bls
  - 1,406.5 – 1,407.5 feet bls
  - 1,450 – 1,451 feet bls
  - 1,505 – 1,506 feet bls
  - 1,603 – 1,604 feet bls

Packer Testing



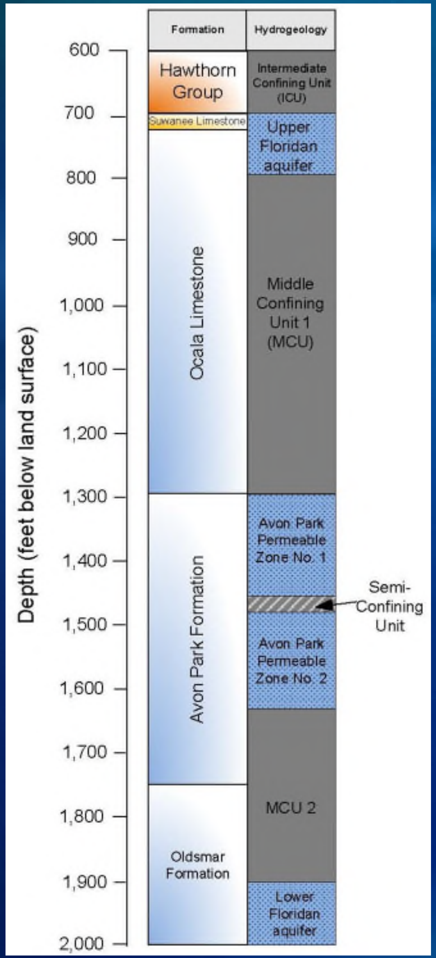


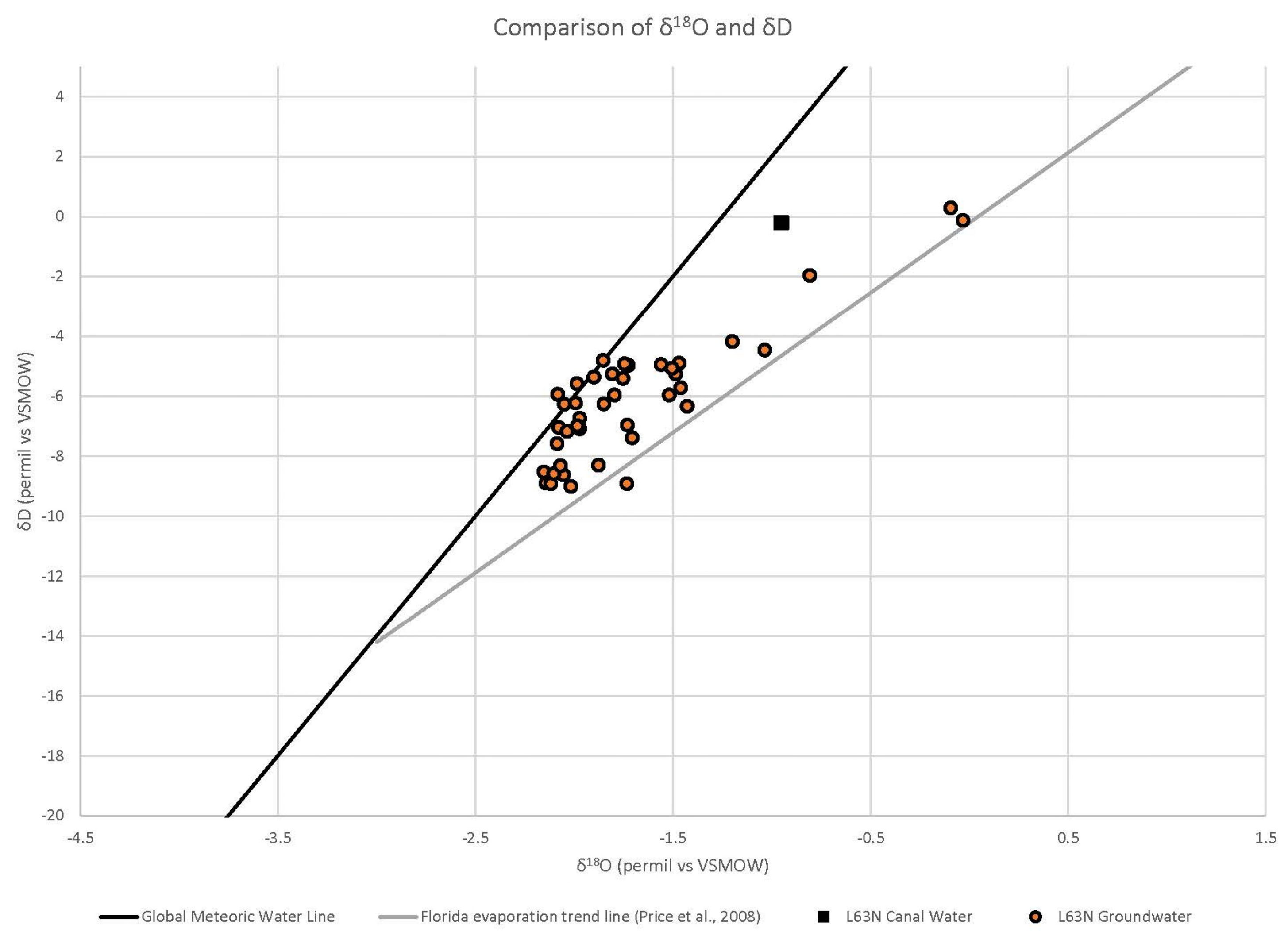
AQTESOLV Analysis

Packer Test Interval (feet bls)	Estimated Transmissivity (Theis Recovery) (ft²/day)	Estimated Transmissivity (Theis) (ft²/day)	Estimated Transmissivity (Cooper-Jacob) (ft²/day)	Empirical Equation (ft²/day)	Estimated Average (Theis Recovery, Theis, Empirical, and Cooper-Jacob) (ft²/day)	Average Estimated Hydraulic Conductivity (ft/day)
PT 1 (700-730)	1,931.00	735.3	***	850.3	1,172.2	39.1
PT 2 (730-760)	164.3	573.3	3,213.5	1,123.0	1,268.5	42.3
PT 3 (760-790)	***	1,593.7	***	561.5	1,077.6	35.9
PT 4 (790-820)	14.98	33.64	40.88	56.1	36.4	1.2
PT 5 (820-850)	11.79	***	70.97	37.4	40.1	1.3
PT 6 (850-885)	11.83	18.13	***	45.5	25.1	0.7
PT 7 (880-910)	4.964	***	3.722	26.7	11.8	0.4
PT 8 (910-940)	11.44	***	10.5	64.2	28.7	1.0
PT 9 (940-970)	44.16	228.2	***	334.2	202.2	6.7
PT 10 (970-1,000)	22.25	75.51	68.46	120.3	71.6	2.4
PT 11 (1,000-1,030)	30.33	217.4	73.8	187.2	127.2	4.2
PT 12 (1,030-1,060)	56.24	385.3	173.5	320.9	234.0	7.8
PT 13 (1,060-1,090)	101.1	868.3	339.3	641.7	487.6	16.3
PT 14 (1,090-1,120)	28.48	401.9	93.16	213.9	184.4	6.1
PT 15 (1,120-1,150)	62.34	***	257.8	427.8	249.3	8.3
PT 16 (1,150-1,180)	23.84	***	23.58	160.4	69.3	2.3
PT 17 (1,180-1,210)	26.9	427.6	141.9	187.2	195.9	6.5
PT 18 (1,210-1,240)	19.74	144.4	58.65	133.7	89.1	3.0
PT 19 (1,240-1,270)	36.76	363.1	115.7	320.9	209.1	7.0
PT 20 (1,270-1,300)	87.55	422.9	296.3	588.2	348.7	11.6
PT 21 (1,300-1,330)	***	***	***	19,818.2	19,818.2	660.6
PT 22 (1,330-1,360)	***	1,019.4	275.60	1,310.2	868.4	28.9
PT 23 (1,360-1,390)	***	***	***	13,633.7	13,633.7	454.5
PT 24 (1,390-1,420)	***	8,854.8	***	33,15.5	6,085.2	202.8
PT 25 (1,420-1,450)	***	9,085.8	***	11,470.6	10,278.2	342.6
PT 26 (1,450-1,480)	98.8	924.8	317.9	732.6	518.5	17.3
PT 27 (1,480-1,510)	***	1530.6	227.8	387.7	715.4	23.8
PT 28 (1,510-1,540)	***	3,501.2	***	4,224.6	3,862.9	128.8
PT 29 (1,540-1,570)	***	***	***	17,139.0	17,139.0	571.3
PT 30 (1,570-1,600)	***	***	***	33,074.9	33,074.9	1,102.5
PT 31 (1,600-1,630)	***	***	***	70,831.6	70,831.6	2,361.1
PT 32 (1,630-1,660)	690.7	641.3	384.6	540.1	564.2	18.8
PT 33 (1,660-1,690)	3.938		7.584	24.1	11.9	0.4
PT 34 (1,690-1,720)	9.137	31.47	17.81	42.8	25.3	0.8
PT 35 (1,720-1,750)	4.186	31.44	3.134	24.1	15.7	0.5
PT 36 (1,750-1,780)	***	***	***	18.7	18.7	0.6
PT 37 (1,780-1,810)	***	***	***	18.7	18.7	0.6
PT 38 (1,810-1,840)	***	***	***	18.7	18.7	0.6
PT 39 (1,840-1,870)	***	***	***	18.7	18.7	0.6
PT 40 (1,870-1,900)	10.88	***	14.68	77.5	34.4	1.1
PT 41 (1,900-1,930)	***	337.9	194.3	478.6	336.9	11.2
PT 42 (1,930-1,960)	***	***	308.6	676.5	659.7	22.0
PT 43 (1,960-2,000)	***	***	***	1,117.6	1,117.6	27.9

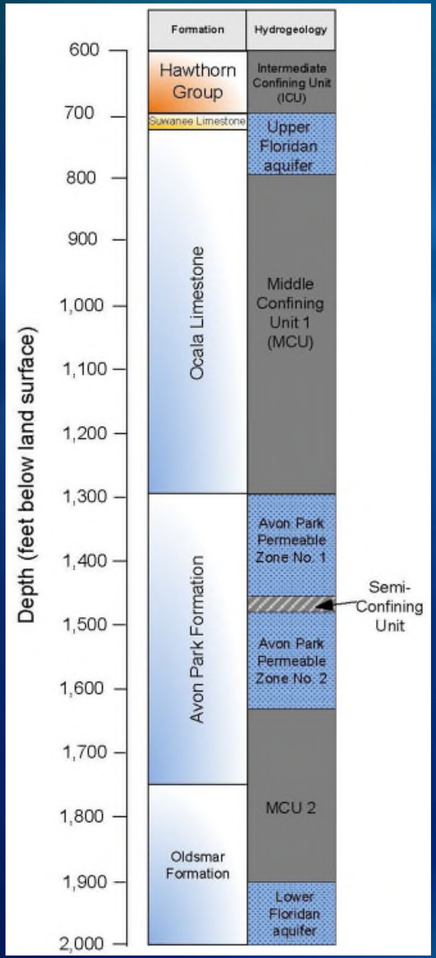
**Blue color indicates flow zones and green color indicates confining units
***Unable to accurately curve match solution in AQTESOLV.
****Accurate storativity values cannot be determined from a single well packer test.
****Packer Tests No. 36 through 39 had a specific capacity <0.07 gpm/feet of drawdown.

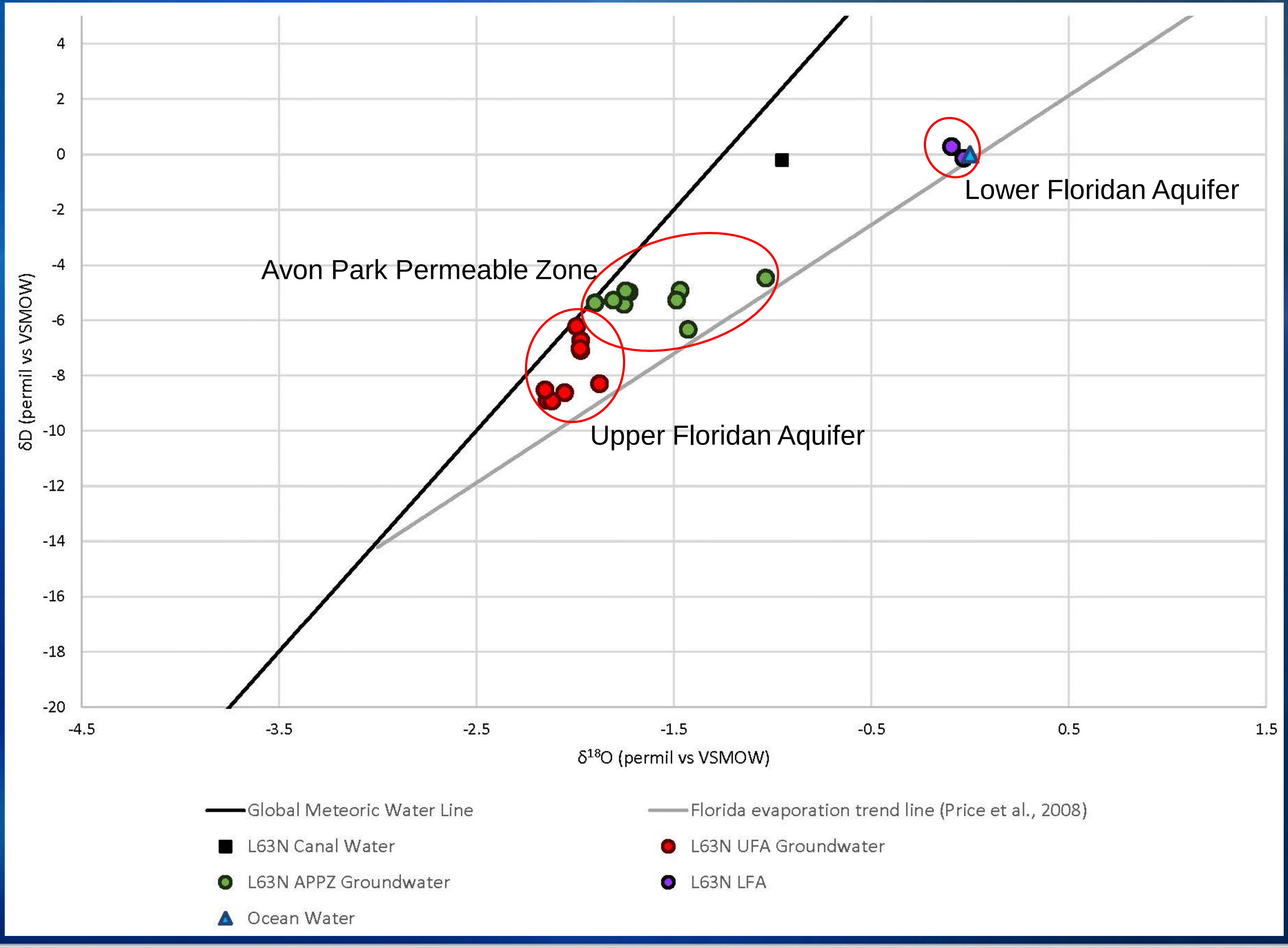
Isotopes - $\delta^{18}O$ vs δD



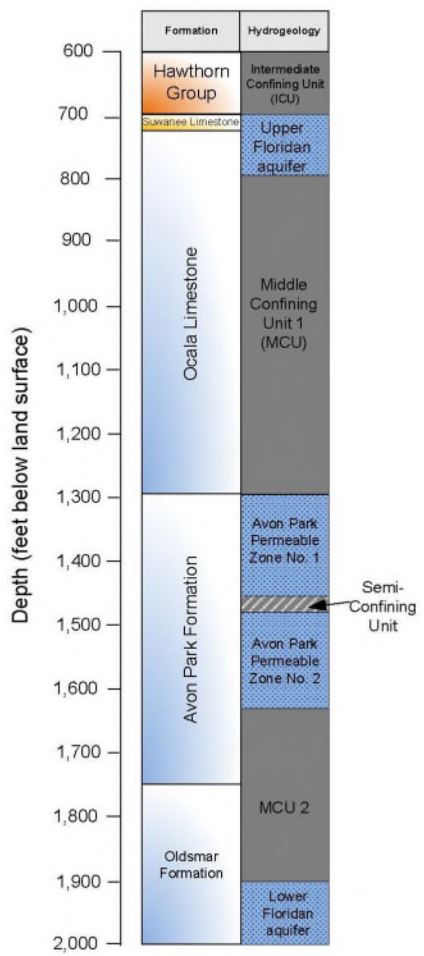


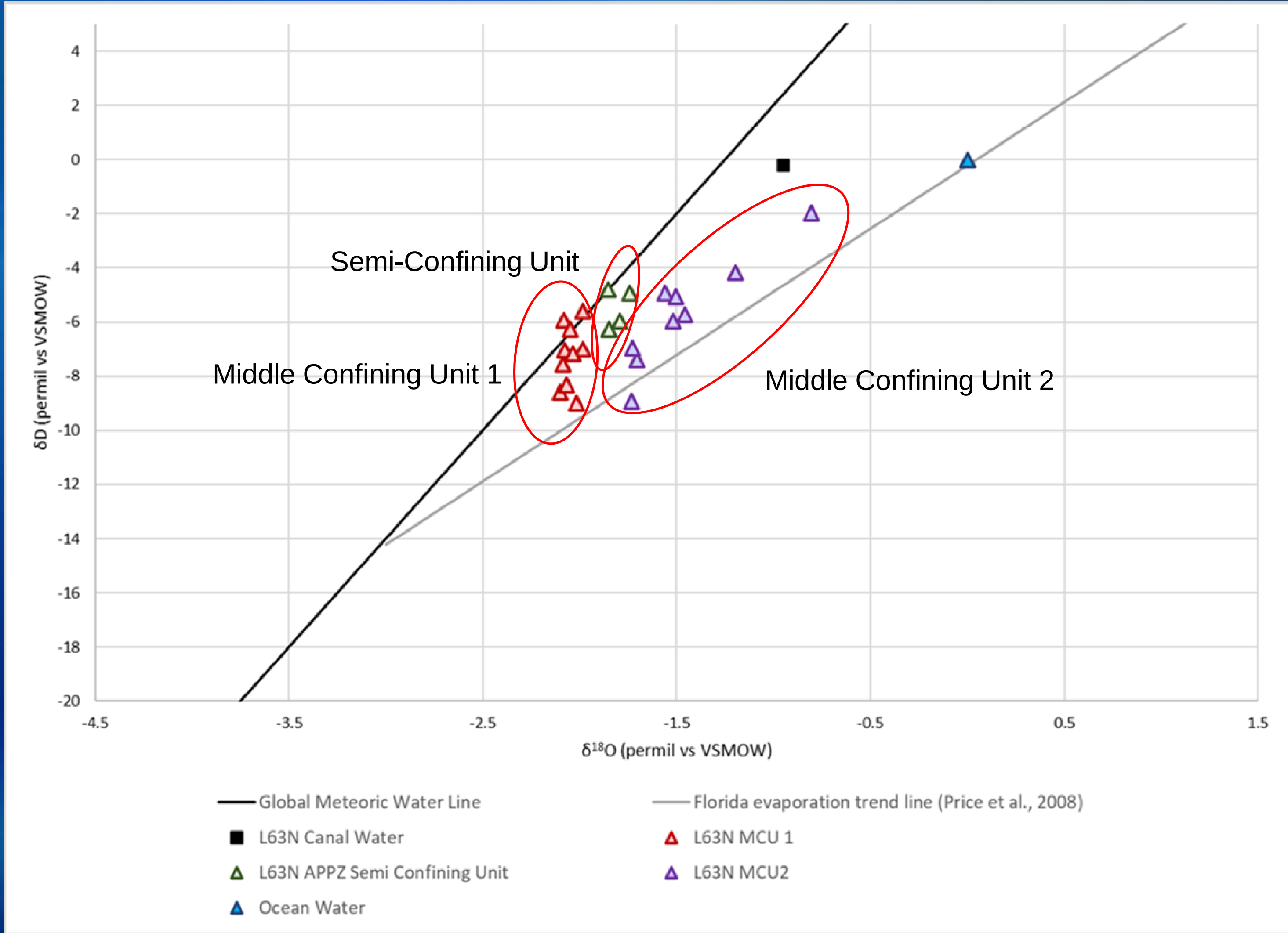
Isotopes - $\delta^{18}O$ vs δD - the Aquifers



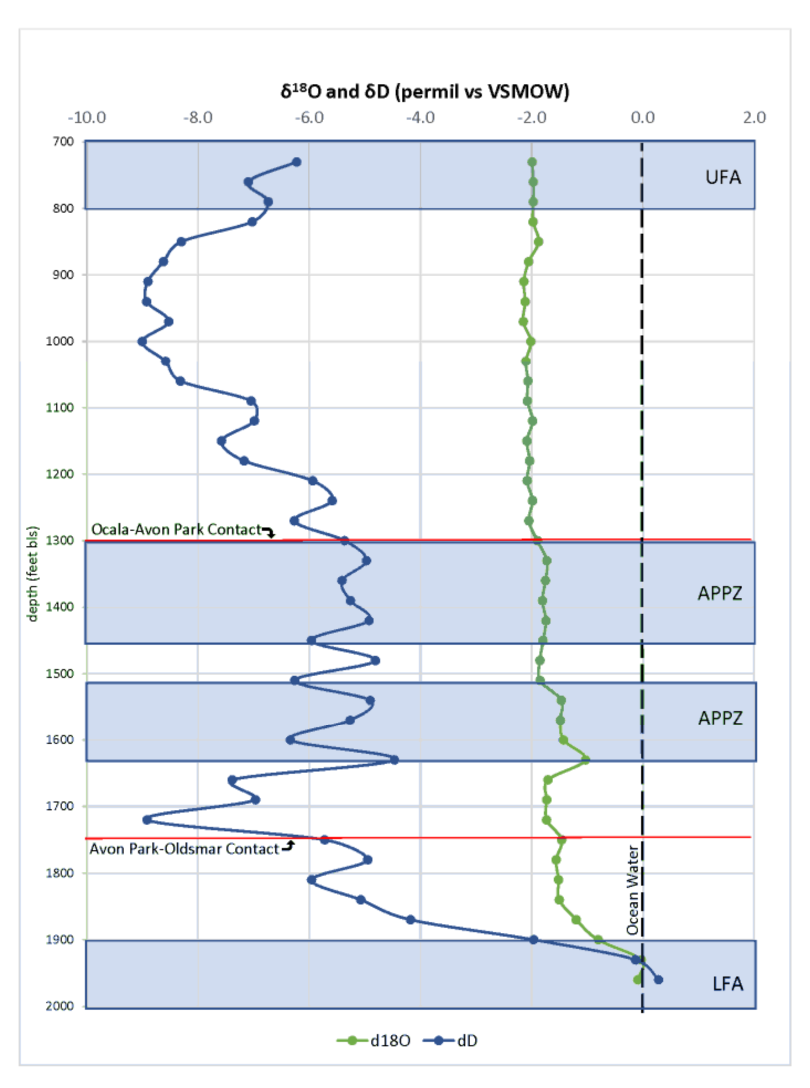


Isotopes - $\delta^{18}O$ vs δD - The Confining Units





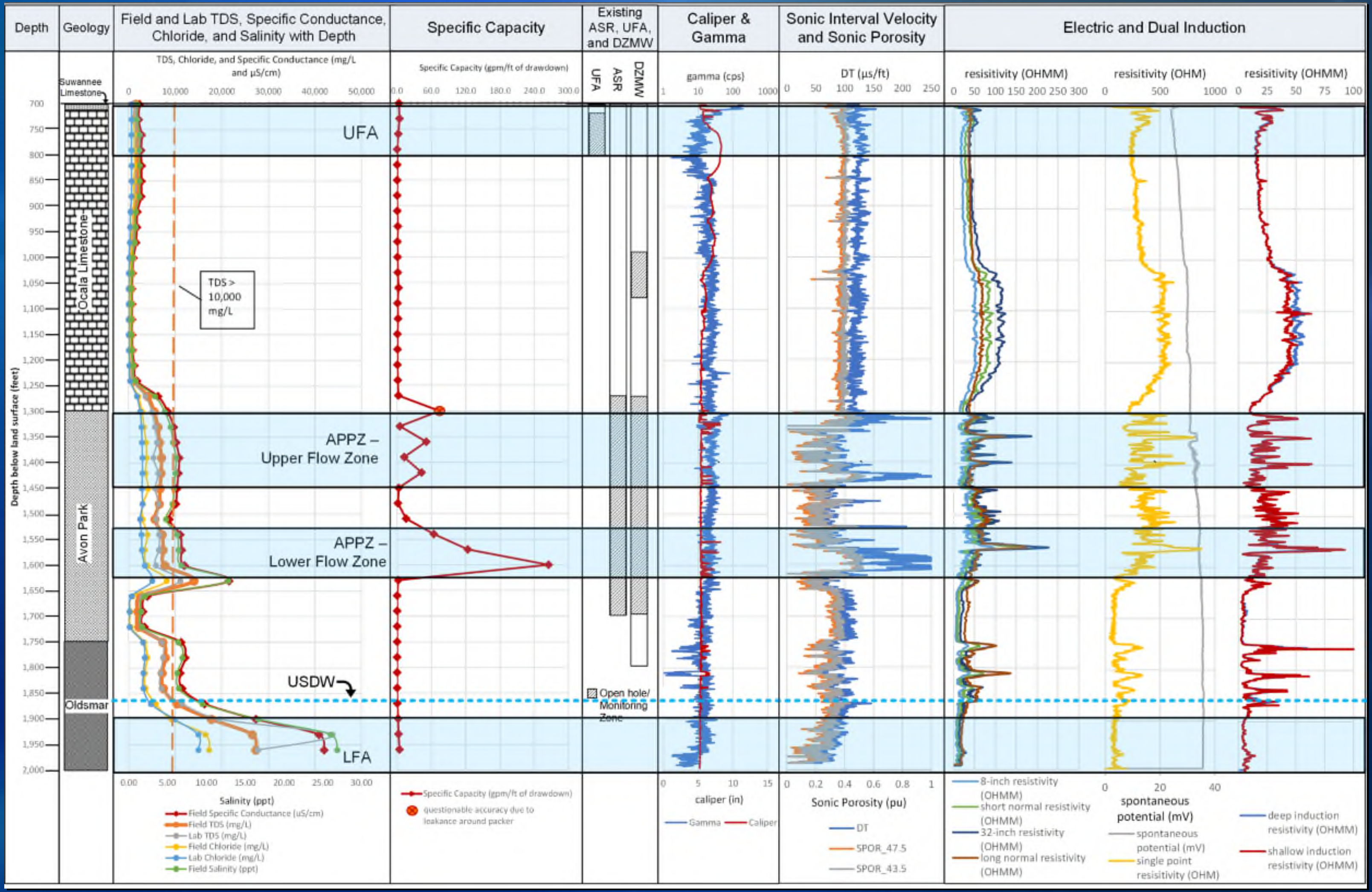
Isotopes - $\delta^{18}O$ vs δD with Depth



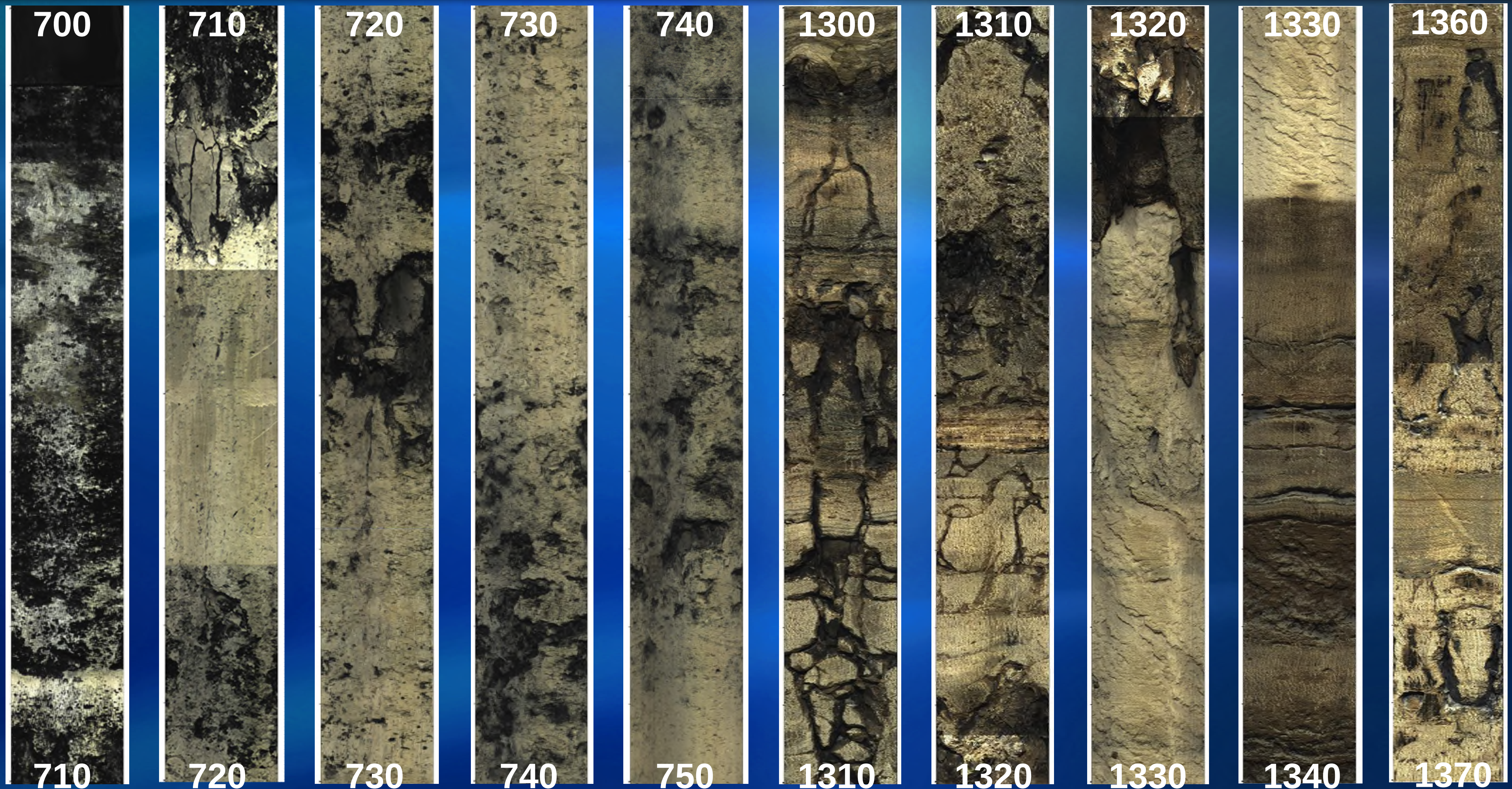
Geophysical Logging

- XY Caliper/Gamma
- Flowmeter
- Borehole Compensated Sonic
- Dual-Induction with Variable Density
- Optical Borehole Imager

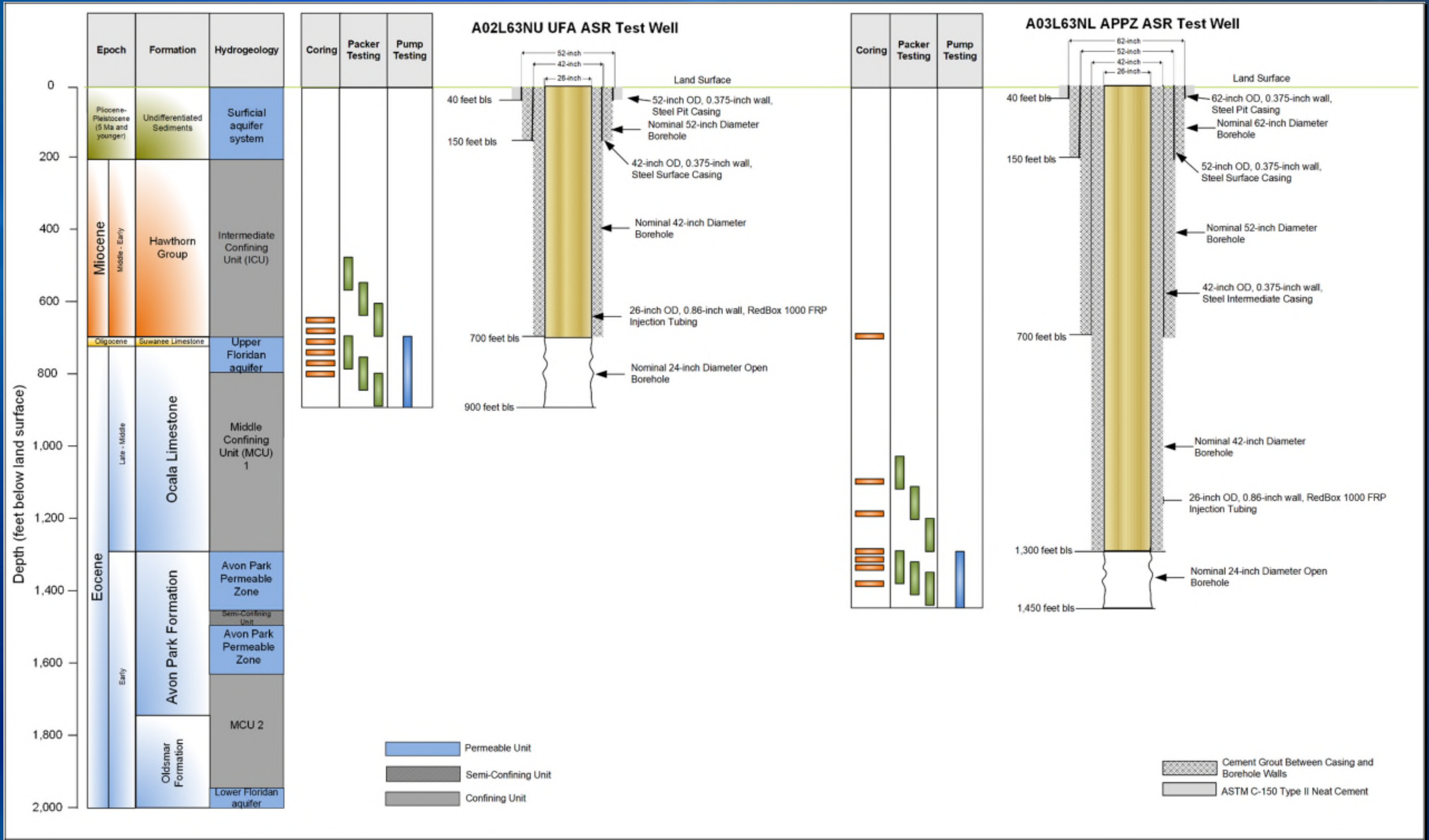
Geophysical Logging



Optical Borehole Imager



L-63N UFA and APPZ ASR Test Wells

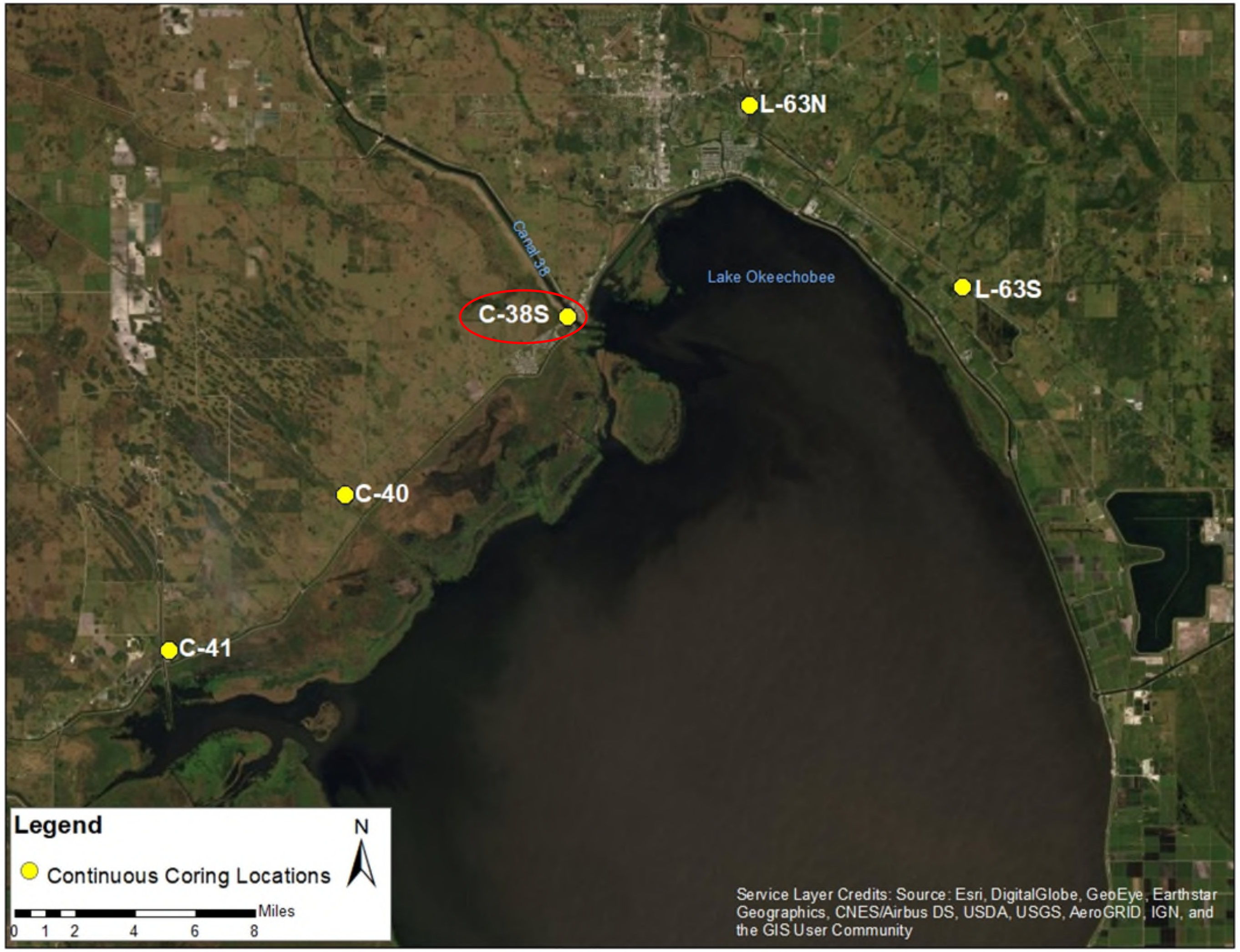


Summary of Well Construction for the Dual-Zone Monitoring Well at L-63N (M01L63NU and M01L63NL)
South Florida Water Management District

Stantec

Continuous Coring Program – C-38S Site

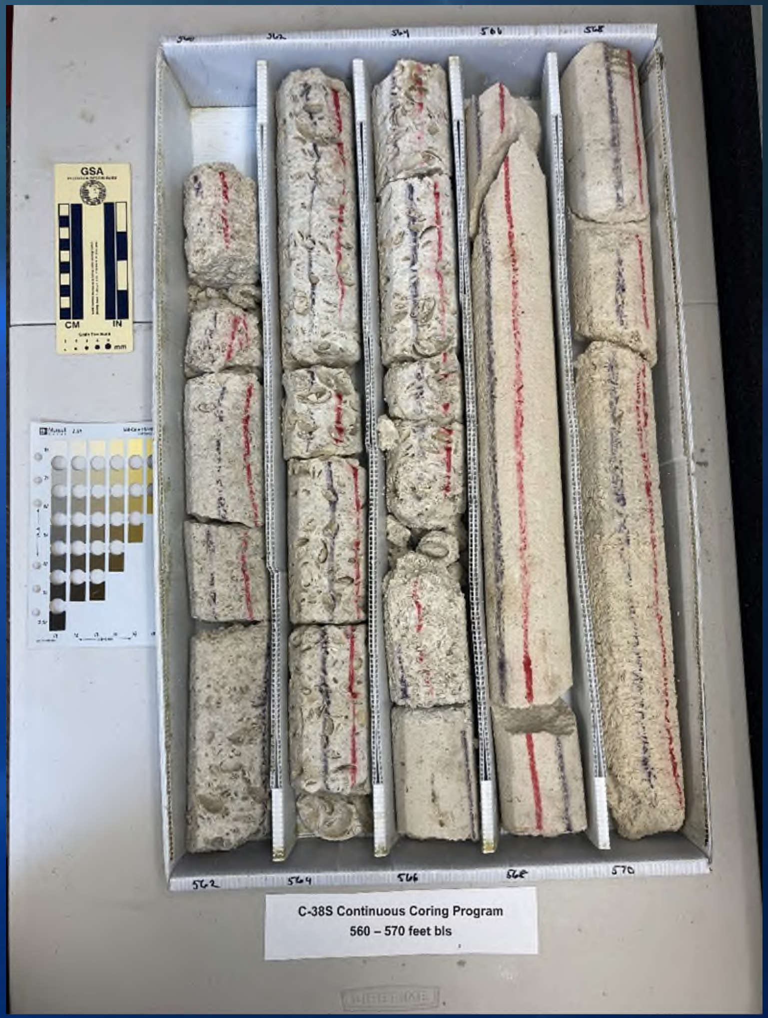
- Underground Injection Control (UIC) permit
  - Permit allows the lawful option of disposal of appropriately treated fluids via the underground injection wells, while protecting Florida's underground sources of drinking waters
- APPZ Monitoring Well Construction



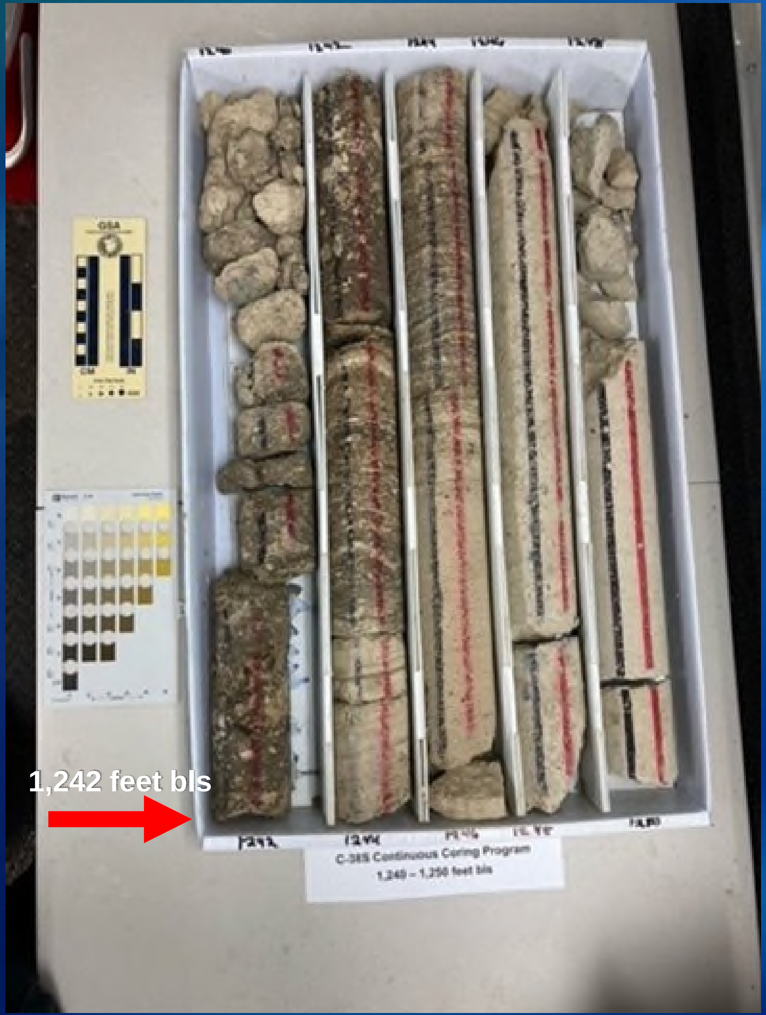
Cores


536 feet bls
C-38S Continuous Coring Program
530 – 540 feet bls


552 feet bls
C-38S Continuous Coring Program
550 – 560 feet bls


C-38S Continuous Coring Program
560 – 570 feet bls

Cores


1,242 feet bls
C-38S Continuous Coring Program
1,240 – 1,250 feet bls


1,376 feet bls
1,370 – 1,380 feet bls


1,380 – 1,390 feet bls

Fossils and Features

Bryozoan – 500-510 feet bls

Oyster Shell – 514 feet bls

Lepidocyclina ocalana – 560-570 feet bls

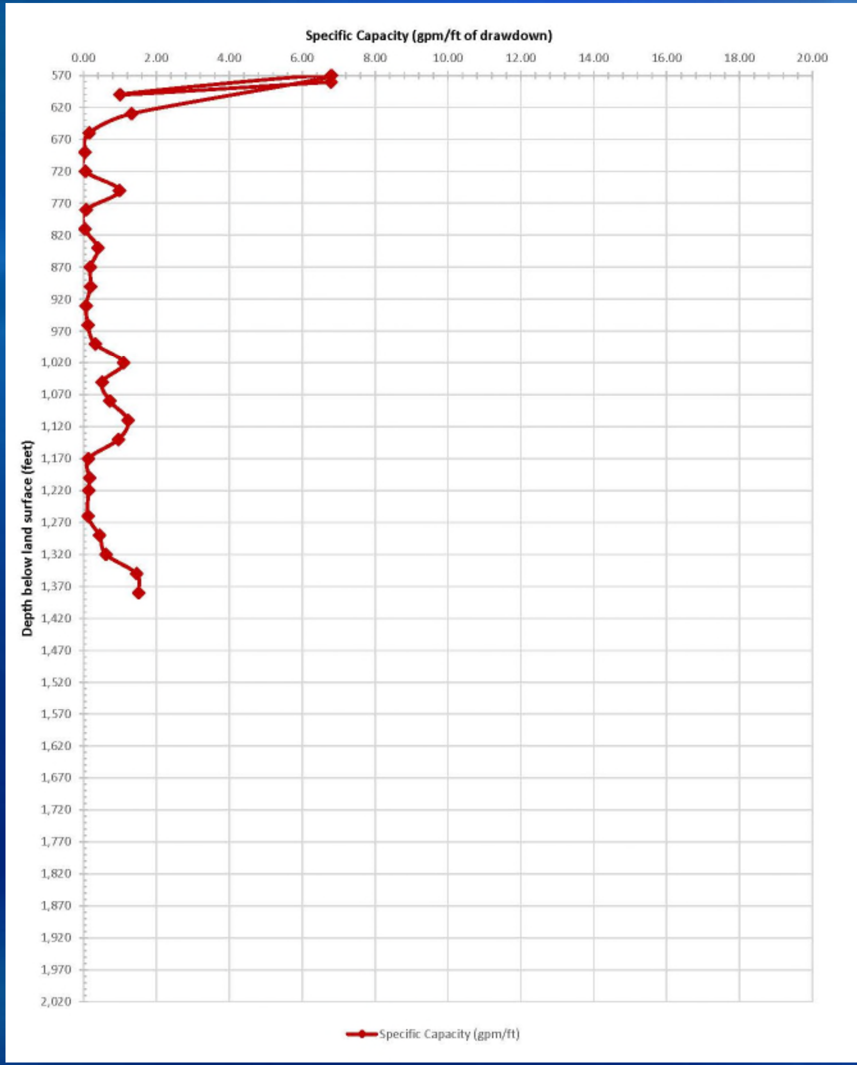
Fossils and Features

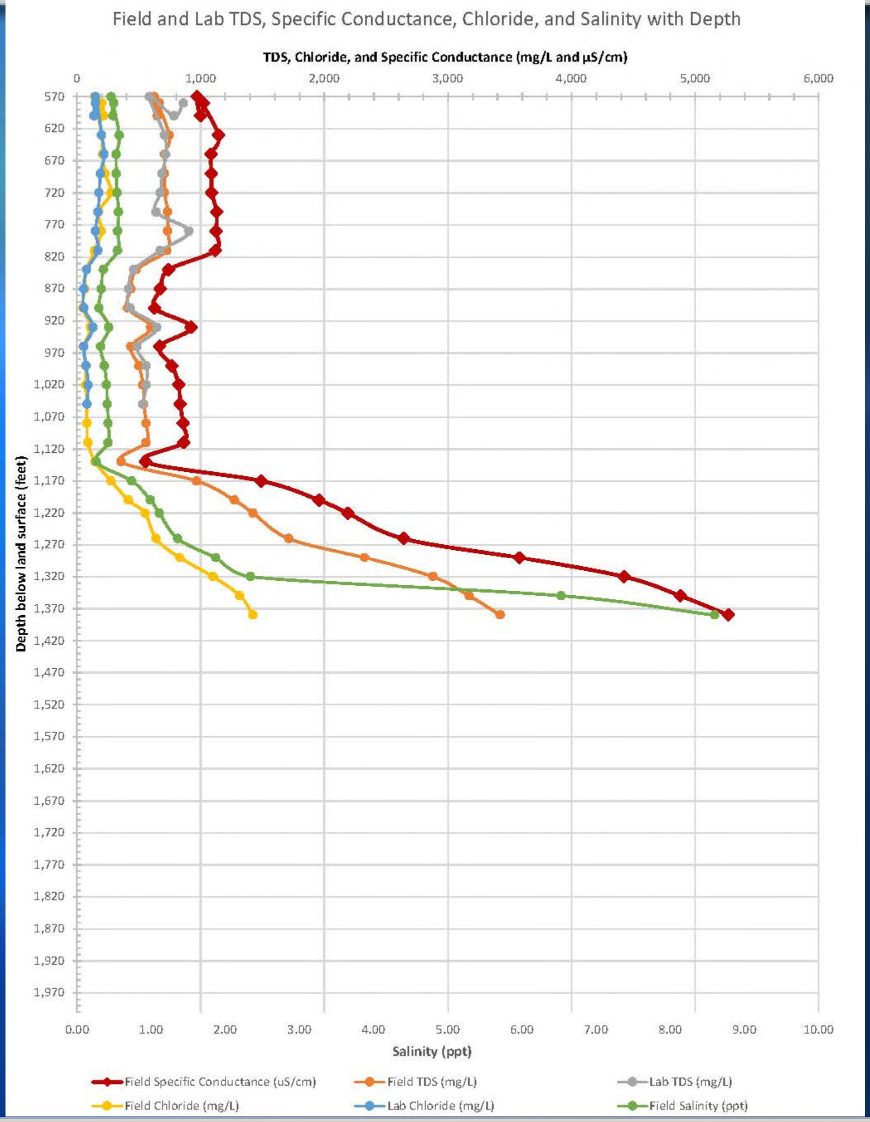
Sand Dollar mold – 577 feet bls

Possible *Oligopygus sp*. – 779 feet bls

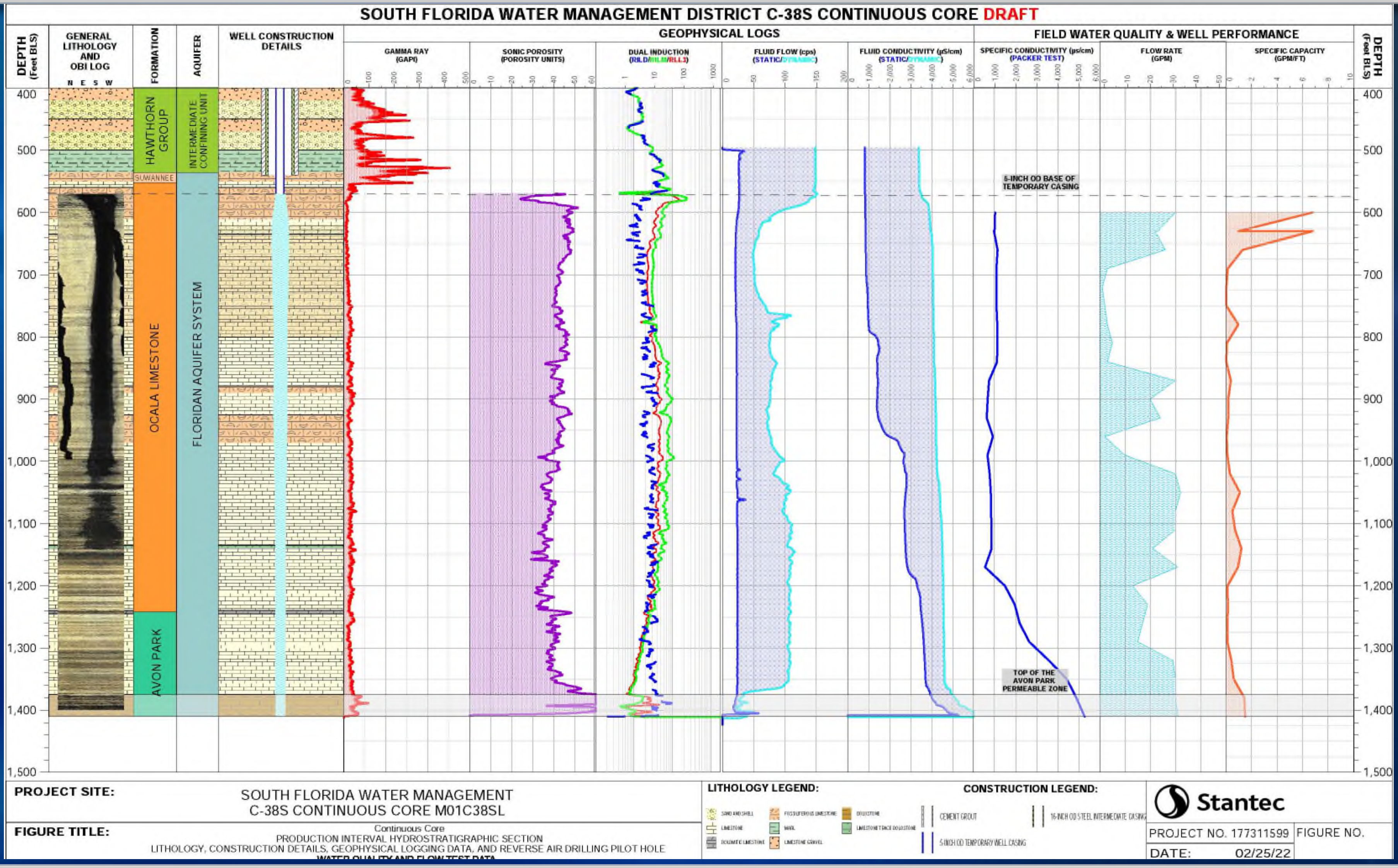
Possible Lignite – 1,204.75 feet bls

Water Quality and Specific Capacity Results

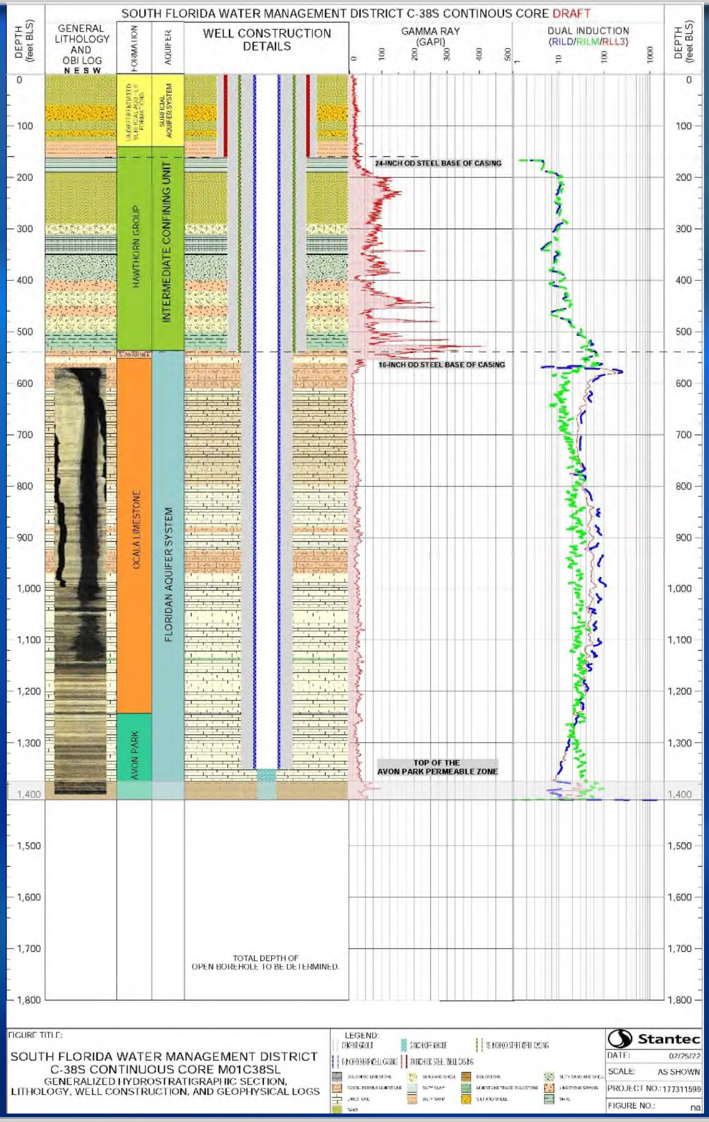




Generalized Hydrostratigraphic Section



APPZ Monitoring Well Construction



Continuous Coring Program – L-63S Site

Panel Discussion (5 min.)

FLORIDA GULF COAST UNIVERSITY

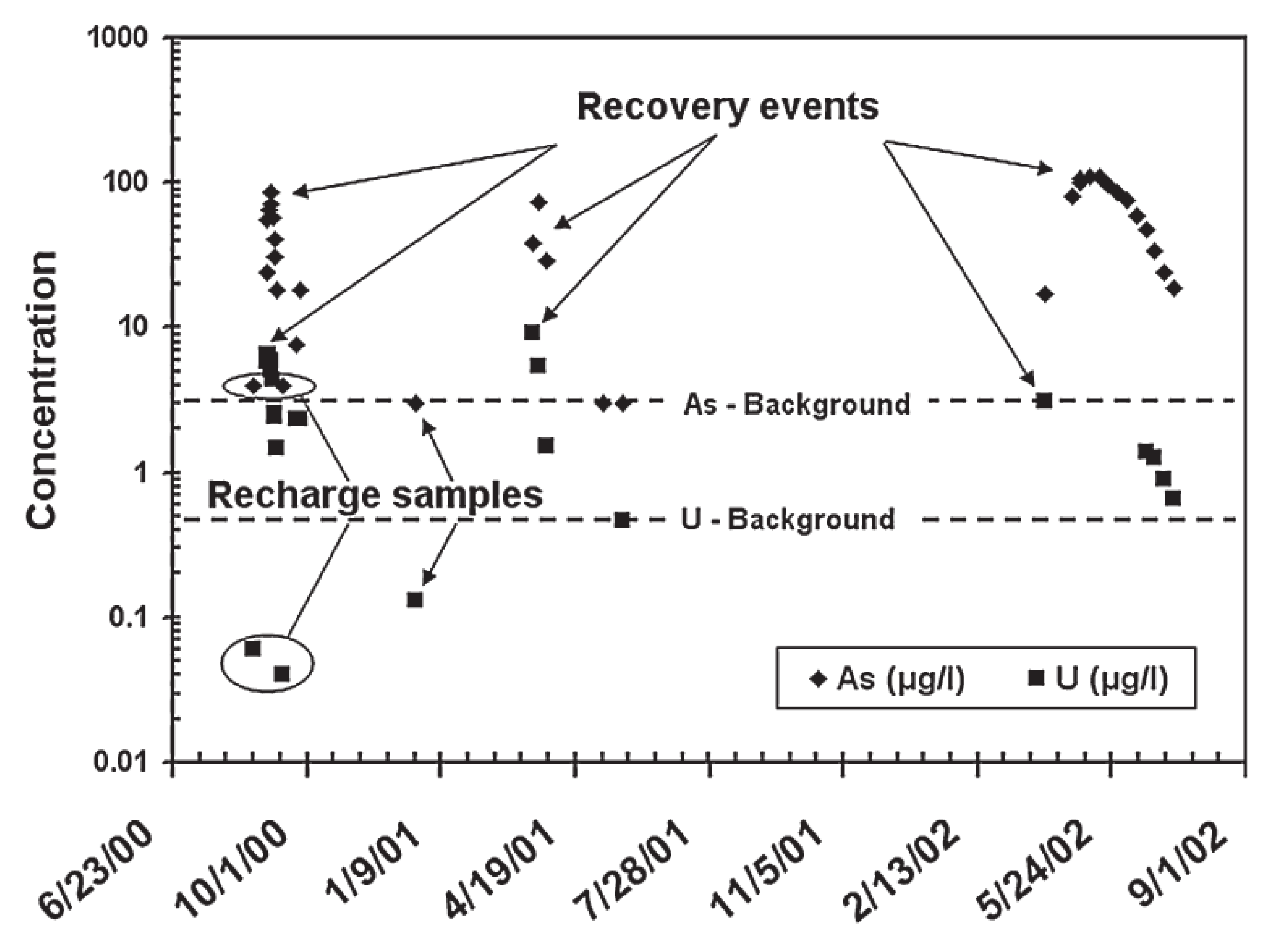
Geochemical Analysis of a Continuous Core: Analysis of L63N Core and Refinement of Methodology

Presenter: Jamie MacDonald, Ph.D.

Contributors: Rachel Rotz, Ju Chou, Richard Molina, Zoie Kassis, Sophia Morejon, & Rachael Waldrop

Florida Gulf Coast University, Fort Myers, FL

Geochemical Analysis of a Continuous Core



ASR has been shown to potentially mobilize metals from the carbonate rock within Florida's aquifers.

Example, As and U mobilization during three ARS cycle tests at Rome Ave. ASR, Hillsborough County, FL (Arthur et al., 2005).

Geochemical Analysis of a Continuous Core

Goal: to chemically analyze the core from ASR L63N to find areas of potentially high metal concentrations using a hand held X-Ray fluorescence (XRF).

Take one analyses every foot – when possible!

Concentrate additional analyses on areas of interest.

Geochemical Analysis of a Continuous Core

X-550 from SciAps.

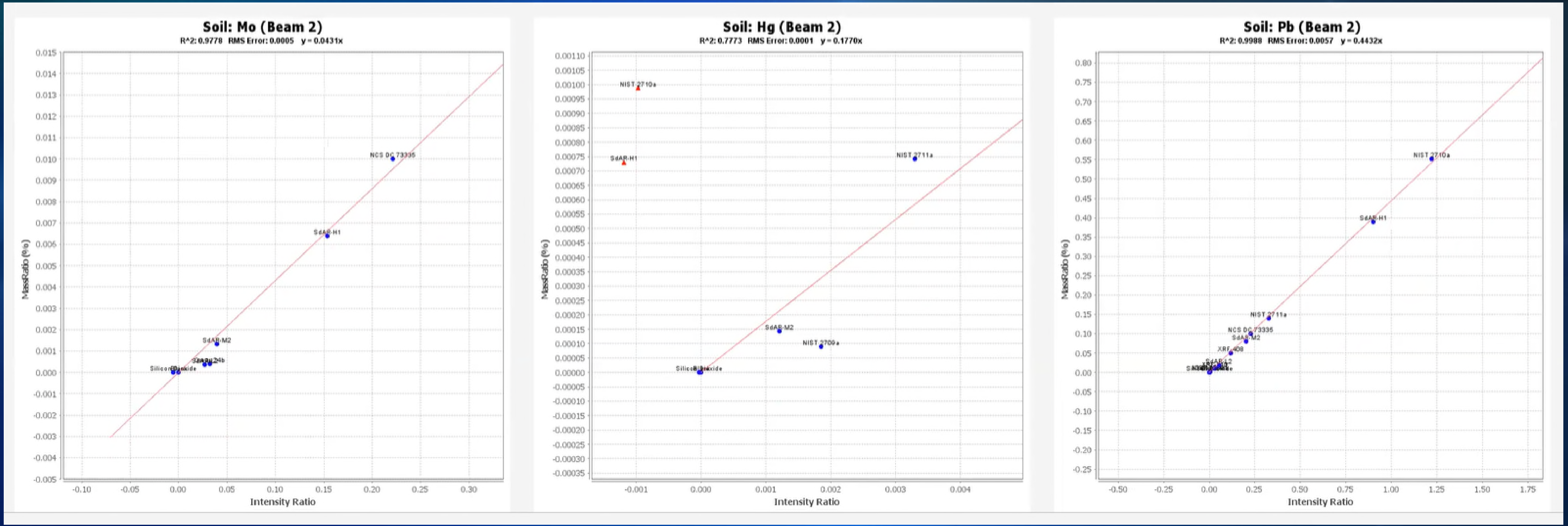
All handheld XRF operate on multiple settings to correct for overlaps in elements.

Soil setting for trace elements with <10 wt. %.

Mining setting for major elements – or elements that occur in higher wt. %.

5 channels operating at different kV and uA to limit overlap of elements during detection.

Instrument comes internally standardized



These are example of calibration curves for Mo, Hg, and Pb. Working with SciAps we modified the calibrations to fit our needs.

Sample Preparation

Debris and rust were cleaned off of the core surface using a wire brush before every analysis.

Far left is a "before" picture of a core segment in the upper confining unit. The near left is the same core "after" cleaning.

Geochemical Analysis of a Continuous Core

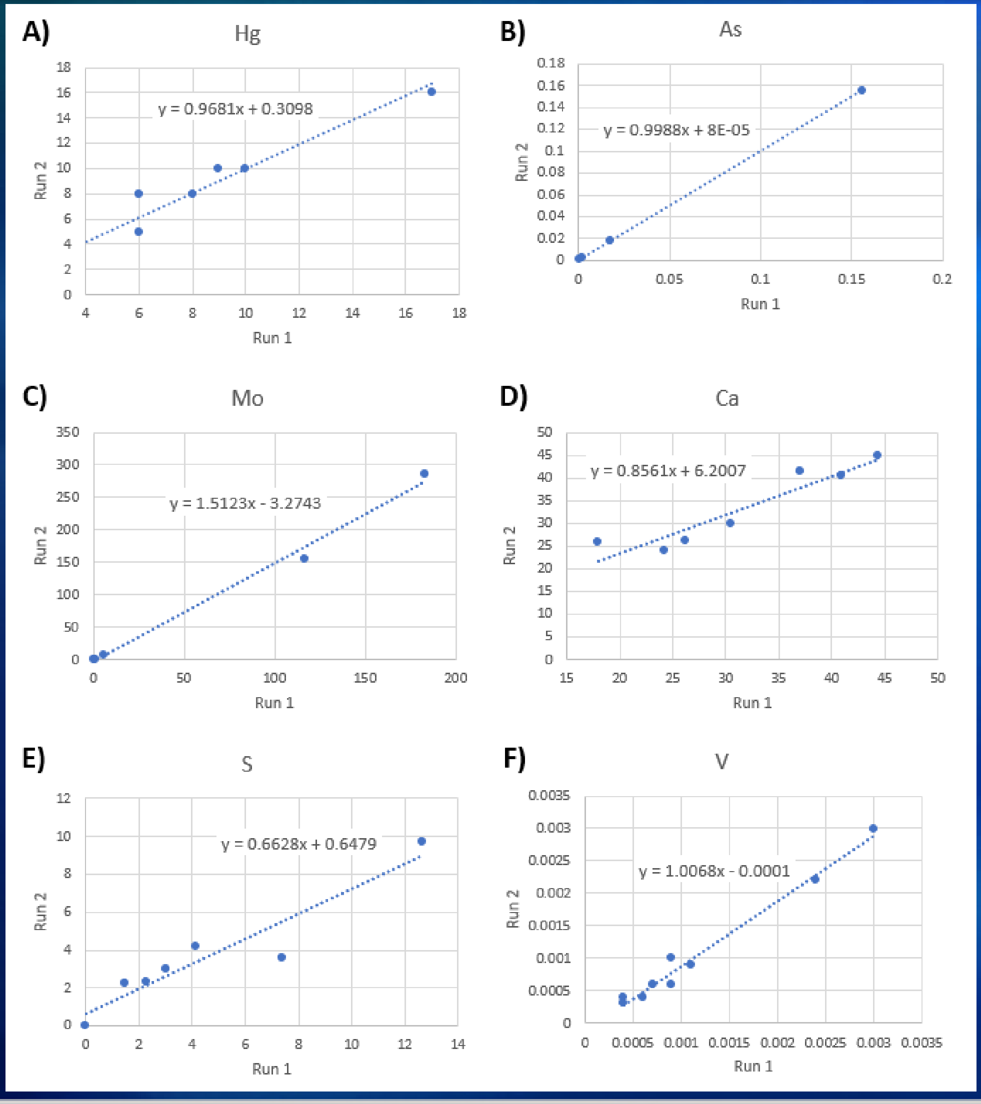
Elements measured with Soil setting:

As, Cu, Cd, Hg, Mo, Pb, U, Na, Ti, V, Cr, Co, Ni, Zn, Be, Rb, Zr, Nb, Ag, Sn, Sb, Ba, and Ra

Elements measured with Mining setting:

Al, Si, P, S, K, Ca, Mn, Mg, and Fe

Data integrity Tests



9 samples from core L63N were each analyzed twice – i.e., run 1 and run 2.

This was to test for the ability of the handheld XRF to duplicate an analysis.

Slopes range from 0.66 for S to 1.51 for Mo.

Ideal slope should be 1.

Data integrity Tests

Table: Correlation coefficient of select elements using handheld XRF

Element	Number of samples analyzed*	Correlation coefficient (r)
Al	5	0.989421
As	4	0.999998
Ca	7	0.940640
Hg	9	0.986544
Mg	7	0.971302
Mo	5	0.995687
Ni	4	0.978713
S	7	0.945692
Si	7	0.999729
Sr	8	0.999969
Ti	9	0.991525
V	9	0.990723

*one sample was only run using Soil setting.

9 samples from core L63N were each analyzed twice – i.e., run 1 and run 2.

This was to test for the ability of the handheld XRF to duplicate an analysis.

Precision was consistently high as all elements have a correlation coefficient close to 1.

Data integrity Tests

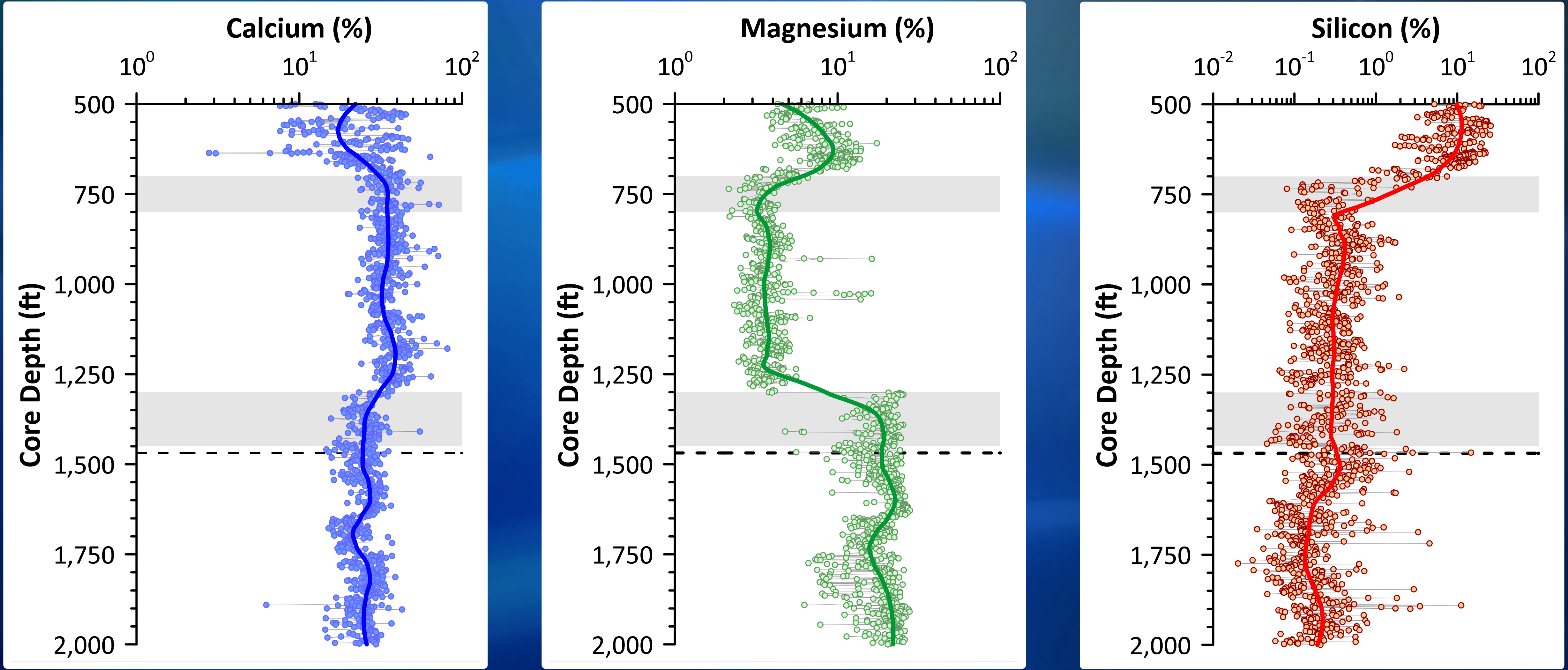
Four standards were run as knowns to also test the precision and accuracy of the instrument.

All element were within 10% of the standard known values except Ag, Cd, Mg, and P, which needed corrections based on the standards.

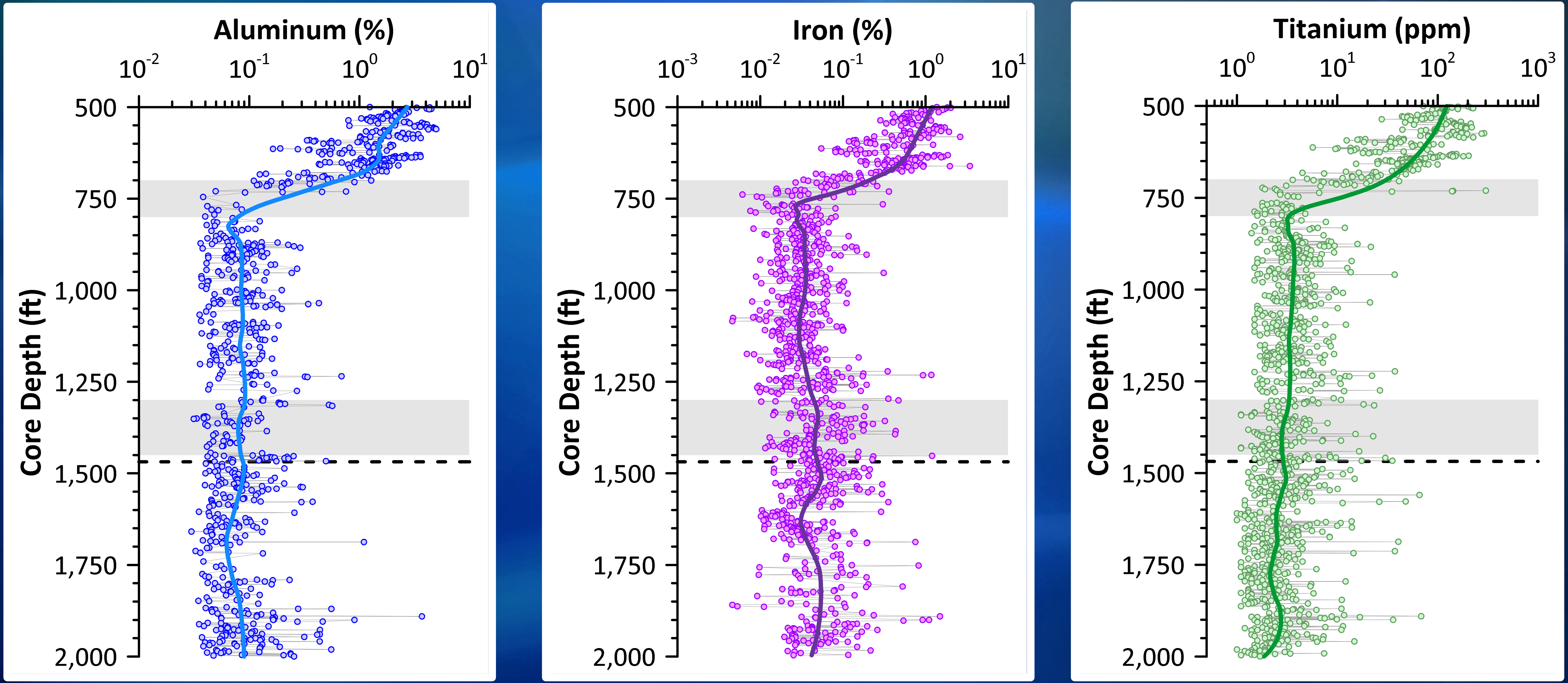
To correct these elements a linear equation Y = fx, where Y is known value and x is the measured value. The correction factor, f, was generated by dividing the known standard value by the instrument measured value for the standard (f = Y/x).

Example for silver (Ag) f = Y/x = 1.04/35 = 0.0297

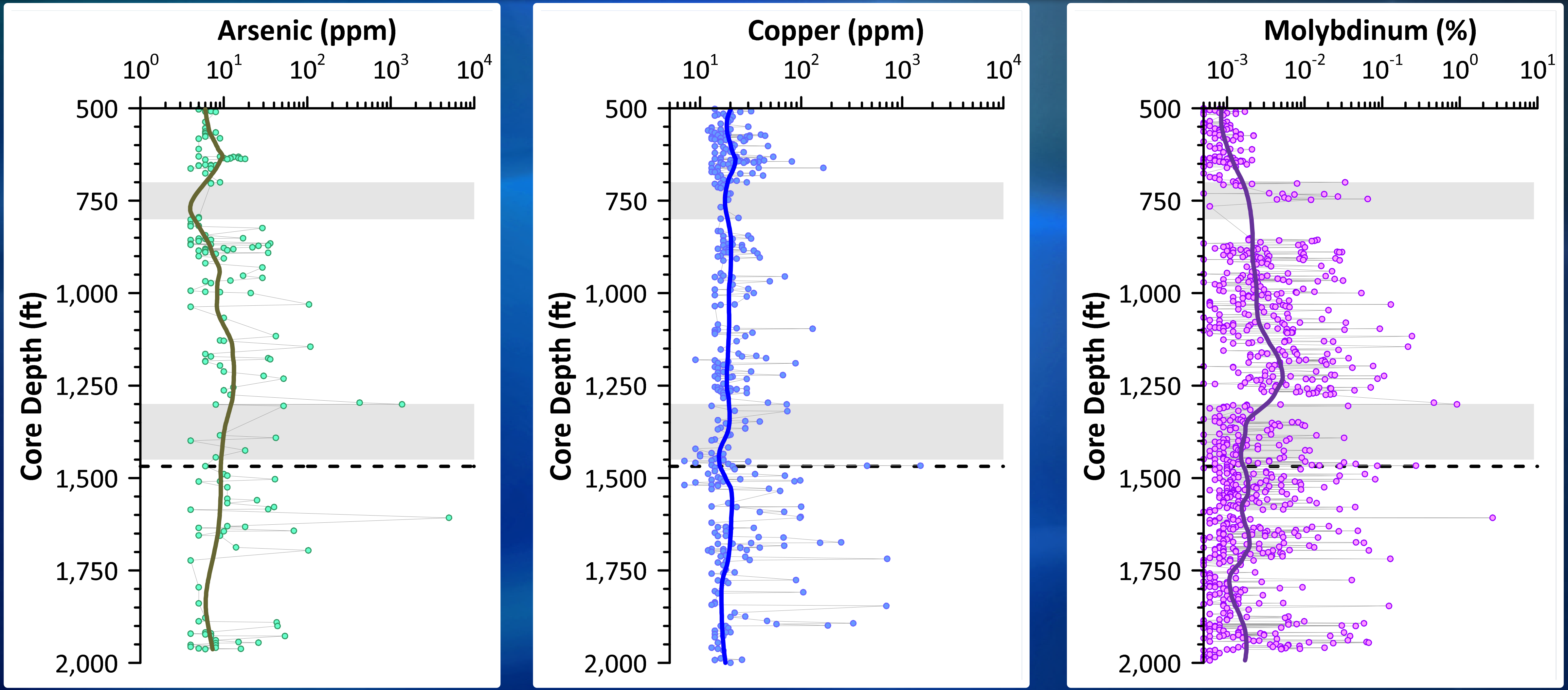
1339 Analyses of Core L63N!



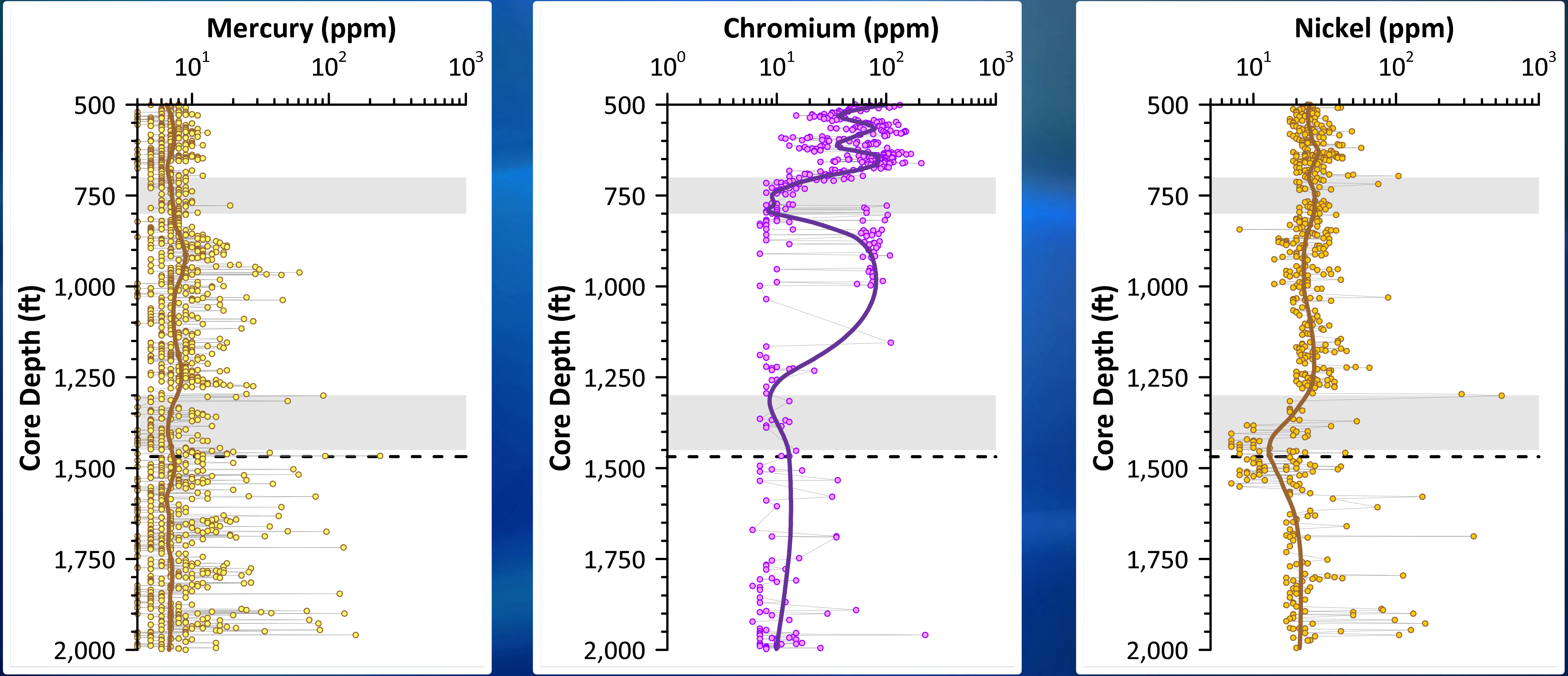
1339 Analyses of Core L63N!



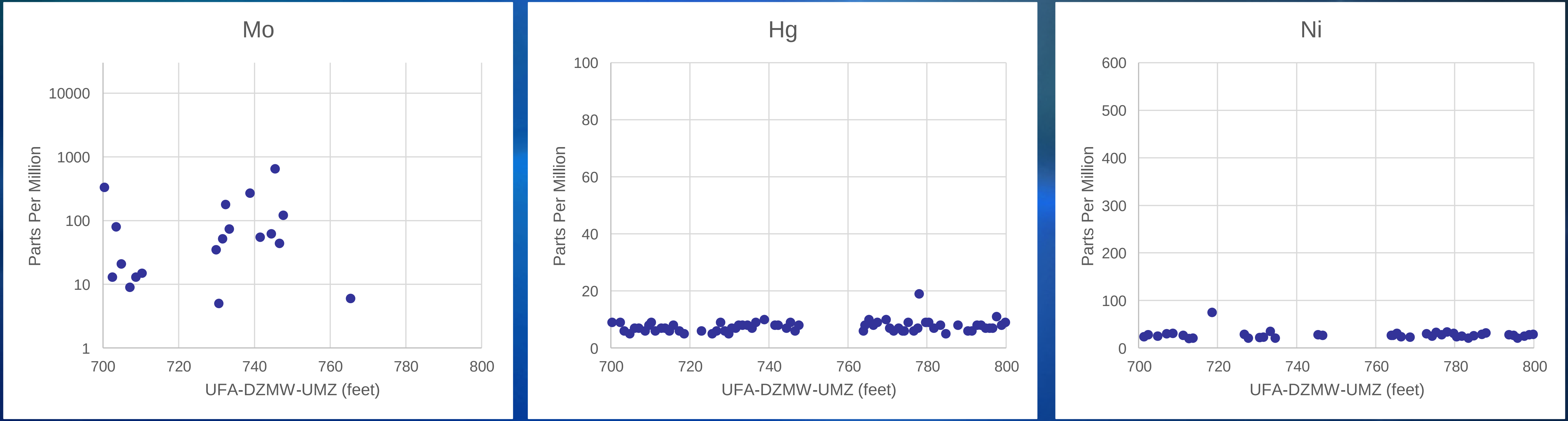
1339 Analyses of Core L63N!



1339 Analyses of Core L63N!

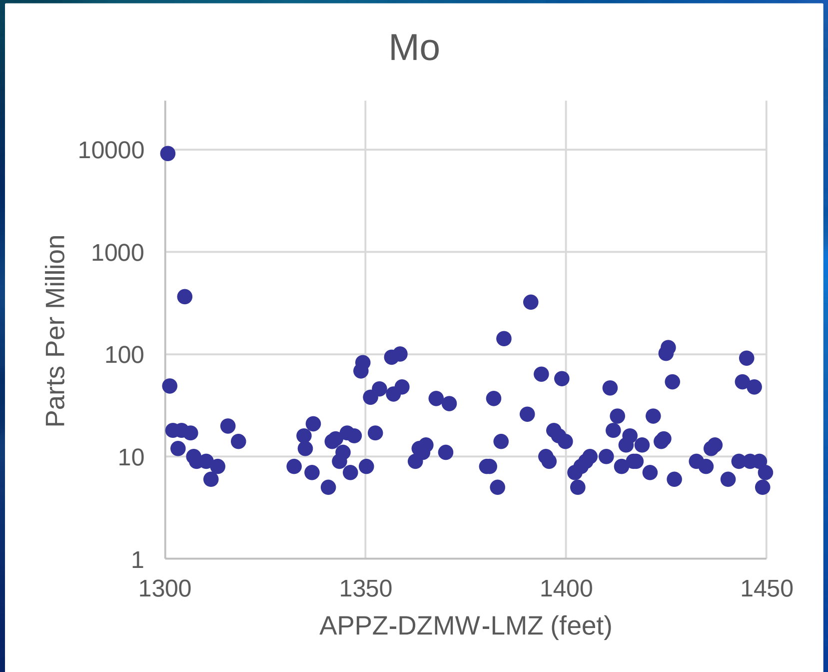


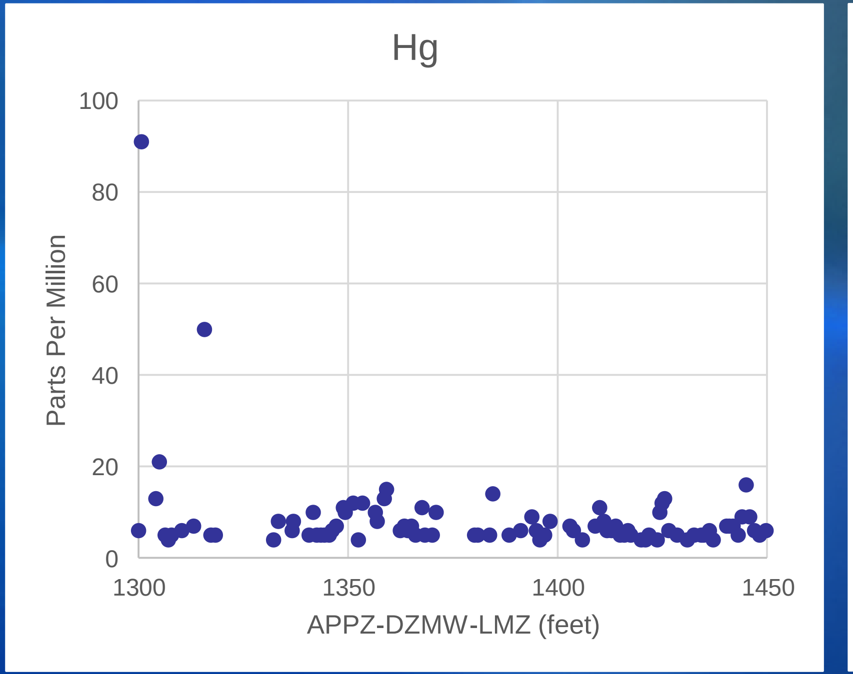
Focus on Metals in the Upper Floridan Aquifer

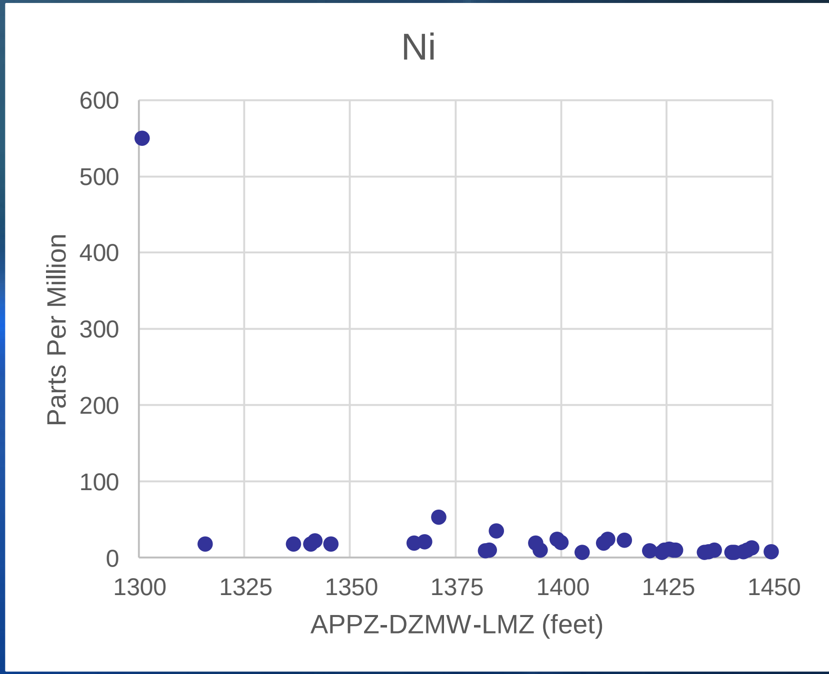


The metals within the Upper Floridan Aquifer (UFA) Dual Zone Monitoring Well (DZMW) Upper Monitoring Zone (UMZ) can be illuminated by plotting from 700 to 800 feet below surface. Mo graph is semi-log.

Focus on Metals in the Avon Park Permeable Zone



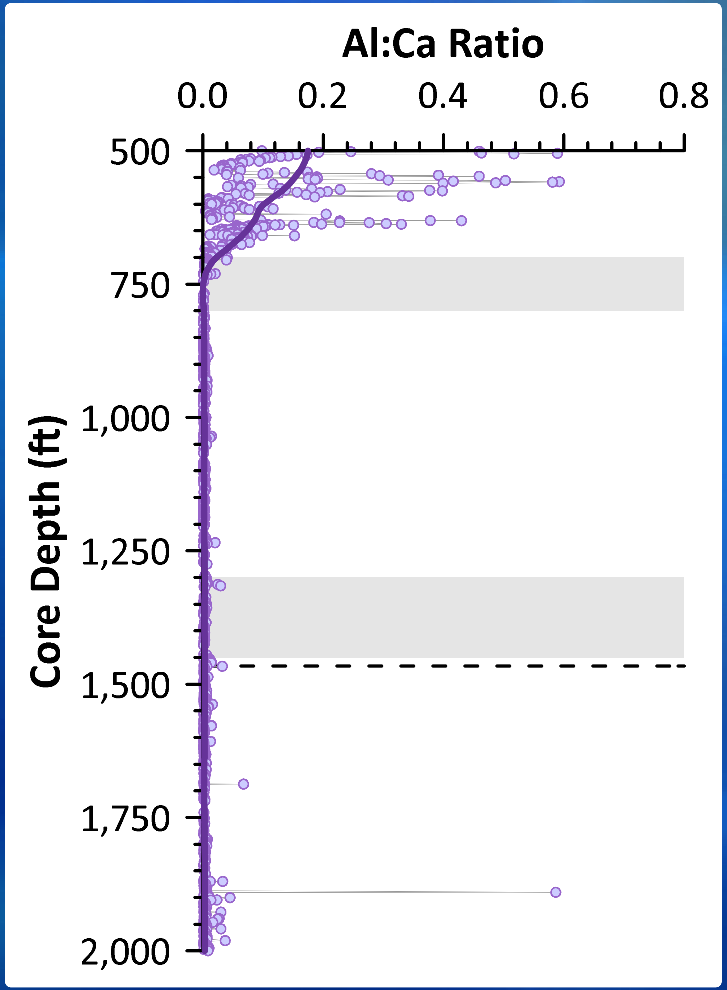




The metals within the Avon Park Permeable Zone (APPZ) Dual Zone Monitoring Well (DZMW) Lower Monitoring Zone (LMZ) can be illuminated by plotting from 1300 to 1450 feet below surface. Mo graph is semi-log.

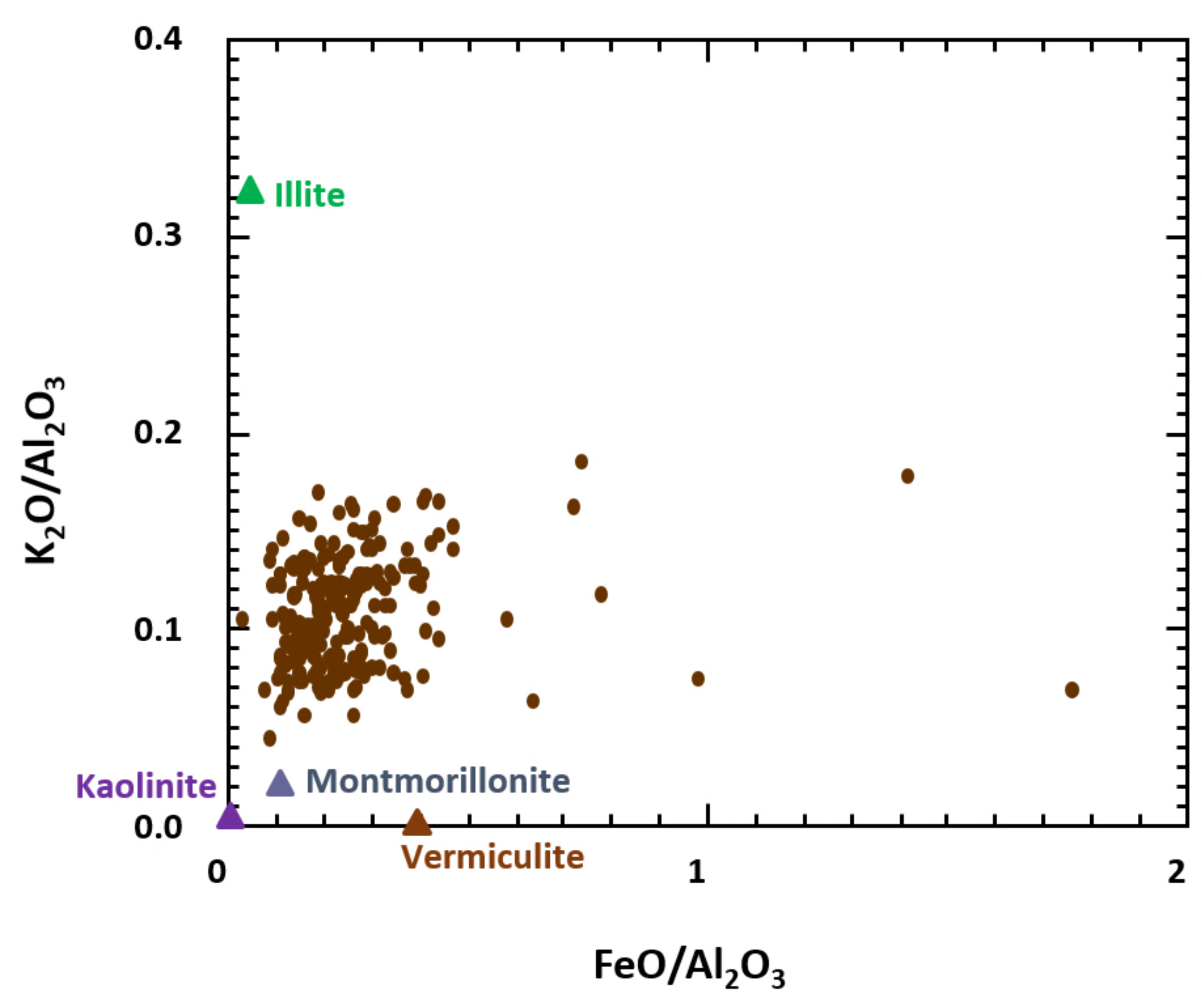
Clay in Confining Unit

500-510 ft.



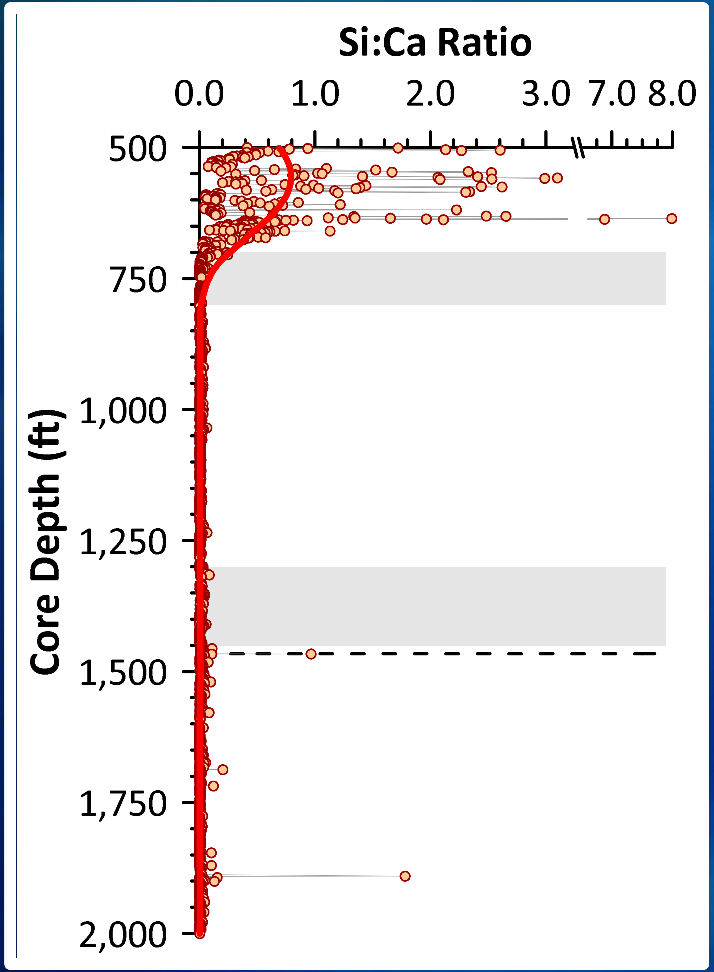
Clay constitutes a large portion of 500-700 foot section of the cores, as seen in the high Al:Ca ratio (McMillan and Verrastro, 2008).

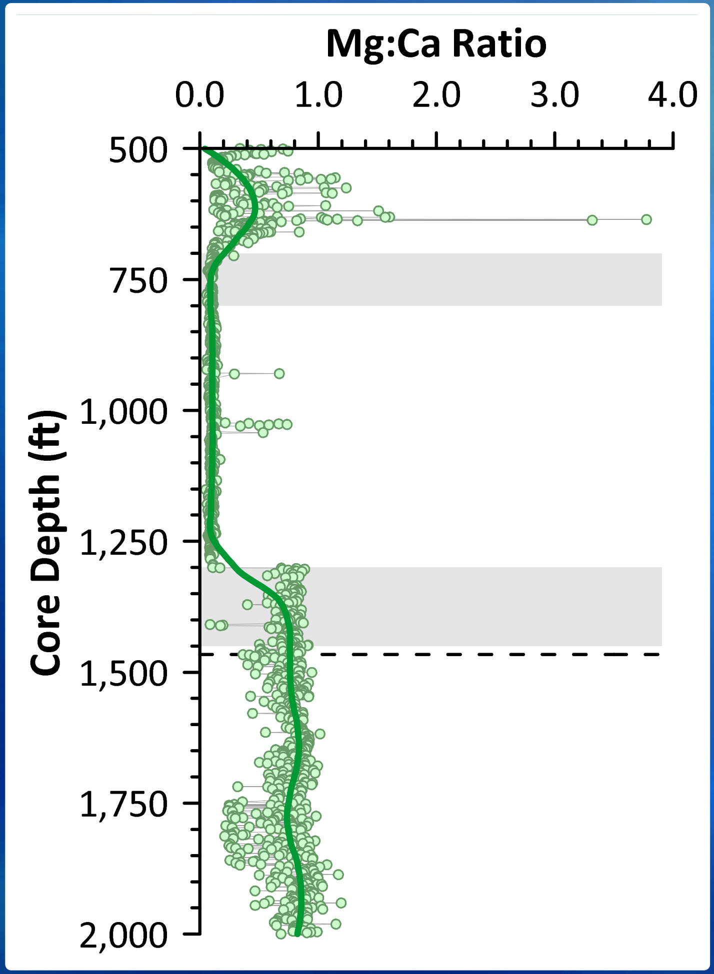
232 samples between 500 feet and 700 feet.



Chemistry suggests clays may be a mixture of montmorillonite and Illite.

Facies Changes





Element ratios can help identify facies changes.

@ 700 foot depth Si:Ca and other ratios greatly decrease, suggesting a facies change to limestone.

@ 1300 foot depth Mg:Ca ratio increases to dolostone levels of 0.8 (Prothero and Schwab, 2014) suggesting facies change.

Massive and Nodular Gypsum in Avon Park Fm.

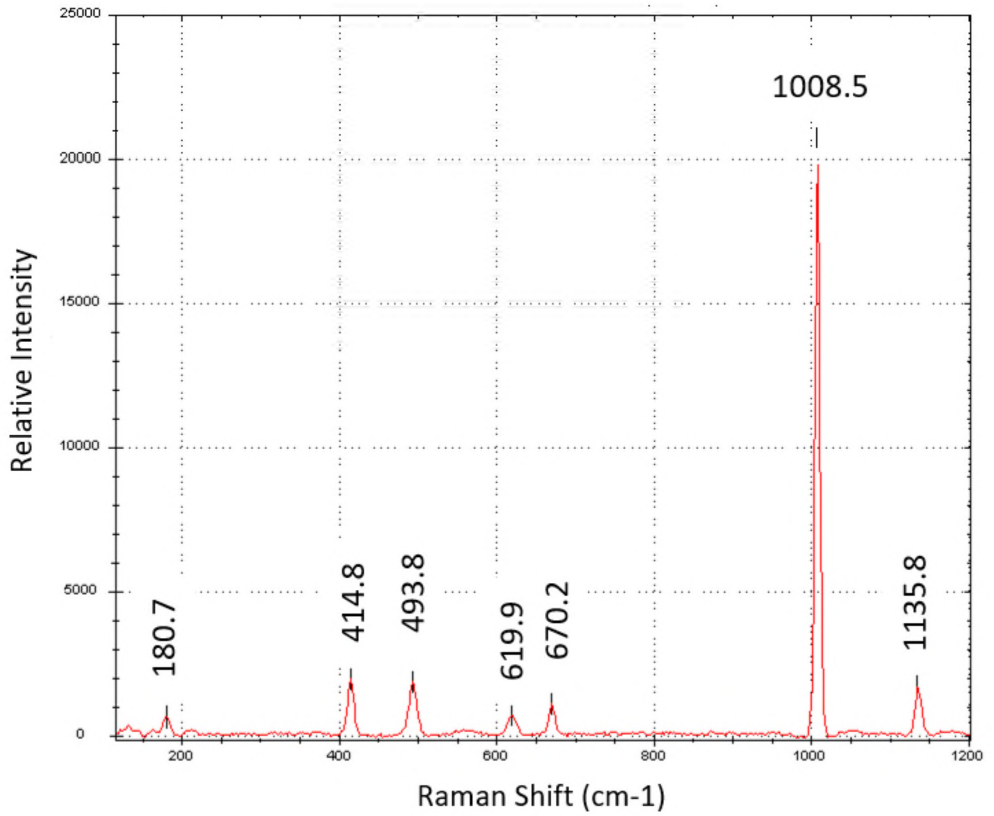
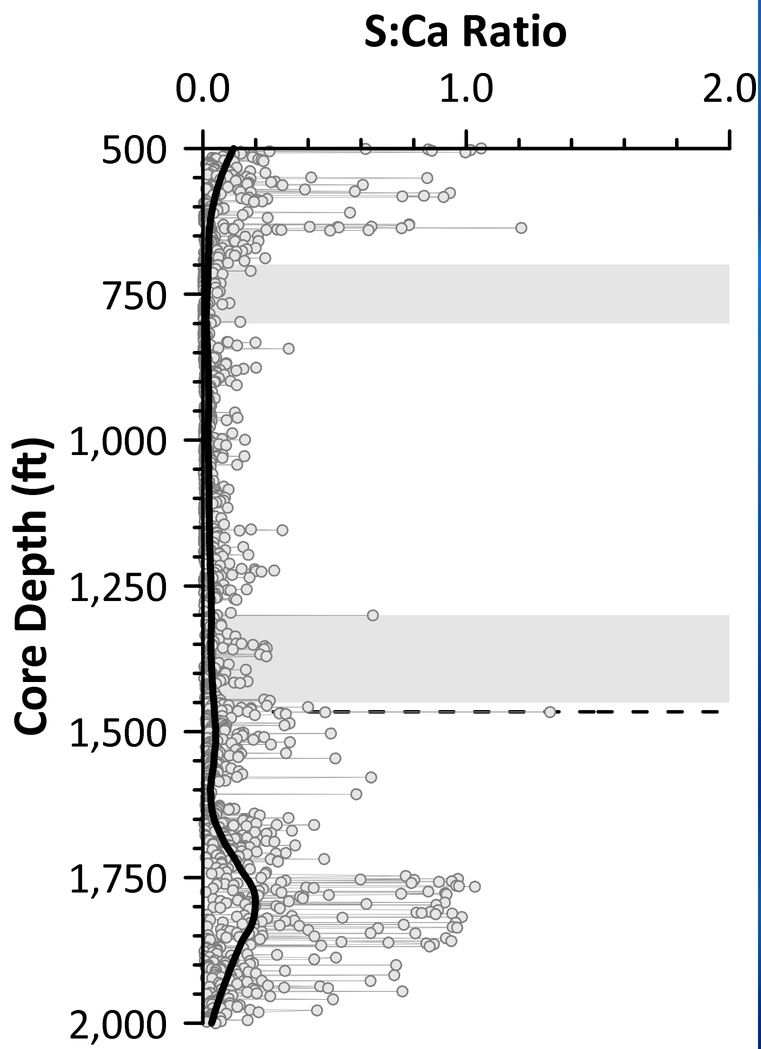


Figure Raman: Raman analysis of gypsum from core L63N. This sample, along with another sample, are a ≥ 97% match to gypsum's Raman wave number positions.

Massive and Nodular Gypsum in Avon Park Fm.



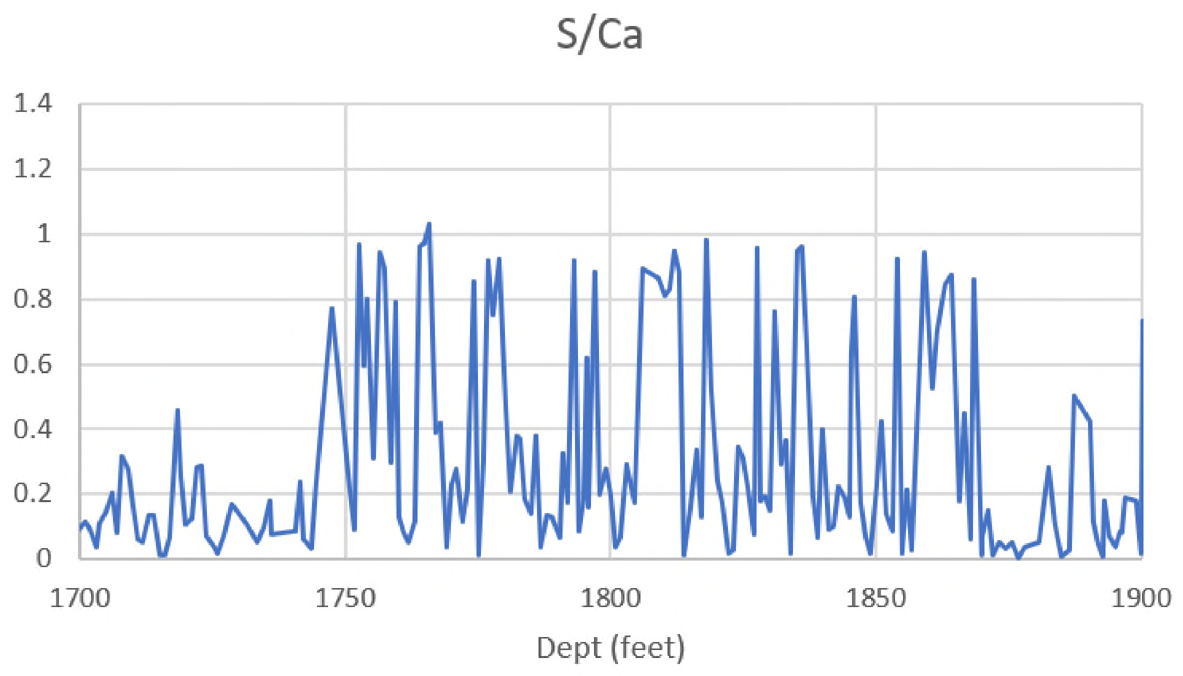


Figure S/Ca: S vs. Ca ratios for core intervals where massive and nodular gypsum occurs. S/Ca ratio for pure gypsum = 1. Change et al. (1998) report a S/Ca ratio of gypsum from limestone of approximately 0.8.

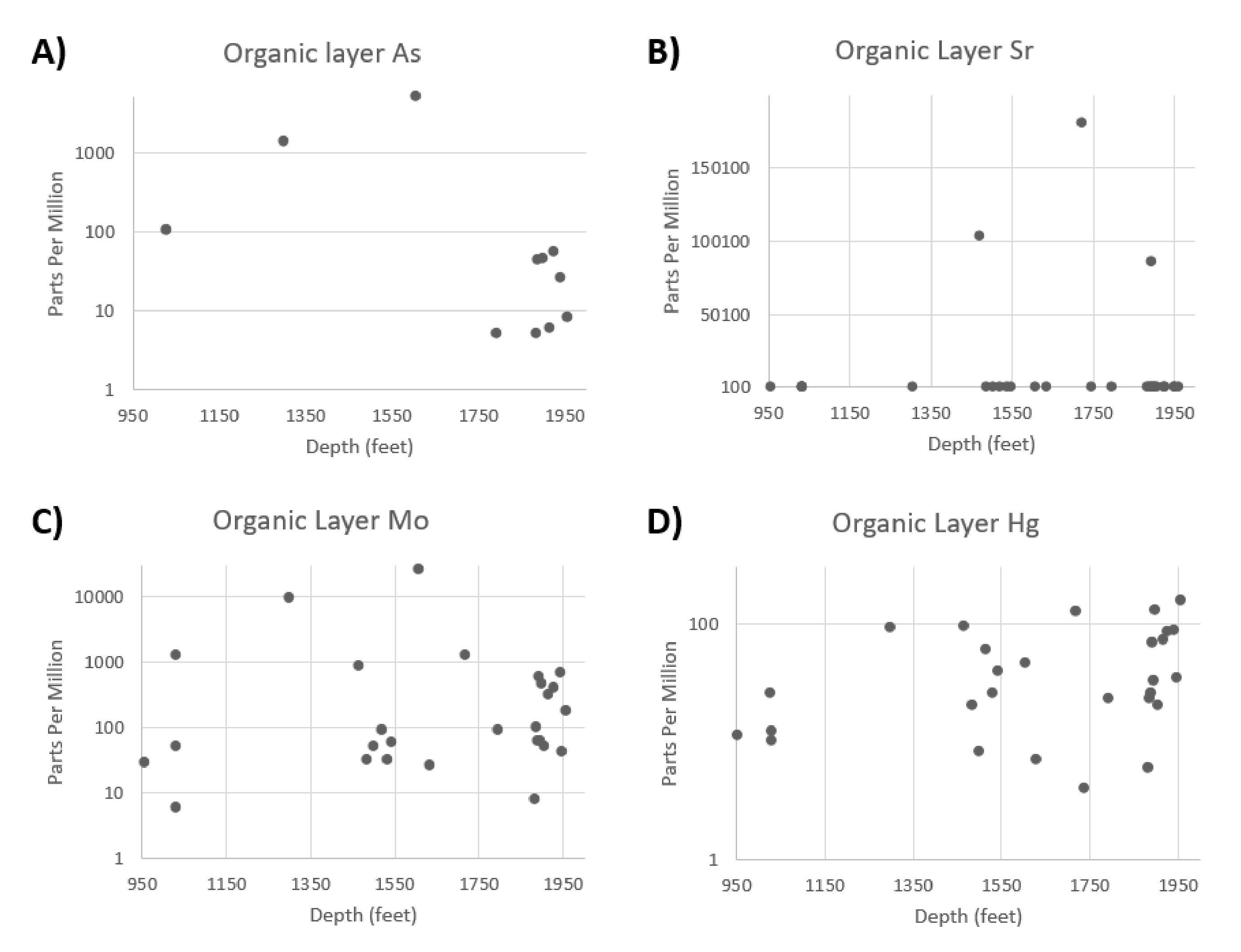
Organic-rich Layers Between 956 & 1958 Feet

1607 ft. depth

1795.5 ft. depth

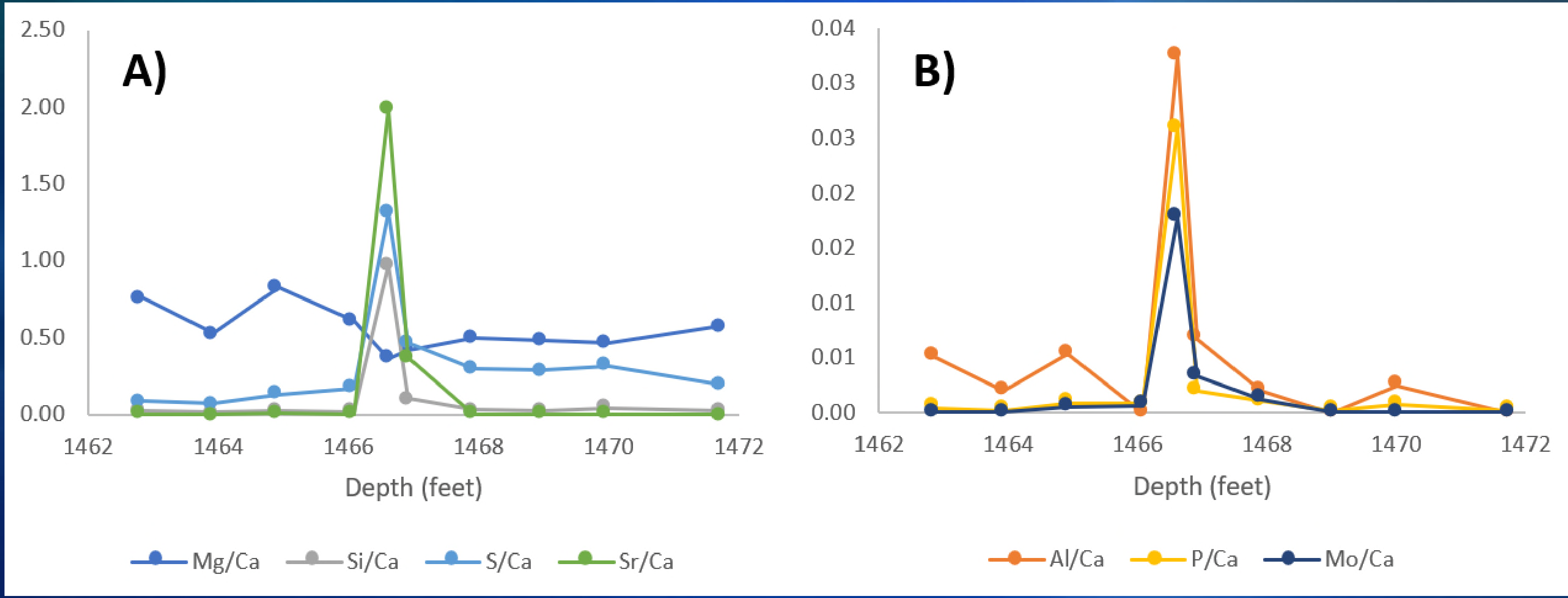
1917.58 ft. depth

Organic-rich Layers Between 956 & 1958 Feet



On average, <u>As is 10.8 times higher</u>; <u>Sr is 9.3 times higher</u>; <u>Mo is 13.7 times higher</u>; <u>Hg is 4.8 times higher</u>; <u>Cu is 3.8 times higher</u>; and <u>Ni is 3.5 times higher</u> in the organic layers than the average for these elements in the entire core.

Possible Volcanic or Ash Fallout Layer



Occurs around 1466 foot depth. Disruption of stratigraphy. Elevated Si, S, Sr, Al, P, and Mo.

"Early" Conclusions

A handheld XRF can be used to rapidly and accurately analyze hundreds of samples from the ASR project.

Metal concentrations can be identified within the potential zones for ASR at site L63N. For example, most metals are higher at the top of the APPZ.

Additionally, other important information can be revealed with the geochemistry. Such as facies changes, possible composition of clays, and areas of high sulfate minerals.

High organic content layers should be avoided.

Panel Discussion (5 min.)

Break

10:15 AM – 10:30 AM

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

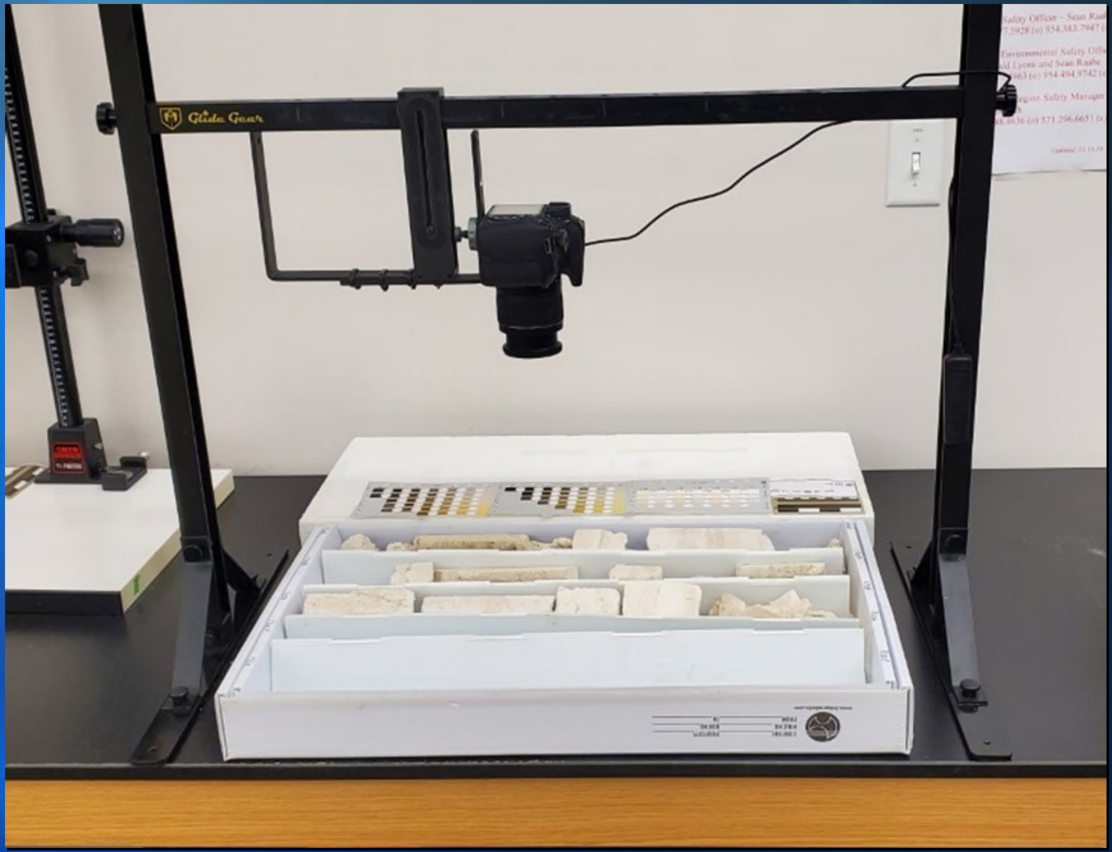
Multi-Well Assessment of Fracture Porosity of the Floridian Aquifer System in Support of Future ASR Wells in Northern Lake Okeechobee

Presenter: Victor Flores
Researcher and Analyst

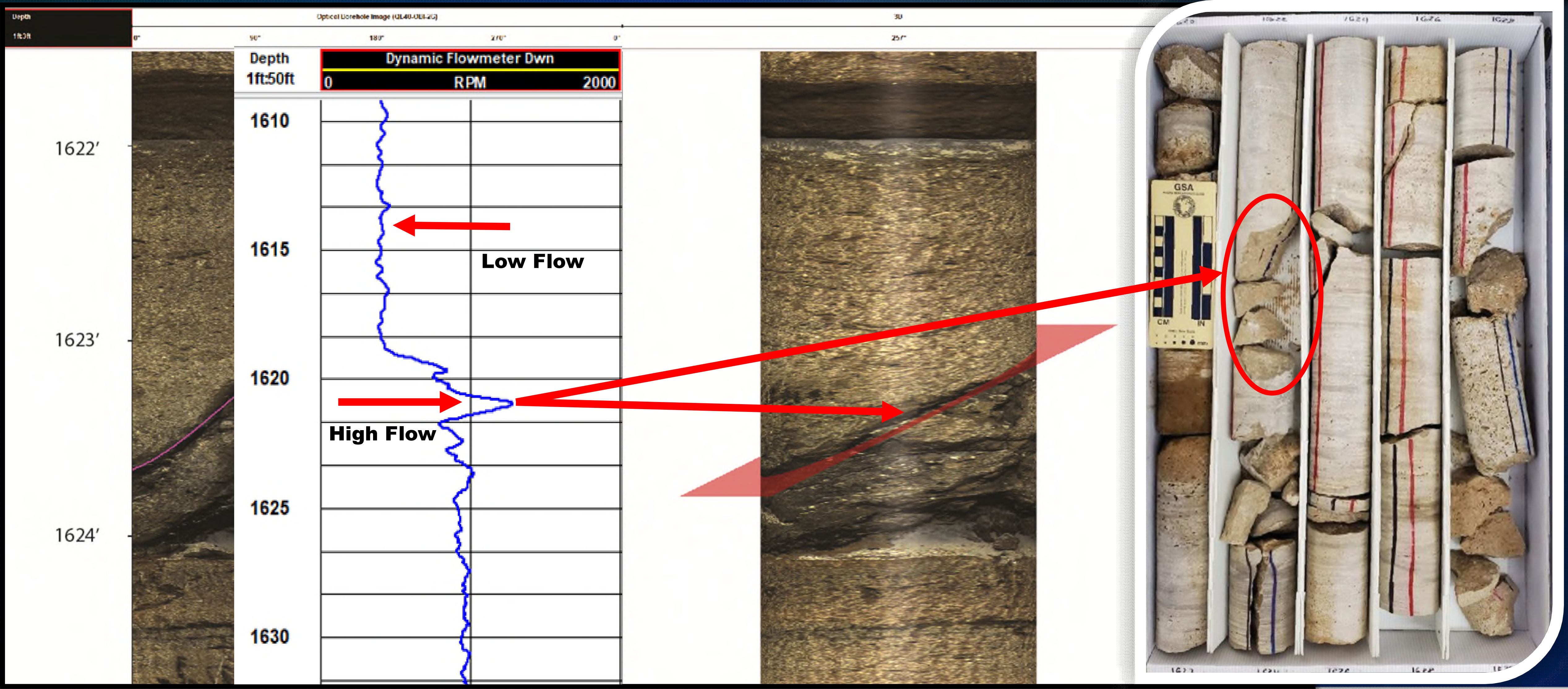
Contributor: Kevin Cunningham (Technical Lead)
U.S. Geological Survey, Davie, FL

sfwmd.gov

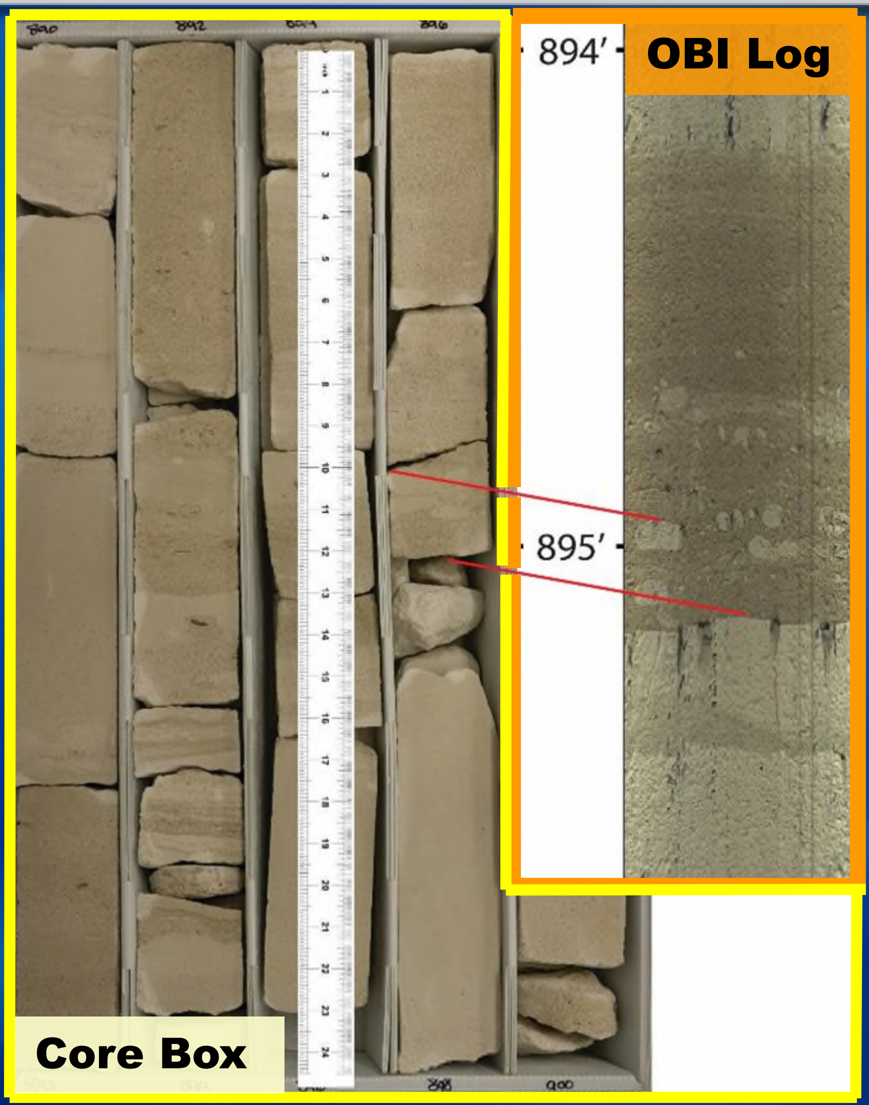
Carbonate Aquifer Characterization Laboratory



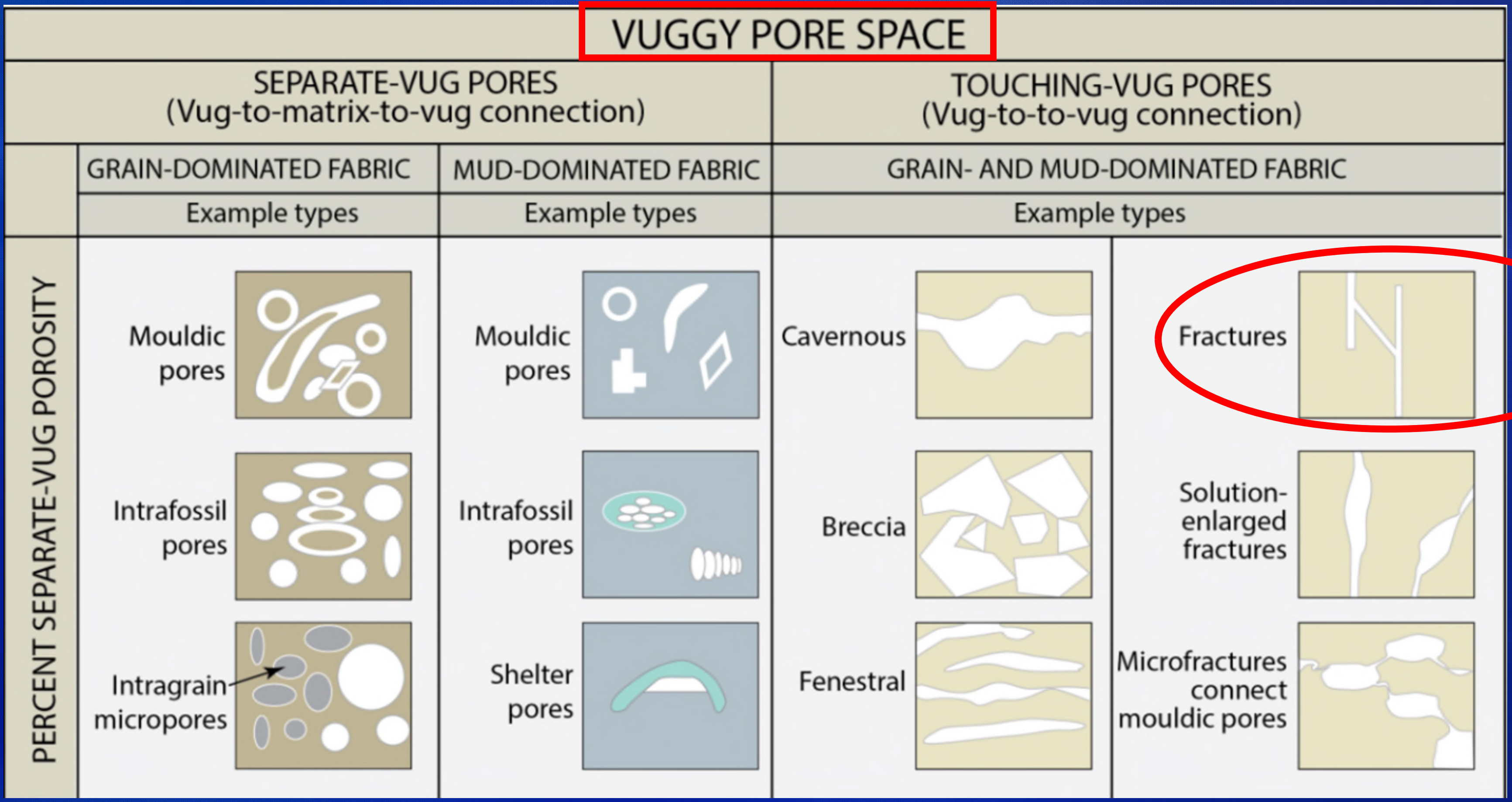
Core Analysis



Core to OBI Depth Calibration



Vuggy Pore Space Classification

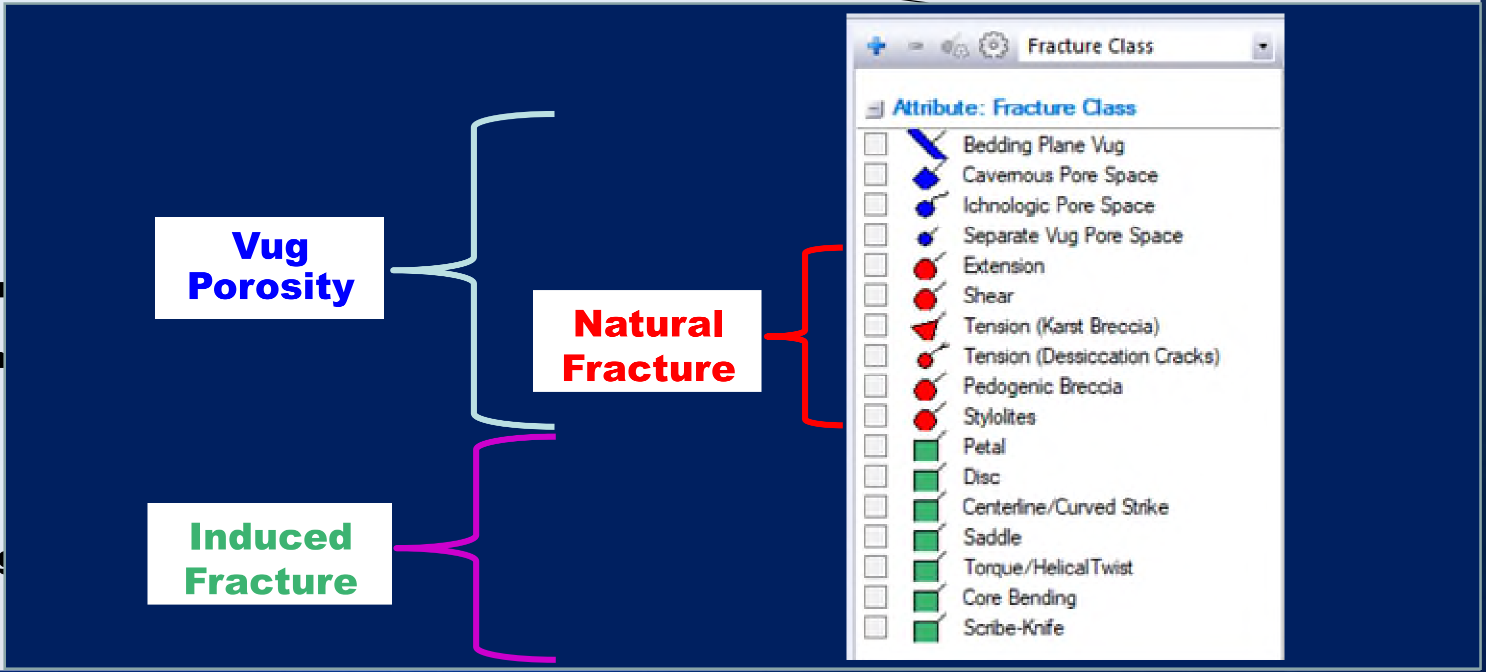


Lucia (2007)

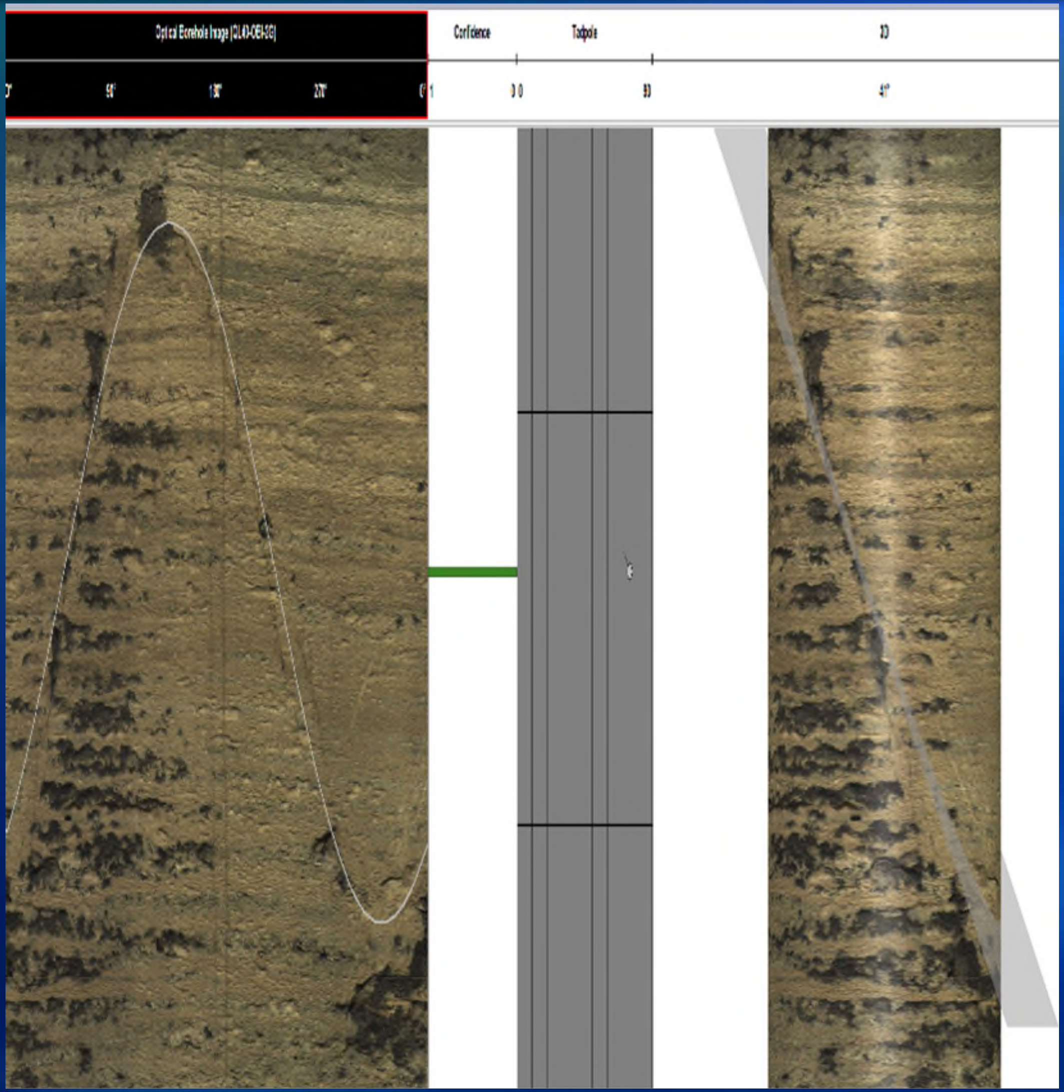
Carbonate Fracture Classification

Vuggy pore space in carbonate rocks

- **Touching-Vug pore space**
  - **Bedding Plane Vug**
  - **Cavernous Pore Space**
  - **Ichnologic Pore Space**
  - **Fracture Pore Space**
    - **Natural Fractures**
      - **Extension (2 rock masses pulled apart)**
      - **Shear (2 rock masses slide past each other**
      - **Tension (produced in response to minimum**
      - **Pedogenic breccia**
        - **Roots**
        - **Freezin**
      - **Stylolites**
      - **Others.....**
- **Separate-Vug pore space**



Fracture Classification



- **Fractures or bedding planes can be identified by outlining the sinusoidal features on the OBI image.**
- **Natural Fracture: Created by geologic forces and processes**
- **Induced Fracture: Created by drilling, coring and handling processes**

Fracture Picking

Induced Fractures

Common Characteristics of Induced Fractures

- Rough, unmineralized, fresh breaks
- Lips at the core edge
- Plumes that interact with the core edge and that follow a core axis
- Fracture planes that are consistently normal or parallel to the core axis

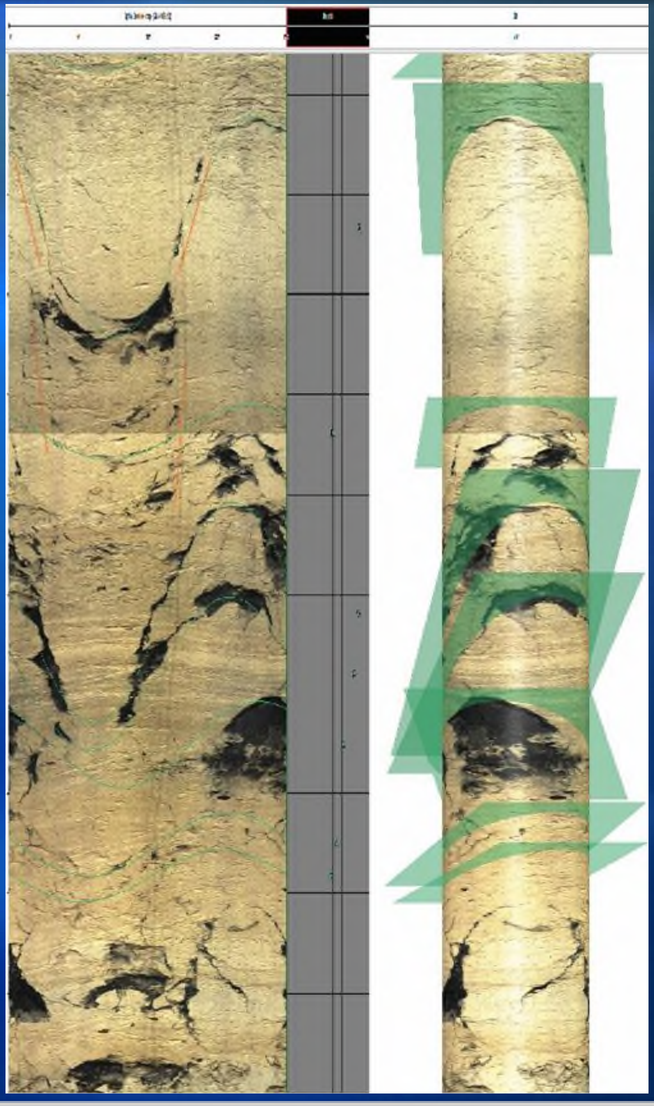
Common Characteristics of Natural Fractures

- Mineralization/cementation
- No interaction with the core surface
- Similar orientations and geometries to mineralized fractures
- Plumes, steps, or slickenlines that have axes that are unrelated to the core axes
- Generally, are more planar than induced fractures

Fracture Picking

Induced Fractures

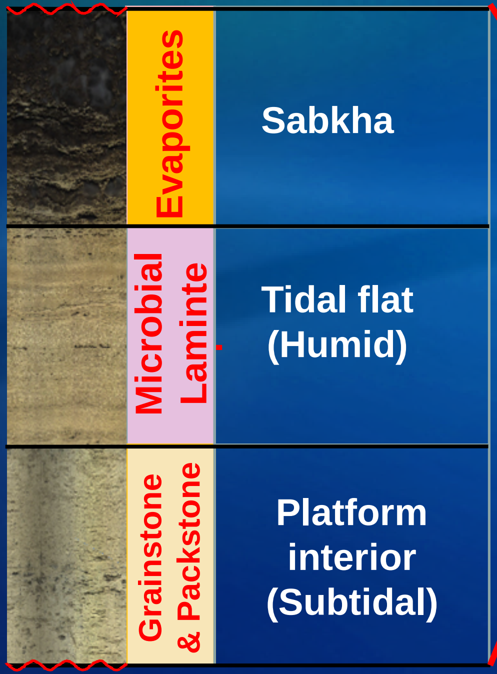
- **Petal shaped parallel cracks**
- **Closely spaced**
- **Nested**
- **Concave propagation**
- **Rib surfaces**
- **Difficult recovery**
- **Rainbow arcs (core sample)**
- **May form on one side of the core only**



Applications of USGS Data Collection

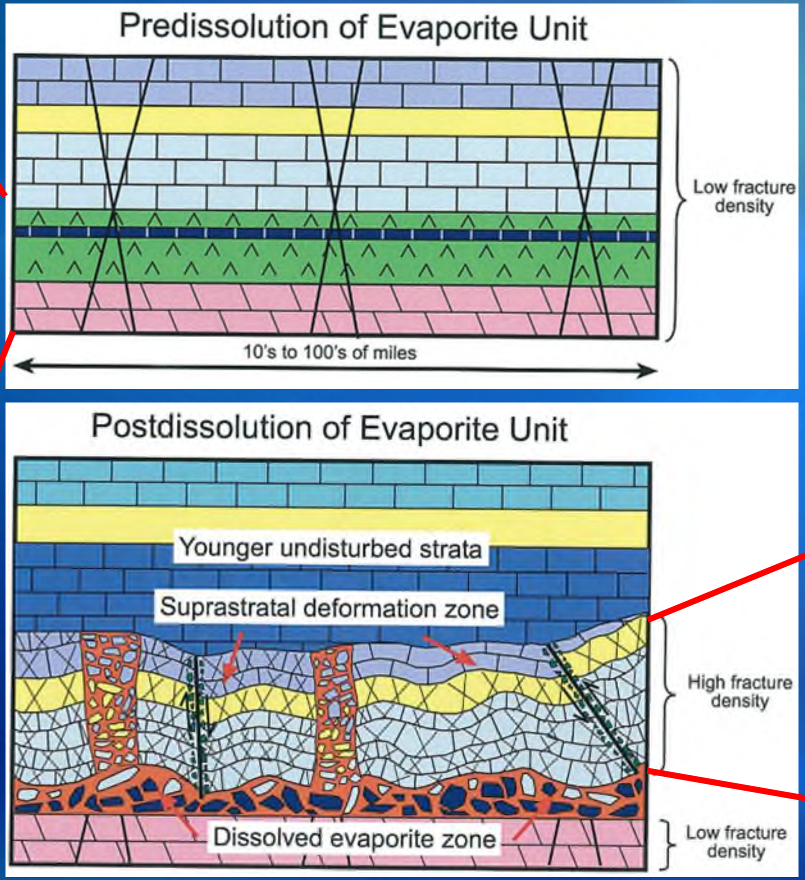
- **Data collected for this project could be used in a USGS phase II study**

Phase II Project Could Investigate Karst Origin of Fractures Through Analog Studies

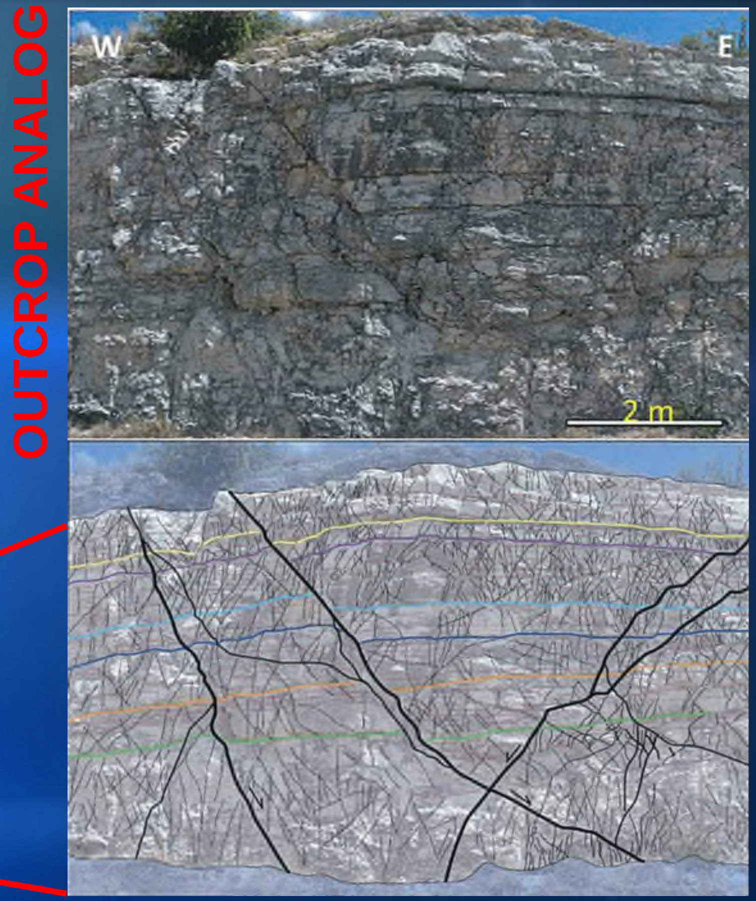


Evaporite-capped ideal cycle, Avon Park Formation

Fractures in Cretaceous Dolomite, Texas

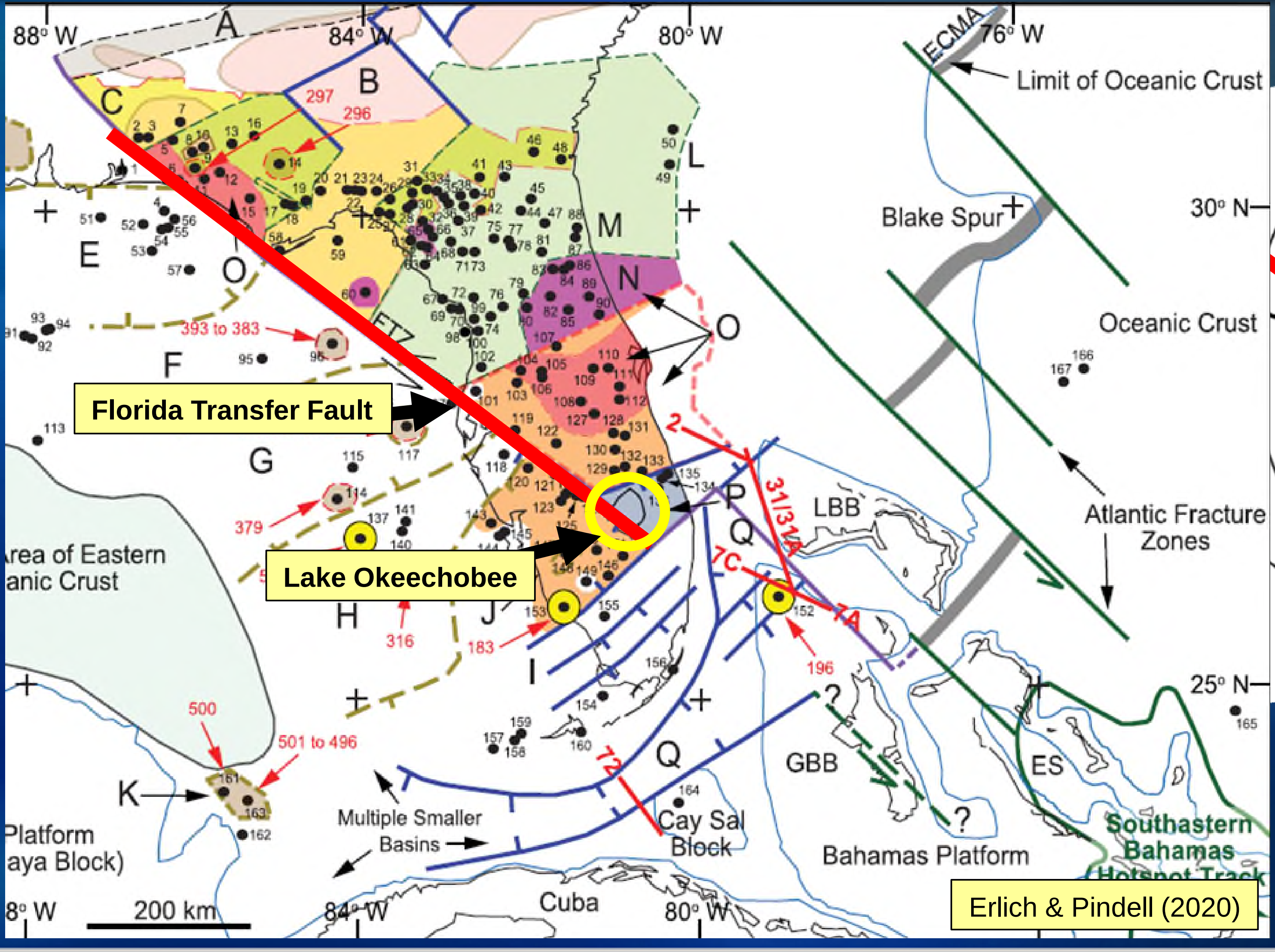


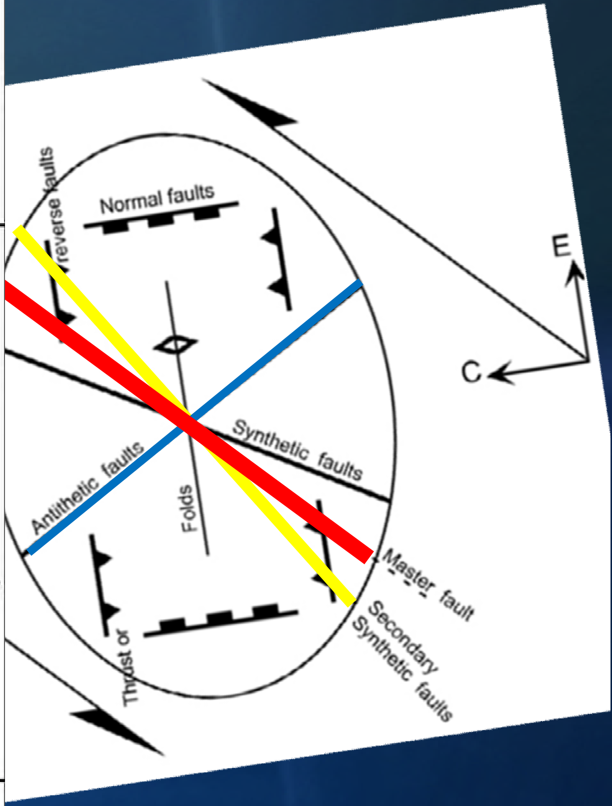
Loucks & Zahm (2014)



Highly fractured evaporite solution collapse breccia, Kirschberg Dolomite, Cretaceous, Central Texas

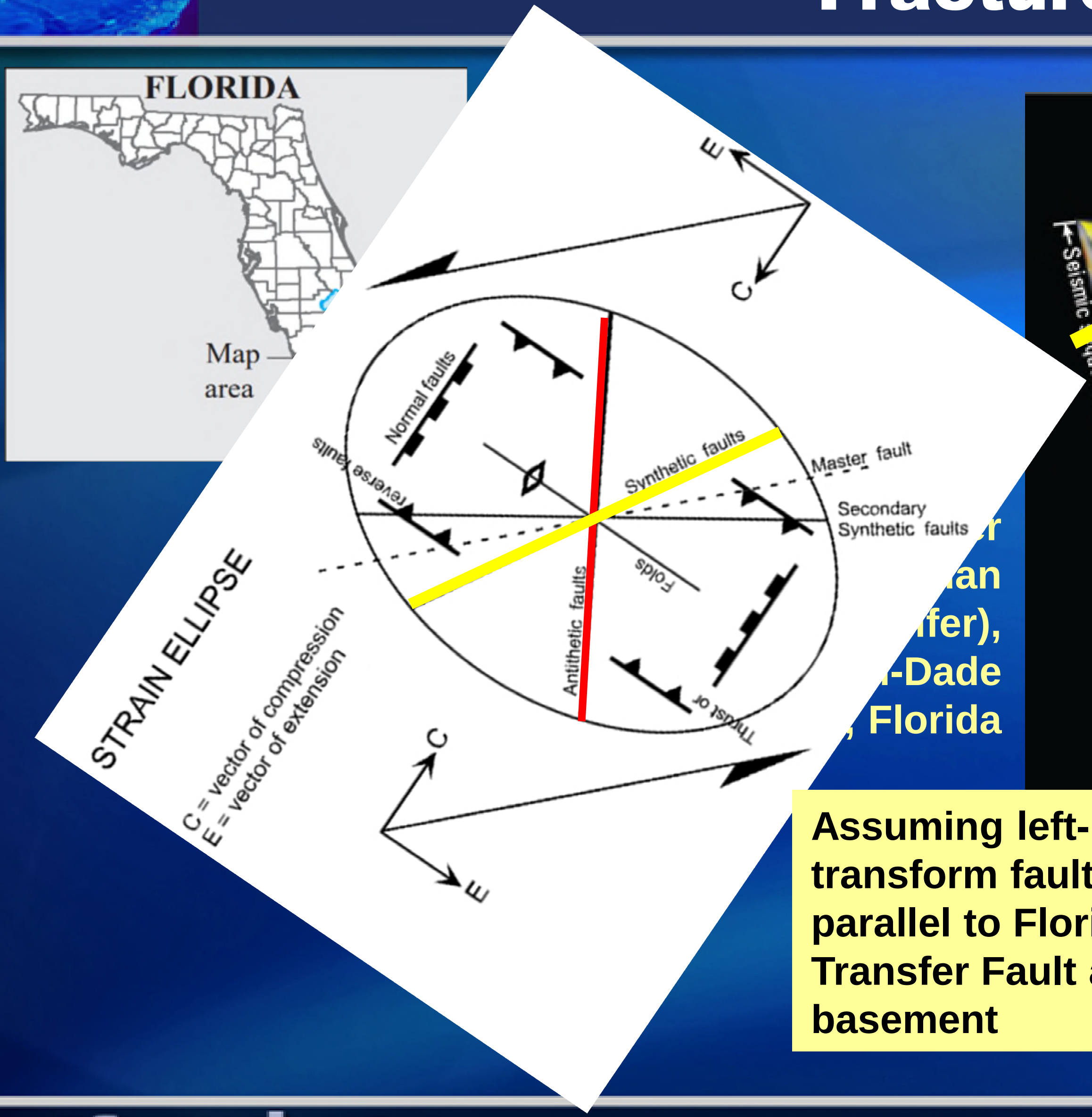
Phase II Project Could Investigate Tectonic Origin of Fractures





"Preliminary Information-Subject to Revision. Not for Citation or Distribution."

Phase II Project Could Investigate Tectonic Origin Of Fractures With 3D Seismic



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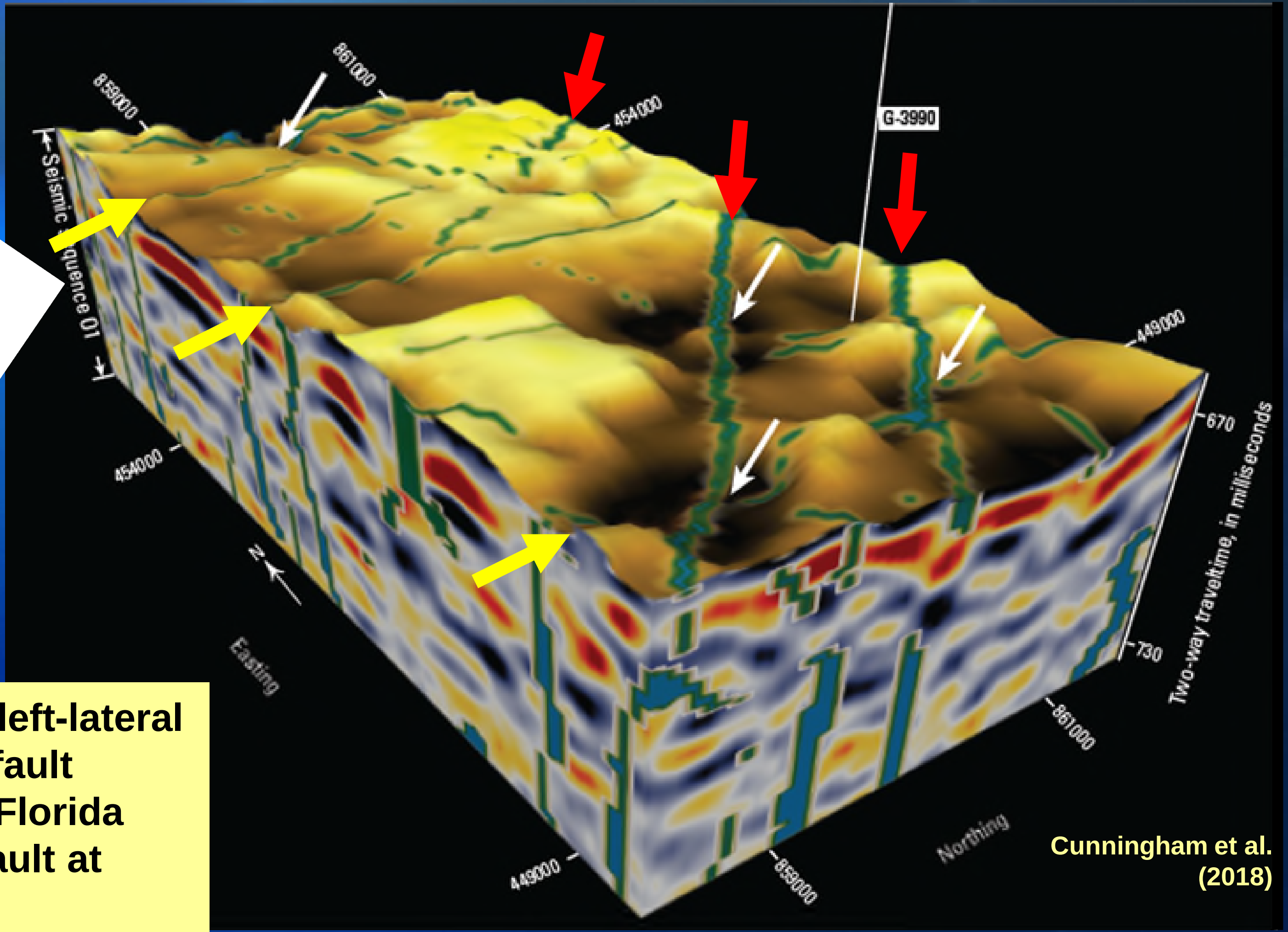
Assuming left-lateral transform fault parallel to Florida Transfer Fault at basement



Cunningham et al. (2018)

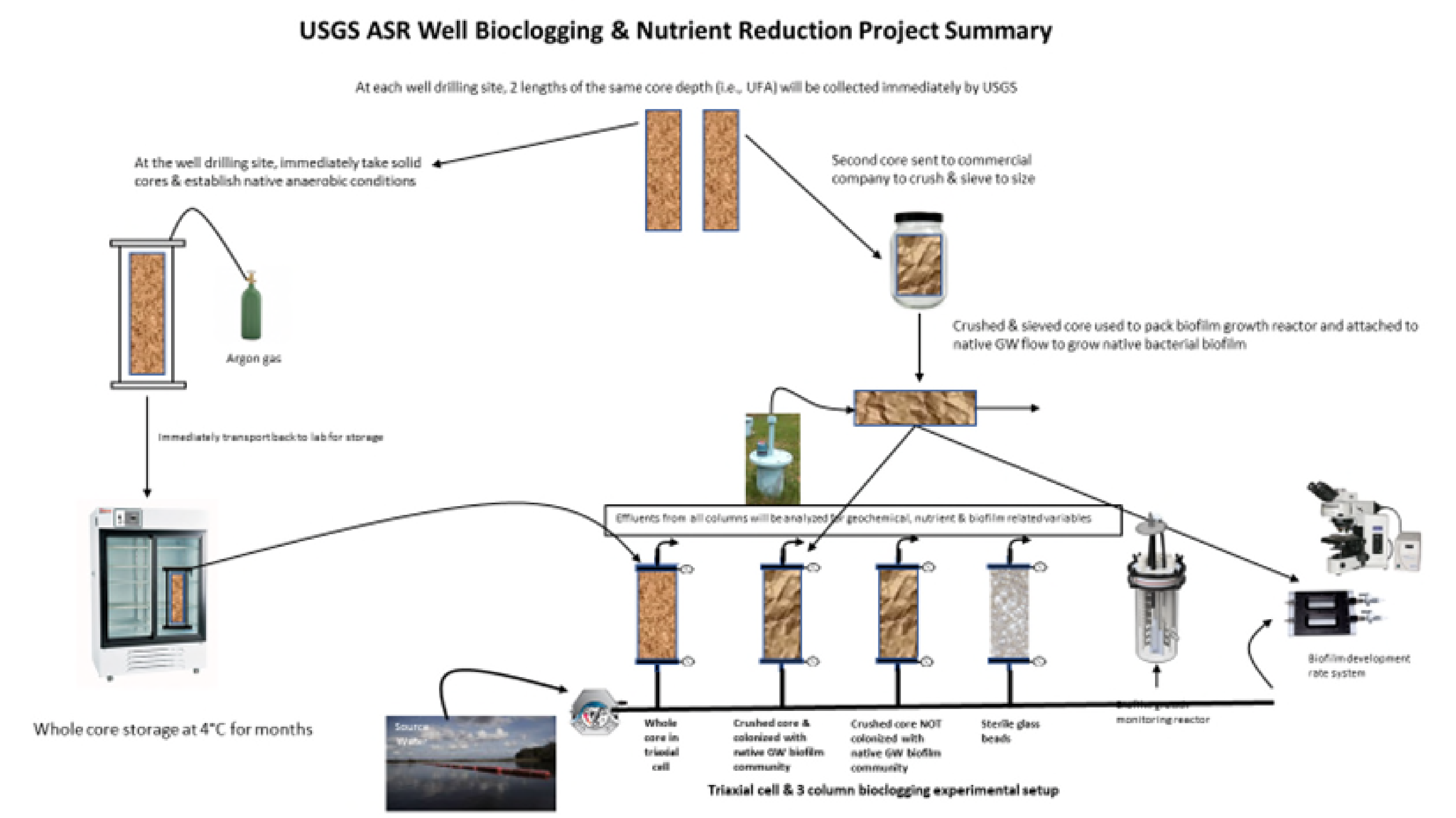
Panel Discussion
(5 min.)

USGS
science for a changing world

Characterization of Microbial & Geochemical Processes Contributing to Nutrient Reduction & Potential Clogging

Presenter: John Lisle
Research Microbiologist
USGS/St. Petersburg Coastal & Marine Science Center
U.S. Geological Survey, St. Petersburg, FL

Project Overview



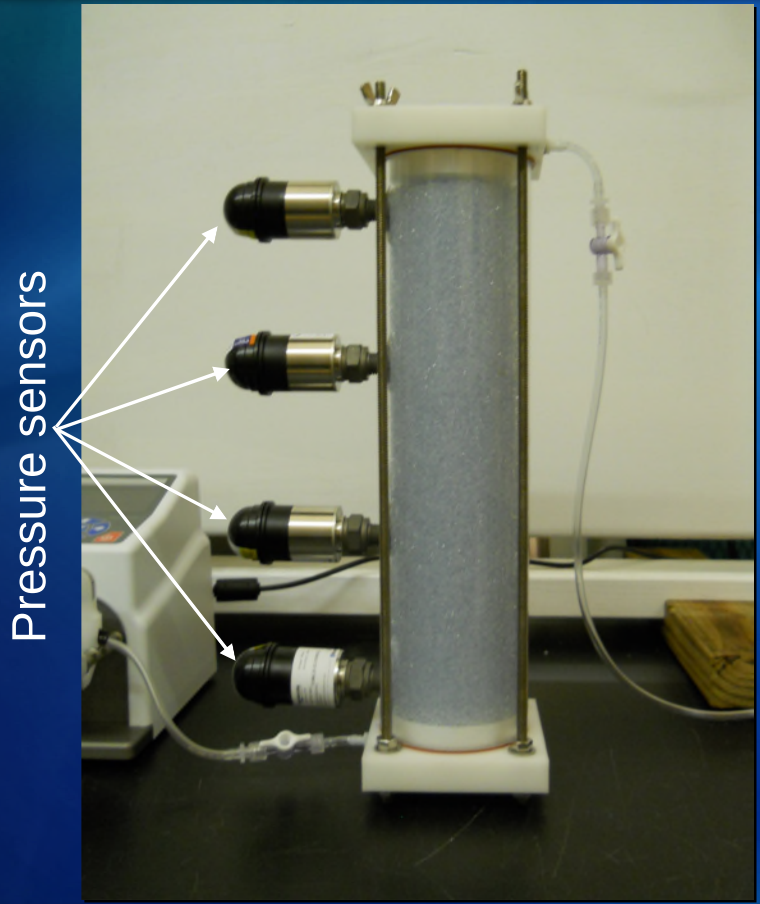
Aquifer Cores Sites

- Cores collected from 3 well sites
- Cores for column studies from 2 zones per well
  - o UFA
  - o APPZ
- From each zone, recovered cores will be used for:
  - o Solid core segments for permeameter
  - o Crushed core for
    - Packing experimental column with no native biofilm
    - Packing experimental column with native biofilm

* 3 wells x 2 zones x 2 experimental crushed core columns per zone = 12 experimental columns using crushed core

Core Collection, Stabilization & Processing

Types of Experimental Columns



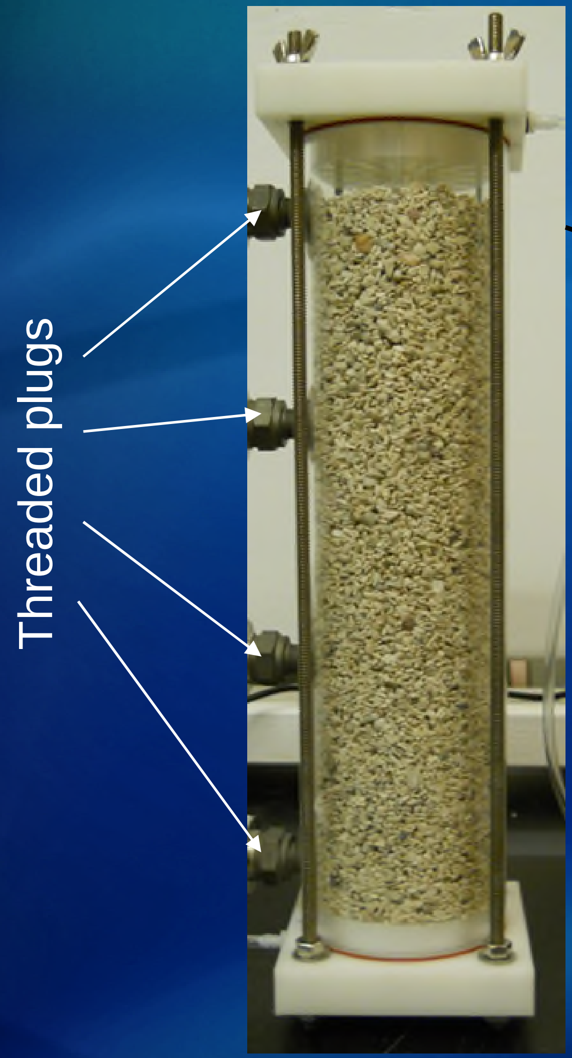
Glass beads (2.0mm)

Crushed core (no biofilm at T_0)

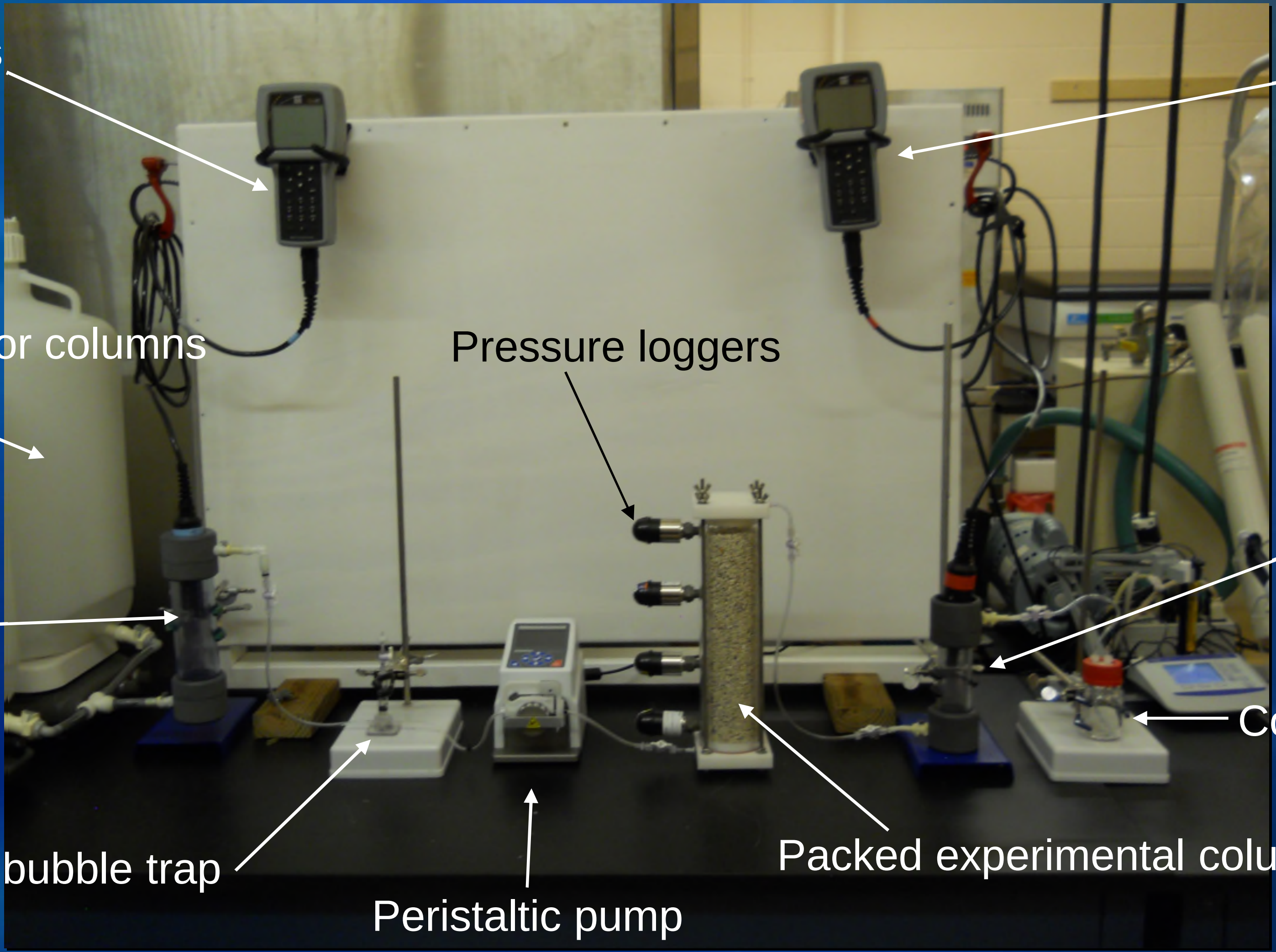
Crushed core (native biofilm at T_0)

* **All columns are 3”(ID) x 12”(L)**

Growing Native Biofilms on Experimental Columns



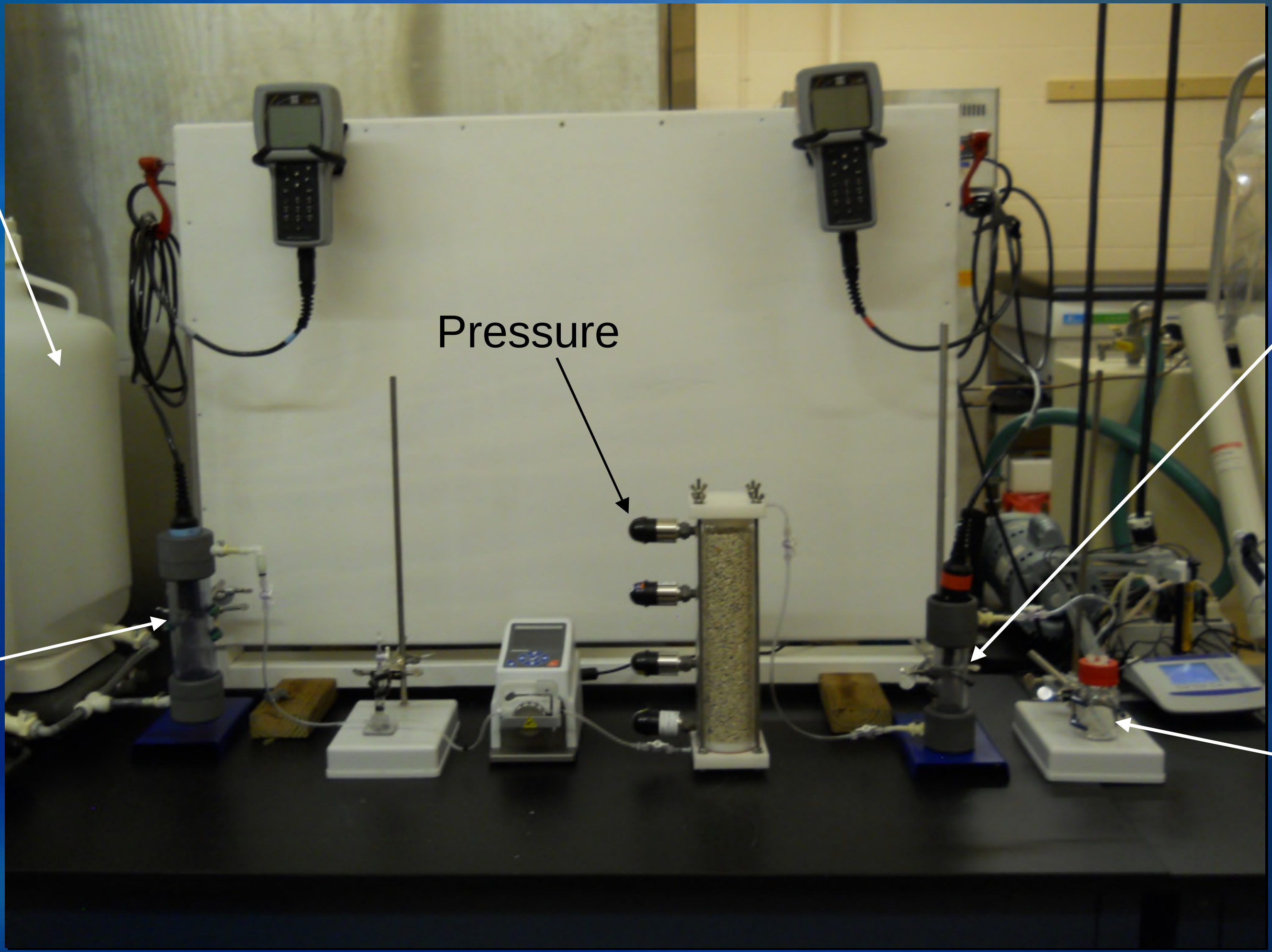
Bioclogging Experimental System



Experimental Data Types & Collection Points

Nutrients (CNP)
Cations
Anions
Redox sensitive metals

Temperature
Sp conductance
Conductivity
TDS
Salinity
DO
pH
ORP



Temperature
Sp conductance
Conductivity
TDS
Salinity
DO
pH
ORP

Nutrients (CNP)
Cations
Anions
Redox sensitive metals

Nutrient & Geochemical Analytes

Carbon
- Biodegradable DOC
- TOC
- DOC
- SUV_{254}

Dr. John Kominoski, FIU

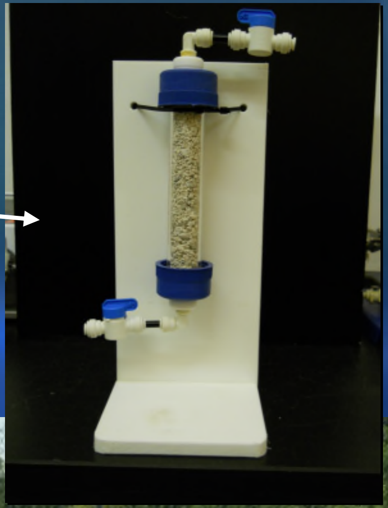
Nitrogen
- NO_3
- NO_2
- NH_4

Phosphorus
- PO_4

Dr. Rob Masserini, University of Tampa

Geochemical
- Cations
- Anions
- Redox sensitive metals

Eurofins Test America, Tampa

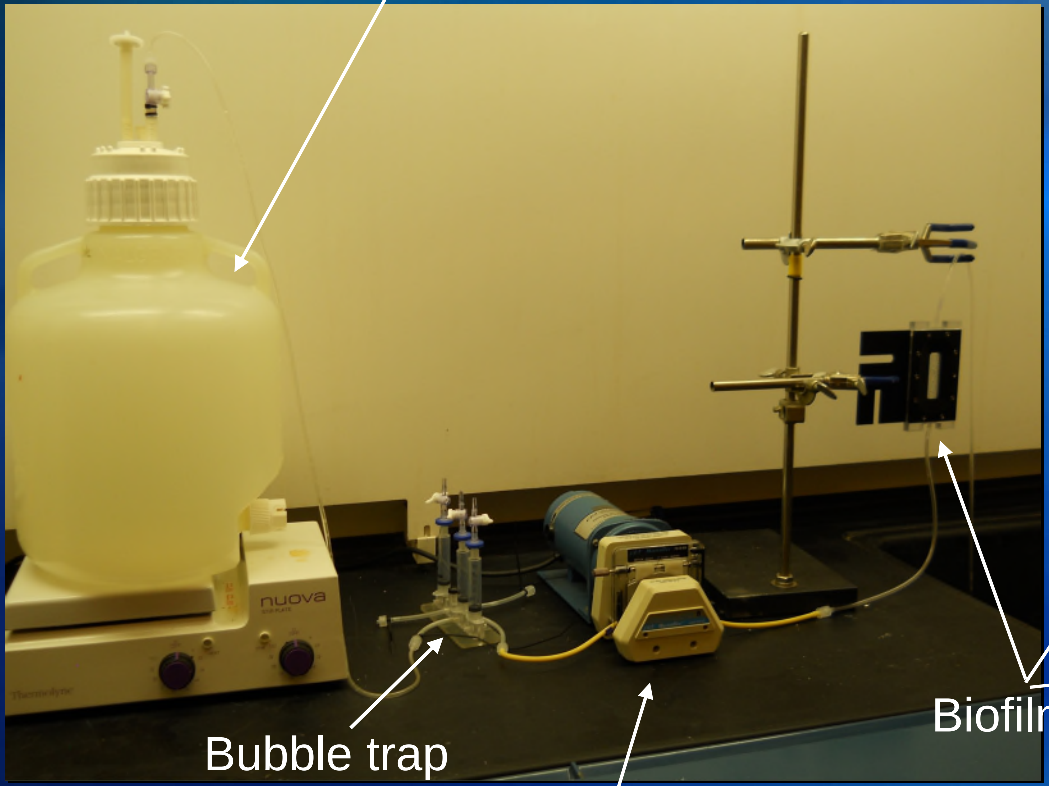


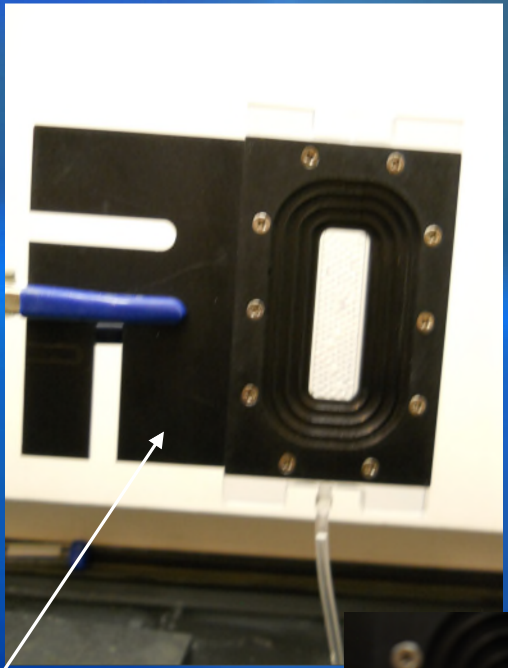
Project Research Task Status

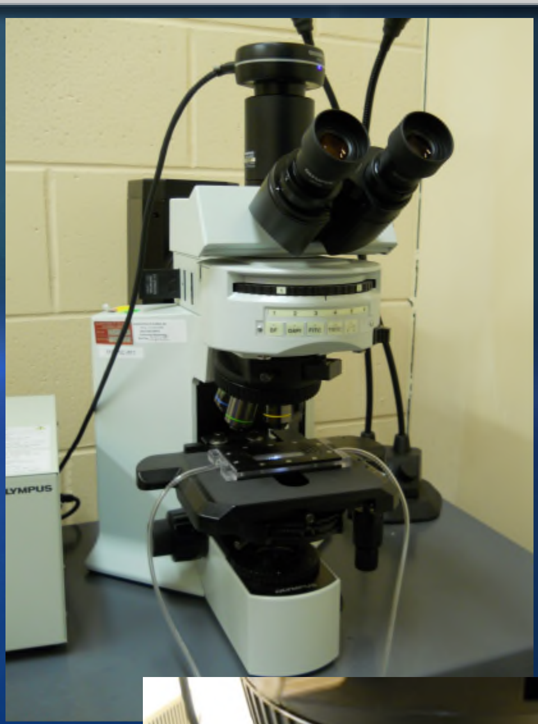
- To date, 1 core has been retrieved from the first site, C38S, at the upper storage zone.
  - The solid core has been stabilized and is in storage.
  - The core section for crushing is currently being processed.
- All laboratory systems are set up and trial experiments have been conducted for optimization.
  - Example: Biofilm development assay

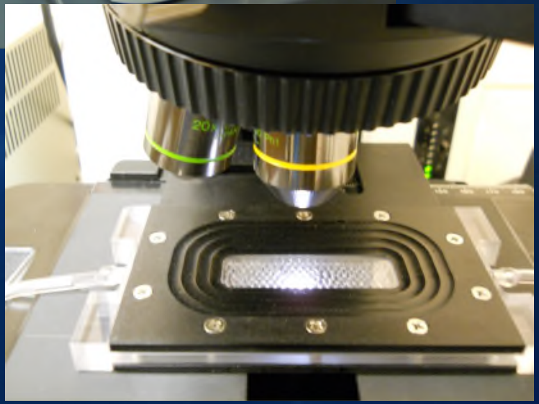
Biofilm Production Rate System

Kissimmee River water (300µm filtered)









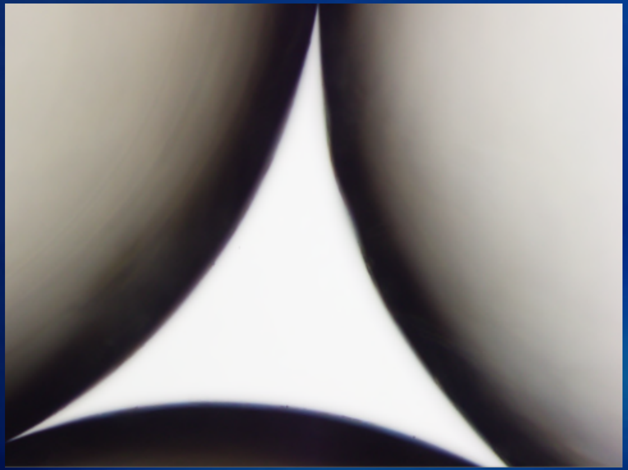
Bubble trap

Biofilm flow cell

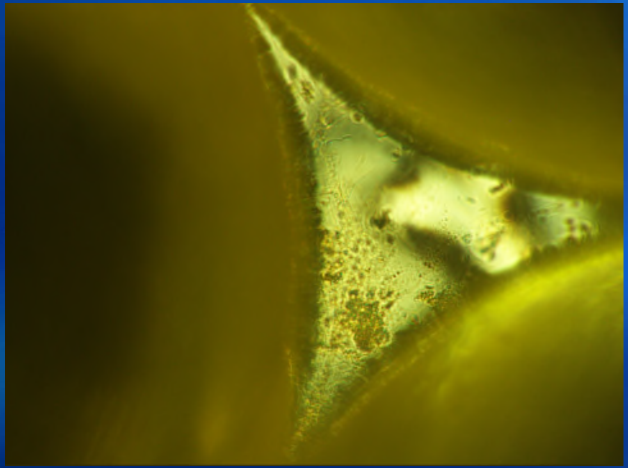
Peristaltic pump

2.0mm glass beads

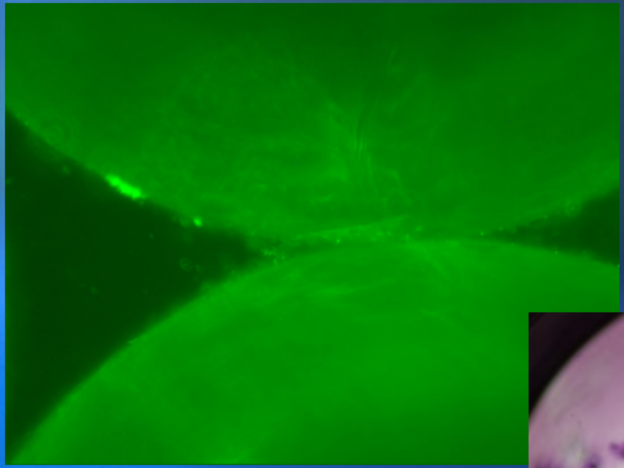
Biofilm Development on Glass Beads

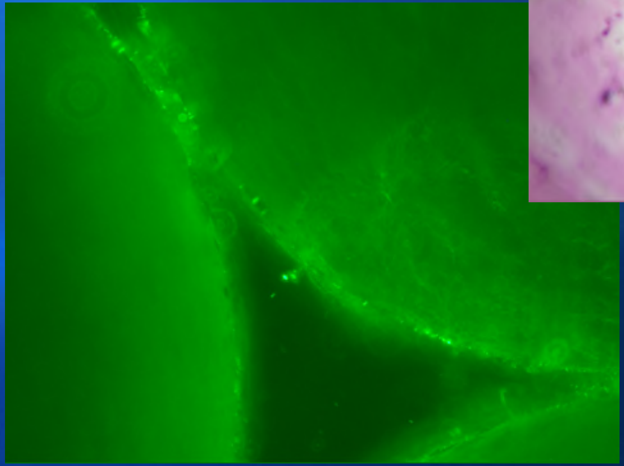


T_0 (visible light)

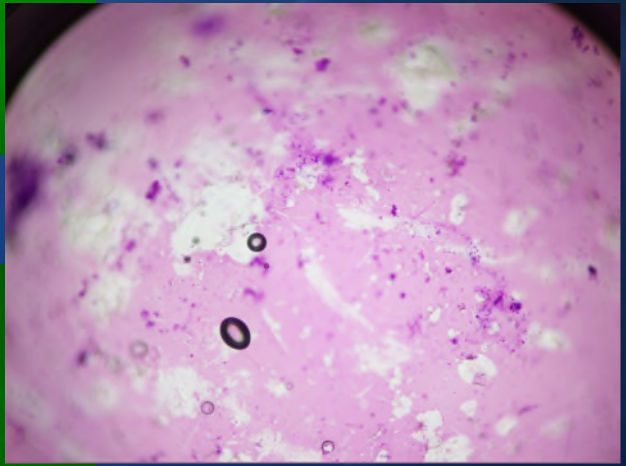


T_{14} (visible light)





T_{14} (SYBR Gold)



T_{14} (crystal violet)

Panel Discussion (5 min.)

Public Comment

11:50 AM – 12:00 PM

Lunch Break

12:00 PM – 12:30 PM

Stantec

Aquifer Storage And Recovery (ASR) Treatment Technology Proof-of-Concept Testing Update

Presenter: Heath Wintz, PE

Stantec Inc

Contributors: Mohini Nemade, EI; Stefani Harrison, PE
Megan Patterson, EI; Michael Price, PE

Overview

- Proof of Concept Testing
- Performance Summary
  - Media Filtration + UV
  - Membrane Filtration
- Backwash and Solids
- Non-Economic Evaluation
- Recovered Water Considerations
- Schedule
- Next Steps

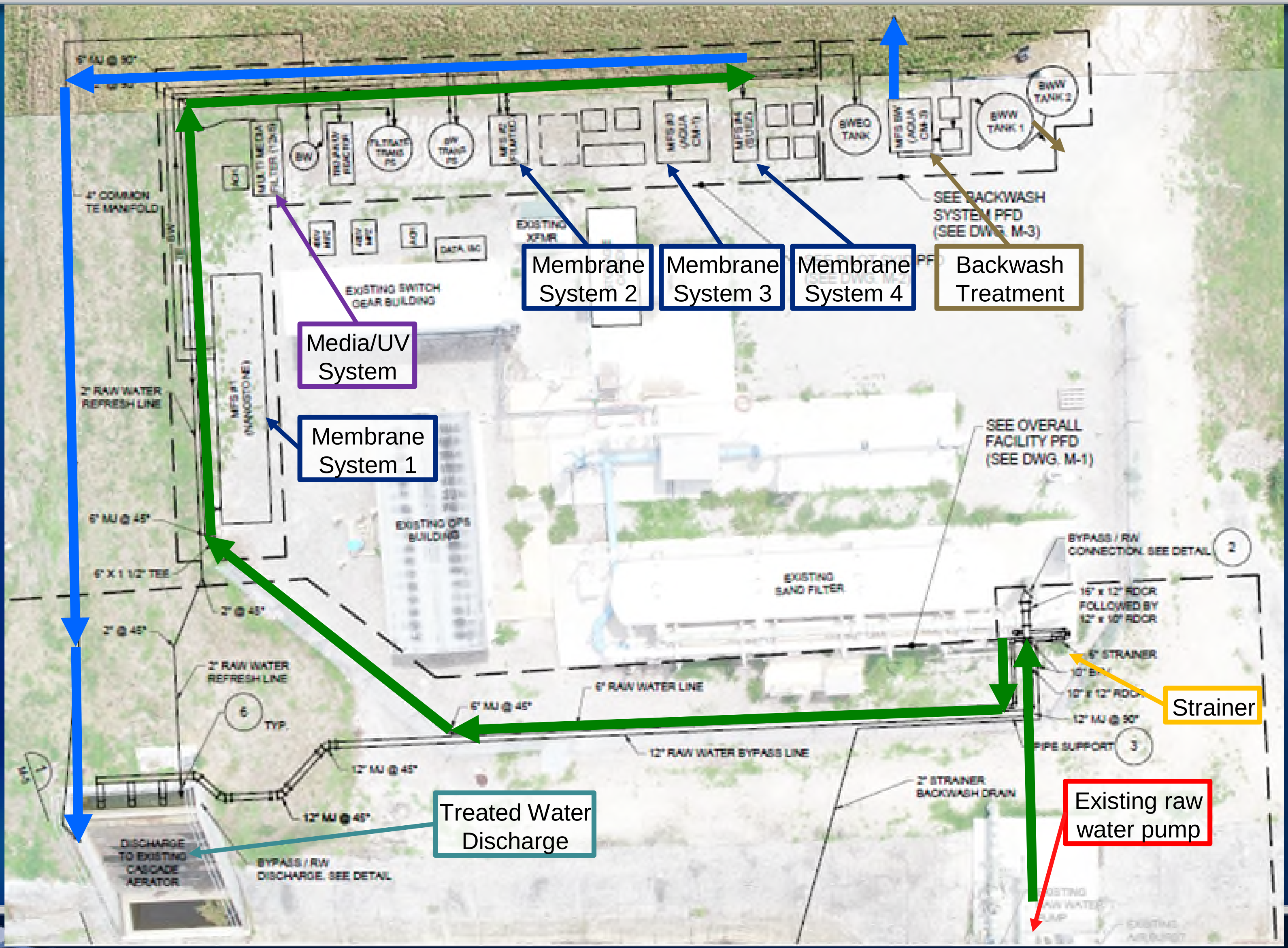
POC Testing

- Proof-of-Concept testing was intended to test and demonstrate treatment systems that can produce water suitable for aquifer recharge, per Rule 62-520.410(1), F.A.C., including:
  - coliform removal to 4 CFU/100 mL, and
  - assess potential for removal of color and dissolved organic carbon (DOC).

POC Testing

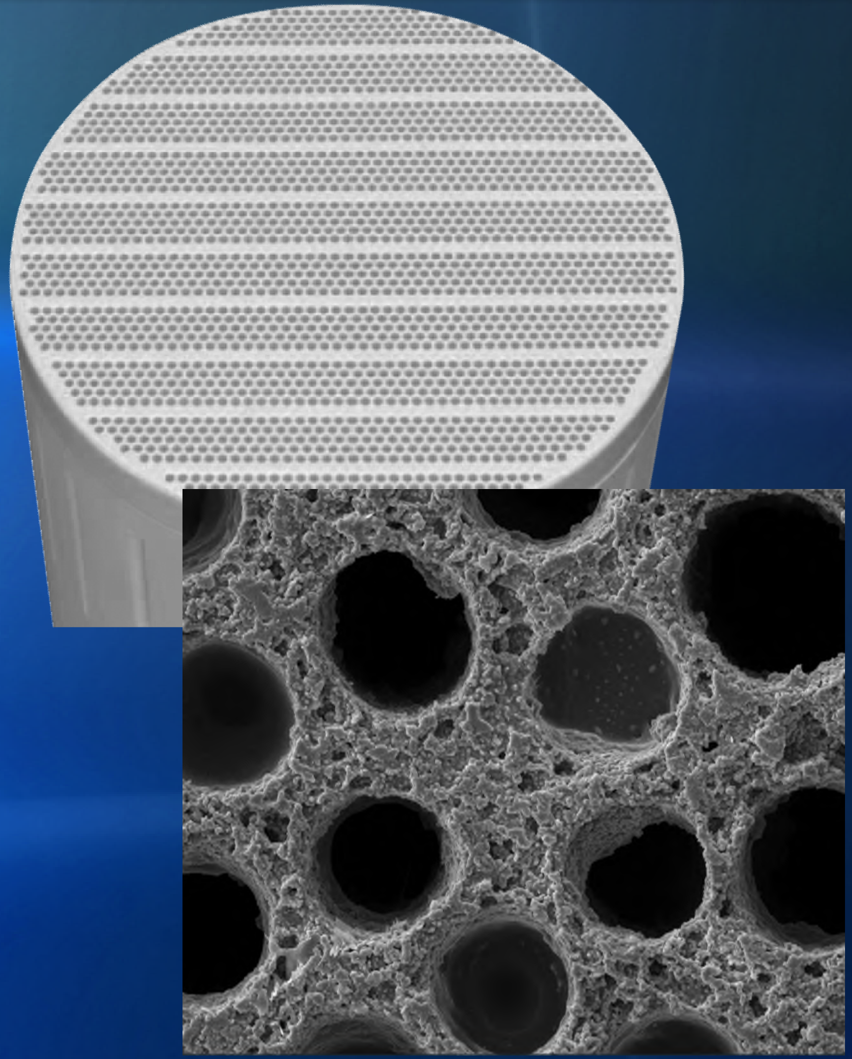
- Test up to two (2) coagulants
- Test membrane filtration including two (2) ceramic and two (2) polymeric membranes
- Test dual-media filtration as pretreatment to UV.
- Evaluate the ability of pressurized UV reactor technology to meet disinfection criteria
- Characterize backwash waste from pilot operation for dewaterability analysis

POC Testing Facility Layout



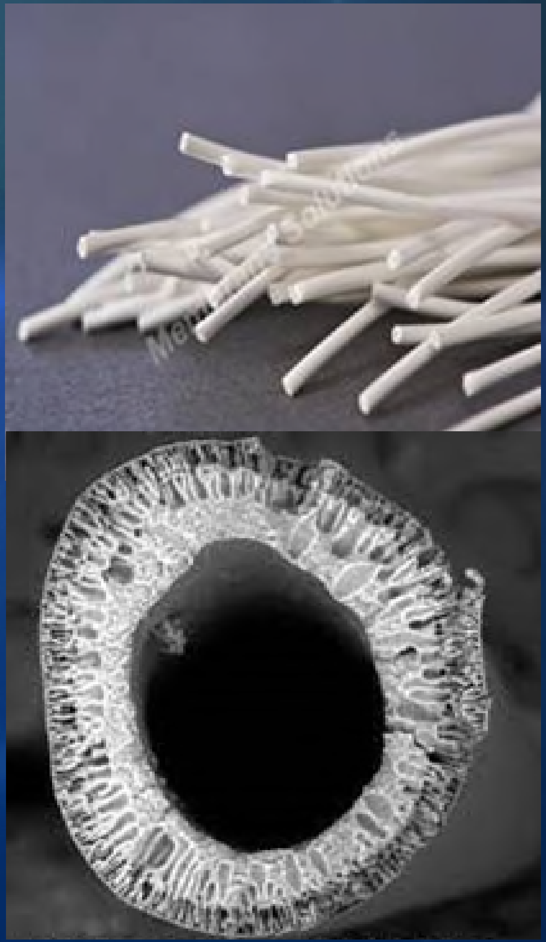
Performance Summary

- **Membranes:**
  - **Microfiltration/ultrafiltration (MF/UF, ALT 2A) removed coliform bacteria by size exclusion and removed significant amounts of color with the aid of a coagulant.**
  - **Ceramic membranes used a greater amount of coagulant than polymeric membranes and would correspondingly produce a greater volume of solids for management.**
  - **However, ceramic membranes demonstrated the ability to reduce color by 93-95% to approximately 7.5-5 PCU. Ceramic membranes would meet secondary drinking water standard for color (15 PCU).**



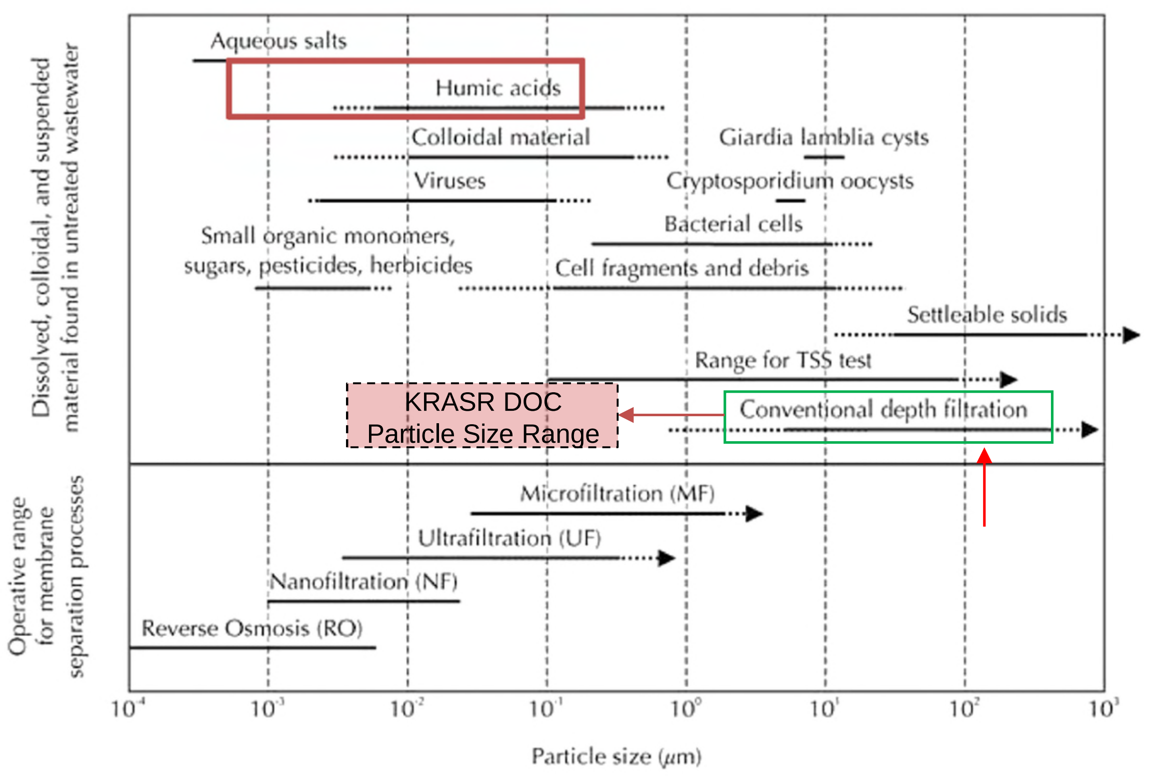
Performance Summary

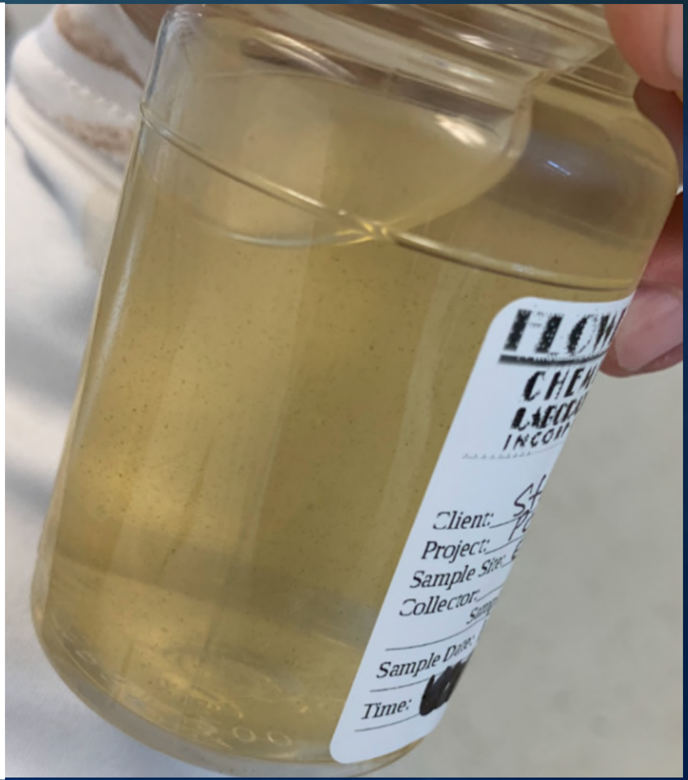
- **Membranes, cont:**
  - Polymeric membranes reduced color by 50-53% to approximately 50 PCU, which <u>would not</u> meet the secondary drinking water standard for color.
- **Media Filtration + UV:**
  - Media filtration prior to UV helps with solids and turbidity reduction but was unable to reduce color to meet secondary drinking water standards and would require a water quality criteria exemption.
  - UV treatment (Alternative 1A/B) does not rely on chemicals for disinfection. However, high color surface water (and coincident low UVT) requires significant doses UV light to remove coliform bacteria.



Performance: Media Filtration

- Media filters did not remove coagulated DOC, Particle sizes 10-100 x smaller than could be captured by sand media.
- Aluminum in media filter effluent was 80% of coagulant dose.
- This represents what would be passed downstream for storage.





Takeaways: Media Filtration + UV

- Media filtration will not remove DOC and would require a Water Quality Criteria Exemption for Color.
- Low filtration rate for media filters translates to a large facility footprint. Backwash ponds require significant land.
- Even at low filtration rate, media filters minimally reduce turbidity/solids, resulting in high UV dose requirement.
- UV can reliably disinfect but requires up to a 30 mJ dose during poor water quality events (as opposed to 21 mJ dosed at KRASR previously)
- Clean water source strongly recommended for backwashing, but utility water may not be available from OUA.

Performance: Ceramic Membranes

NANOSTONE		TRIAL			
	Success Criteria	1	2	3	4
Runtime	>12 days	4.3 (equipment issues)	8.4 (equipment issues)	✓	✓
Fouling	<50% decline in specific flux (30d extrapolation)	N/A	N/A	✓	✓
Treated water turbidity	95th %ile <0.100 NTU	N/A	N/A	✓	✓
Treated water coliform	<4 CFU/100mL	N/A	N/A	✓	✓
CIP recovery	>80% recovery of clean membrane specific flux	N/A	N/A	✓	✓

- After a shaky start, Nanostone's nominal flowrate was not sustainable during Trial 4, though the cause is undetermined (e.g. equipment vs. fouling).

AQUA AEROBIC		TRIAL			
	Success Criteria	1	2	3	4
Runtime	>12 days	10.6 (equipment issues)	✓	✓	✓
Fouling	<50% decline in specific flux (30d extrapolation)	N/A	56% decline (coagulant delivery issues, tubing)	✓	✓
Treated water turbidity	95th %ile <0.100 NTU	N/A	✓	✓	✓
Treated water coliform	Treated water <4 CFU/100mL	N/A	✓	✓	✓
CIP recovery	>80% recovery of clean membrane specific flux	N/A	✓	✓	✓

- Aqua Aerobic had very sustainable operations throughout the POC test, including Trial 4.

Performance: Polymeric Membranes

FILMTEC		TRIAL			
	Success Criteria	1	2	3	4
Runtime	>12 days	10.7 (fouling shutdown, reduced coagulant)	☑	☑	☑
Fouling	<50% decline in specific flux (30d extrapolation)	N/A	100% decline (coagulant dose too high)	94% decline (maintenance chemicals insufficient)	☑
Treated water turbidity	95th %ile <0.100 NTU	N/A	☑	☑	☑
Treated water coliform	Treated water <4 CFU/100mL	N/A	☑	☑	☑
CIP recovery	>80% recovery of clean membrane specific flux	N/A	☑	☑	☑

- FilmTec had **very sustainable operations** during Trial 4, once chemicals were optimized.

SUEZ		TRIAL			
	Success Criteria	1	2	3	4
Runtime	>12 days	☑	6.4 (coagulant pump not delivering)	☑	☑
Fouling	<50% decline in specific flux (30d extrapolation)	N/A (data not recorded)	N/A	☑	☑
Treated water turbidity	95th %ile <0.100 NTU	N/A (data not recorded)	N/A	☑	☑
Treated water coliform	Treated water <4 CFU/100mL	☑	N/A	☑	persistent coliform
CIP recovery	>80% recovery of clean membrane specific flux	N/A (data not recorded)	N/A	☑	☑

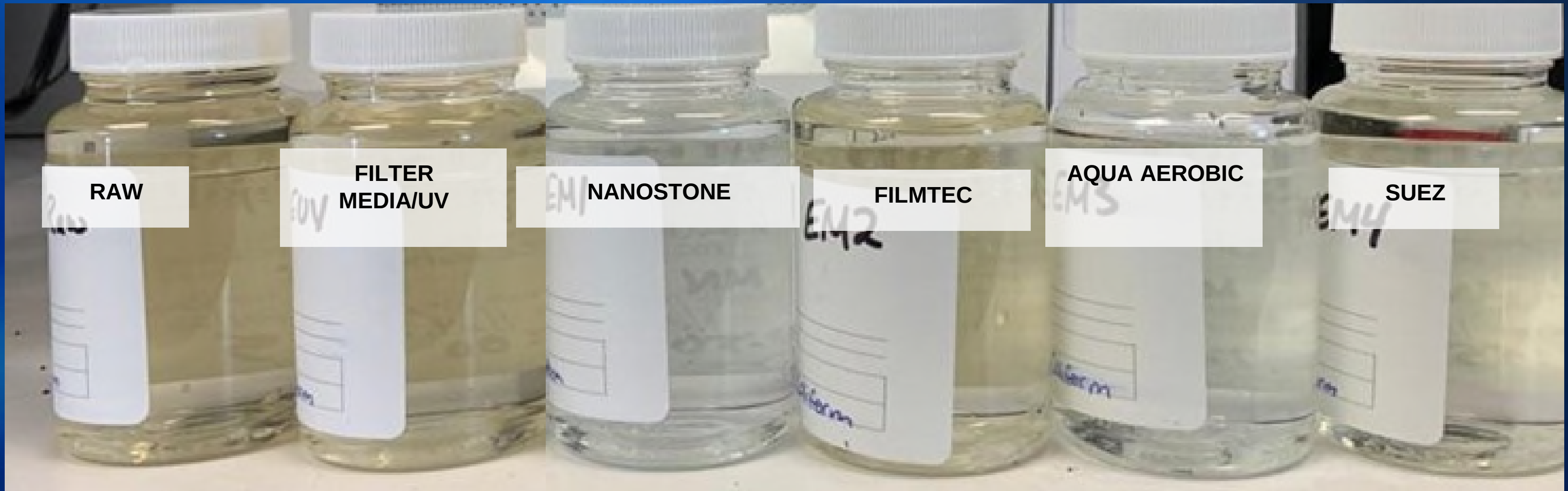
- Suez had **persistent high coliform** throughout Trial 4, despite many attempts to chlorinate the sample tap, membrane housing, piping, etc. Operations were otherwise very steady.

Treated Water Quality By Process

➢Water quality summary

ALT 1A/B ← → ALT 2A

			% REDUCTION				
ANALYTE	UNITS	RAW	MEDIA FILTER / UV	NANOSTONE	FILMTEC	AQUA AEROBIC	SUEZ
Color	PCU	100	4%	95%	53%	93%	50%
DOC	mg/L	18.7	11%	66%	22%	59%	20%
Total Phosphorus	mg/L	0.0705	26%	93%	86%	93%	86%
Total Nitrogen	mg/L	1.25	12%	54%	26%	50%	27%
Aluminum	ug/L	67.5	43%	92%	0%	91%	78%



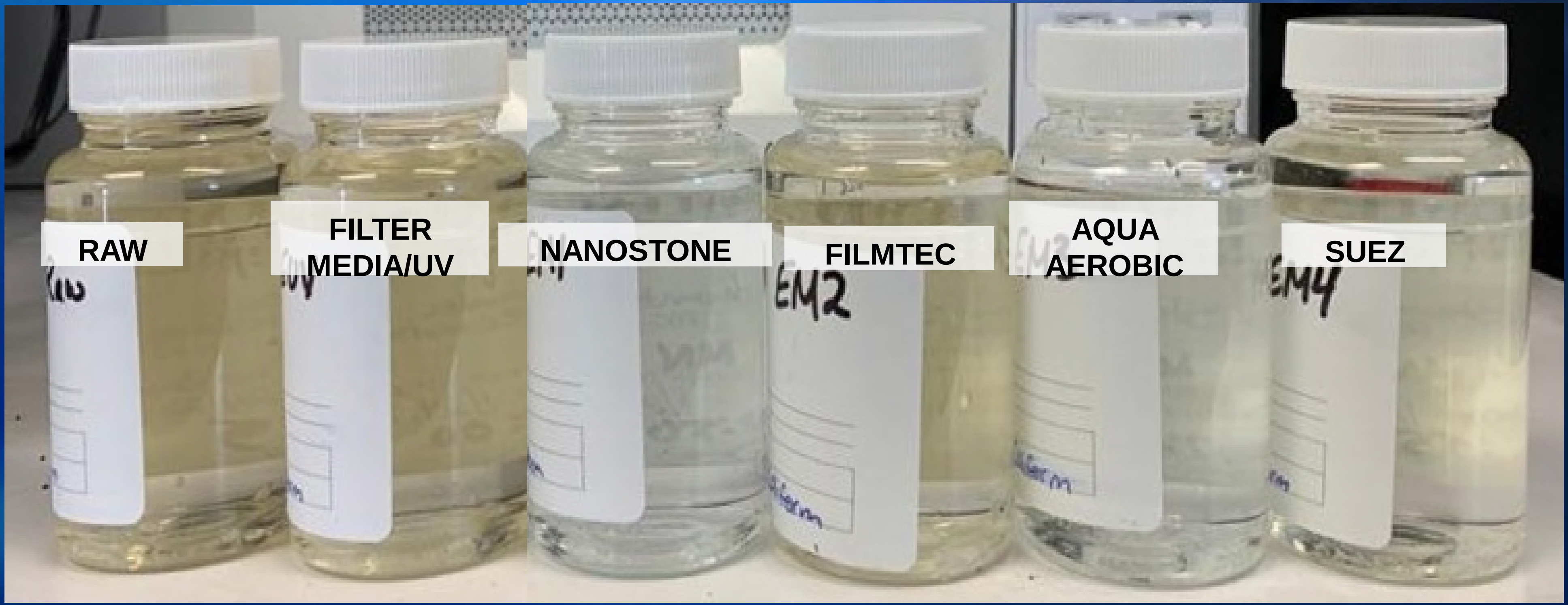
green results indicate favorable treatment (greater removal than red results)

Treated Water Quality By Process

- Primary drinking water standards were met for all treatment trains*

*Disinfection standards were not met for Suez during extended trial #4

- Secondary Standards were met by ceramic membrane manufacturers: Aqua Aerobic & Nanostone



Backwash Solids

- Laboratory analysis quantified the solids remaining in the treated effluent of each treatment process.
- Maximum dry solids production from each process is the sum of: DOC removed, TSS removed, and coagulant added.
- Higher doses of coagulant yield greater solids production

Design Criteria	Alternative 1A/B Granular Media Filtration, UV Vessel	Alternative 2A M1, Nanostone	Alternative 2A M2, Filmtec	Alternative 2A M3, Aqua Aerobic	Alternative 2A M4, Suez	Units
TSS, RAW	6.80	6.80	6.80	6.80	6.80	mg/L
DOC, RAW (median)	18.7	18.7	18.7	18.7	18.7	mg/L
DOC, Effluent (median)	16.6	6.3	14.6	7.8	14.9	mg/L
DOC, Reduction	2.1	12.4	4.2	11.0	3.8	mg/L
Turbidity, RAW	4.50	4.50	4.50	4.50	4.50	NTU
Turbidity, Effluent (95th percentile)	3.50	0.011	0.049	0.018	0.043	NTU
Turbidity, Reduction	1.00	4.49	4.45	4.48	4.46	NTU
TS Reduction	1.50	6.73	6.68	6.72	6.69	mg/L
Coagulant	0.00	73.18	15.71	48.15	8.81	mg/L Solids
Max Dry Solids Production	1.5	92.3	26.5	65.8	19.3	mg/L treated w
	656	38,942	11,090	28,029	8,052	lb/d

green results indicate lower solids removed than red results

Backwash Solids And Aquifer Recharge

- Water from POC testing was NOT used to recharge the aquifer.
- However, the difference between solids in the raw water and solids in the backwash stream gives us the amount of solids in the recharge water.
- Higher solids in recharge water to the Aquifer indicate a higher potential for fouling (or more frequent need for maintenance acidization)

red results indicate greater solids in recharge water than green results

Design Criteria	Alternative 1A/B Granular Media Filtration, UV Vessel	Alternative 2A M1, Nanostone	Alternative 2A M2, Filmtec	Alternative 2A M3, Aqua Aerobic	Alternative 2A M4, Suez	Units
Recharge Water / Well Maint						
Flow	50.0	50.0	50.0	50.6	50.0	mgd
DOC, Effluent (median)	16.6	6.3	14.6	7.8	14.9	mg/L
Turbidity, Effluent (95th percentile)	3.5	0.011	0.049	0.018	0.043	NTU
TS, Effluent	5.3	0.0	0.1	0.0	0.1	mg/L
Total Solids to Aquifer	21.9	6.4	14.6	7.8	15.0	mg/L
	9,117	2,652	6,102	3,245	6,244	lb/d
	1,664	484	1,114	592	1,140	tons/yr

Membrane Backwash (Bw) and Solids

- Membrane solids content and BW settleability was highly variable
  - Polymeric membrane BW did not settle
  - Additional coagulant dosed to BW to thicken solids, based on jar testing
  - Thickened samples sent offsite for laboratory dewaterability analysis

Solids settling after 90 minutes (Left: ceramic Aqua Aerobic, Right: polymeric Suez)

Membrane Backwash and Solids

- Samples were sent to Andritz laboratory for a Centrifuge dewatering evaluation with the following objectives:
  - Analyze the physical properties of the sludge samples received
  - Conduct a polymer evaluation with the sludge sample received
  - Conduct Centrifuge spin-down testing

3.5 Sample Analysis

Lab Number	L-14730	L-14731	L-14732	L-14733
Sample Type	Aqua	Dupont	Suez	Nanostone
Total Solids* (%TS @ 105°C)	1.36	0.23	0.07	0.45
Suspended Solids** (%SS @ 105°C)	1.36	0.23	0.07	0.45

EPA Methods: *1684, **160.2

- 2% solids is the target concentration for centrifuge dewatering

Conclusions: Membrane Filtration

- Coliform was reliably removed without additional disinfection technology.
- Excellent removal of solids and turbidity results in greater solids content in backwash.
- Operations are sensitive to coagulant dose
- Parameters vary significantly by vendor:
  - Membrane life
  - Chemical use
  - Settleability and dewaterability of backwash waste

NON-ECONOMIC EVALUATION

How do treatment technologies compare?

sfwmd.gov

Presenter: Heath Wintz

Facility Footprint

PROCESS/AREA DESCRIPTION	ALT 1A/B Granular Media Filtration, UV Vessel	ALT 2A M1, Nanostone	ALT 2A M2, Filmtec	ALT 2A M3, Aqua Aerobic	ALT 2A M4, Suez
Raw Water Pump Station	3,400	3,400	3,400	3,400	3,400
Hydroburst Mechanical Room	500	500	500	500	500
Strainers & Access Way for Pumps	3,000	3,400	3,400	3,400	3,400
Pressure Media Filters	26,000	N/A	N/A	N/A	N/A
UV Disinfection	8,500				
MF/UF membrane	N/A	54,000	20,000	37,000	40,000
Ground Storage Tank	8,100	N/A	N/A	N/A	N/A
Floc/Sedimentation Basin	N/A	2,600	N/A	N/A	4,500
2nd Stage Membranes	N/A	N/A	7,400	9,700	N/A
Settling Pond or Gravity Thickening	12,200	10,052	N/A	N/A	7,297
Sludge Holding Tank	N/A	5,655	4,000	5,600	3,927
Solids Dewatering	N/A	2,023	1,550	1,550	1,550
Polymer	N/A	1,350	1,489	1,205	1,350
Coagulation	N/A	1,549	990	1,600	1,067
Hypochlorite	N/A	1,063	215	1,174	461
Sulfuric Acid	N/A	N/A	373	1,180	N/A
Hydrochloric Acid	N/A	879	N/A	N/A	357
Citric Acid	N/A	N/A	373	500	369
Sodium Hydroxide (Caustic)	N/A	360	360	360	248
Sodium Metabisulfite (SMBS)	N/A	-	-	-	-
Process Area Subtotal	69,700	86,800	44,100	67,200	68,400
Overall Site Total	195,000	200,000	150,000	165,000	175,000
Total Area, Ac	4.5	4.6	3.4	3.8	4.0

Non-Economic Scoring

- Weighting of categories based on previous study
- Organics removal, operational considerations and reliability carried greatest weighting

Non-Economic Criteria	Weighting	ALT 1A/B Granular Media Filtration, UV Vessel	ALT 2A M1, Nanostone	ALT 2A M2, Filmtec	ALT 2A M3, Aqua Aerobic	ALT 2A M4, Suez
Color/Organics Removal	15	0	15	6	15	6
Waste Disposal	5	5	2	0	2	3
Operational Considerations	25	20	16	15	18	15
Staffing Requirements	5	5	3	3	3	3
Minimal Risk for Aquifer Plugging	10	0	10	4	10	4
Process Reliability	20	6	14	15	16	12
Environmental, Health and Safety	10	10	8	5	7	5
Constructability	10	9	5	7	8	5
Footprint	10	6	6	8	7	7
Subtotal	110	**61**	**79**	**63**	**86**	**60**

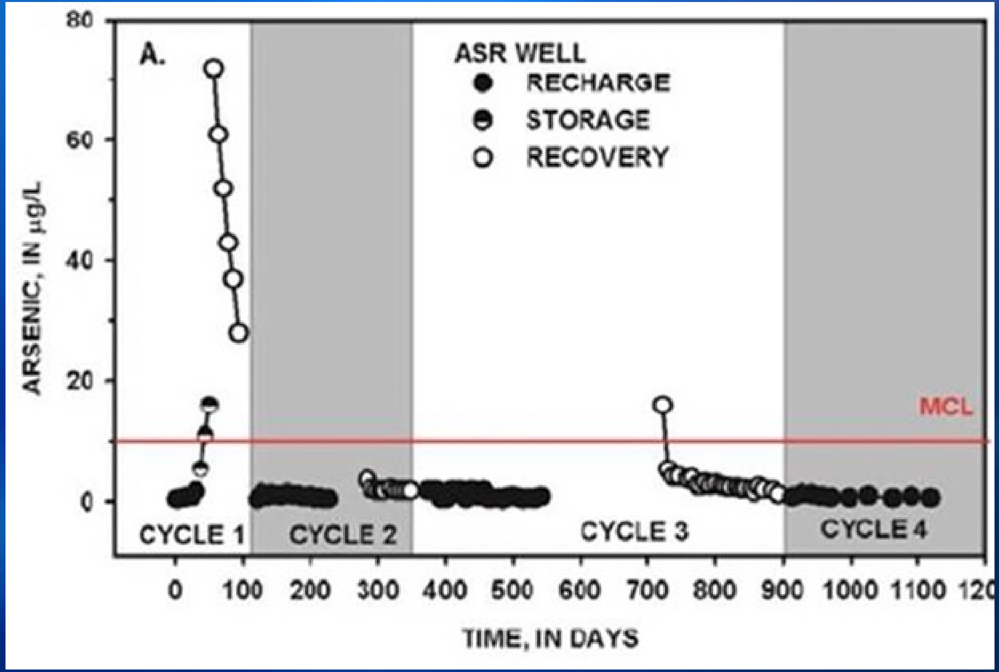
RECOVERED WATER CONSIDERATIONS

How do we handle potential arsenic issues during recovery?

Presenter: Heath Wintz

Recovered Water Considerations

- During cycle testing at KRASR, Arsenic was present in recovered water. Arsenic was 7x the MCL during cycle 1.
- Based on data from the 2013 CERP report, this situation appears to be short-term (commissioning) in nature rather than long-term.
- Characteristics of POC treated water (conductivity, ORP) are similar to that of Kissimmee River surface water, and similar to that used for KRASR testing.



2013 CERP ASR Final Tech Data Report

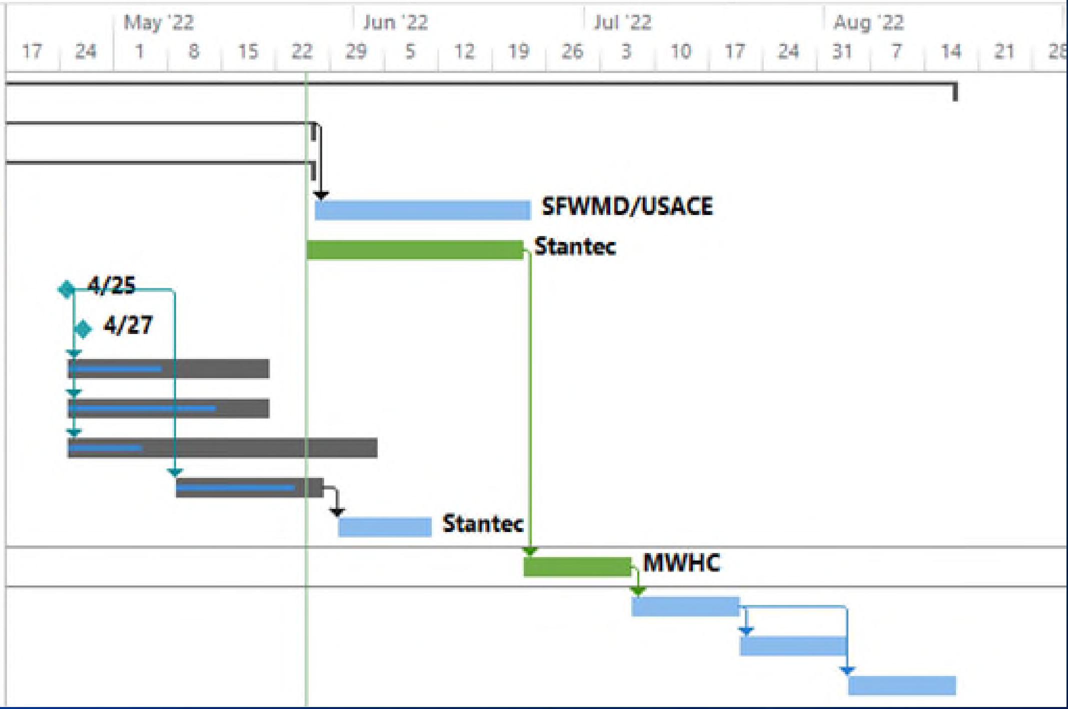
Recovered Water Considerations

- During previous KRASR testing, a "first flush" of recovered water was directed to a retention pond.
- For full-scale facilities, allocating large areas of land for retention ponds to address a short-term issue does not appear productive.
  - A regulatory approach to addressing Arsenic in recovered water could involve establishing a mixing zone, and could be discussed further with FDEP.
- However, if there is a desire to treat and remove Arsenic during cycle testing, membranes could be used to accomplish this.
  - With piping and sodium hypochlorite, recovered water could be oxidized from Arsenite (III) to Arsenate (V), precipitated, coagulated and removed using micro or ultrafiltration membranes

Schedule – Poc Testing Report

- SFWMD & USACE review draft report: 5/27/22 - 6/21/22
- Conceptual Discipline Design: 4/27/22 – 6/23/22,
- Final report: 7/20/22   TRB mid-August.

Ta M	Task Name	Durati	Start	Finish	Predecess	Resource Names
	2.4 POC Testing Report (WO12R2)	140 days	Thu 2/3/22	Wed 8/17/22		
	+2.4.1 Draft POC Testing Report	81 days	Thu 2/3/22	Thu 5/26/22		
	Completed	81 days	Thu 2/3/22	Thu 5/26/22		
	+2.4.2 SFWMD +USACE Review of POC Report	4 wks	Fri 5/27/22	Thu 6/23/22	276	SFWMD/
	Conceptual Discipline Design (CDD) for Potential (Pref) Alt	1 mon	Thu 5/26/22	Wed 6/22/22		Stantec
	Early Start	0 days	Mon 4/25/22	Mon 4/25/22		
	MCASES discussion (USACE, District, Stantec)	0 days	Wed 4/27/22	Wed 4/27/22		
	I&C	4 wks	Mon 4/25/22	Fri 5/20/22	298	
	Process Mech	4 wks	Mon 4/25/22	Fri 5/20/22	298	
	Civil	6 wks	Mon 4/25/22	Fri 6/3/22	298	
	Electrical	3 wks	Mon 5/9/22	Fri 5/27/22	298FS+2 wk	
	QA/QC	2 wks	Mon 5/30/22	Fri 6/10/22	303	Stantec
	Detailed MCASES Cost Estimation	2 wks	Thu 6/23/22	Wed 7/6/22	297	MWHC
	2.4.3 Final POC Testing Report	2 wks	Thu 7/7/22	Wed 7/20/22	305	
	2.4.5 District Stakeholder Meetings	2 wks	Thu 7/21/22	Wed 8/3/22	306	
	2.4.4 TRB	2 wks	Thu 8/4/22	Wed 8/17/22	306FS+2 wk	



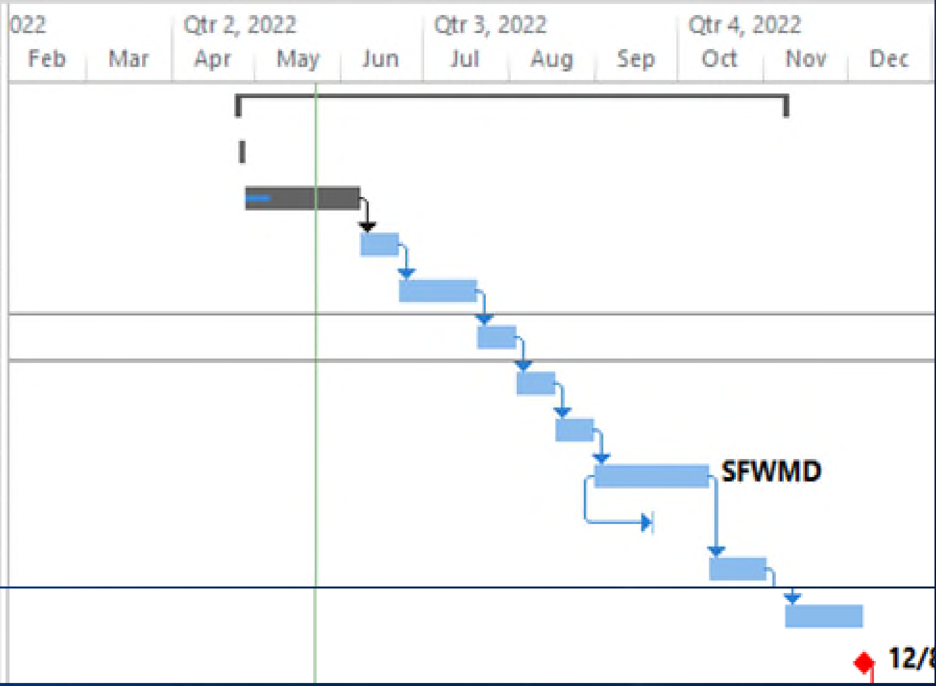
Next Steps

- Develop conceptual design drawings based on an apparent preferred technology.
- Develop MCASES detailed cost estimate for USACE
- Final Proof-of-Concept report / TRB
- Treatment technology procurement / pre-selection
- Facility pre-design (survey, geotech investigation)
- Design overall facility around pre-selected technology

Next Steps - Technology Procurement

- Equipment Preselection RFP package
- Competitive Solicitation
- Evaluation

Task Name	Duration	Start	Finish	Predecessors	Resource Names
Membrane EQPS Bid Package	**142 days**	**Mon 4/25/22**	**Tue 11/8/22**		
2.6.1 Procurement Review Workshops	2 days	Mon 4/25/22	Tue 4/26/22		
2.6.2 Draft Membrane EQPS Proposal package	6 wks	Wed 4/27/22	Tue 6/7/22		
QA/QC	2 wks	Wed 6/8/22	Tue 6/21/22	314	
2.6.3 SFWMD +USACE Review of EQPS proposal	4 wks	Wed 6/22/22	Tue 7/19/22	315	
2.6.4 Final Membrane EQPS RFP package	2 wks	Wed 7/20/22	Tue 8/2/22	316	
QA/QC	2 wks	Wed 8/3/22	Tue 8/16/22	317	
District procurement processing to advertise	2 wks	Wed 8/17/22	Tue 8/30/22	318	
Advertisement of RFP	6 wks	Wed 8/31/22	Tue 10/11/22	319	SFWMD
2.4.13 Response to RAIs & Addenda	1 day?	Wed 9/21/22	Wed 9/21/22	320SS+3 wk	
2.4.14 Evaluation & Recommendaton of Award	3 wks	Wed 10/12/22	Tue 11/1/22	320	
District develop & submit Gov Board Agenda Item	4 wks	Wed 11/9/22	Tue 12/6/22	323	
Gov Board Approval	0 days	Thu 12/8/22	Thu 12/8/22		SFWMD



Panel Discussion (5 min.)

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

FORMATION ENVIRONMENTAL

intertek psi

Aquifer Storage and Recovery (ASR) Quantitative Ecological Risk Assessment

Presenter: Joe Allen

Senior Wildlife Biologist /Risk Assessor

Formation Environmental LLC

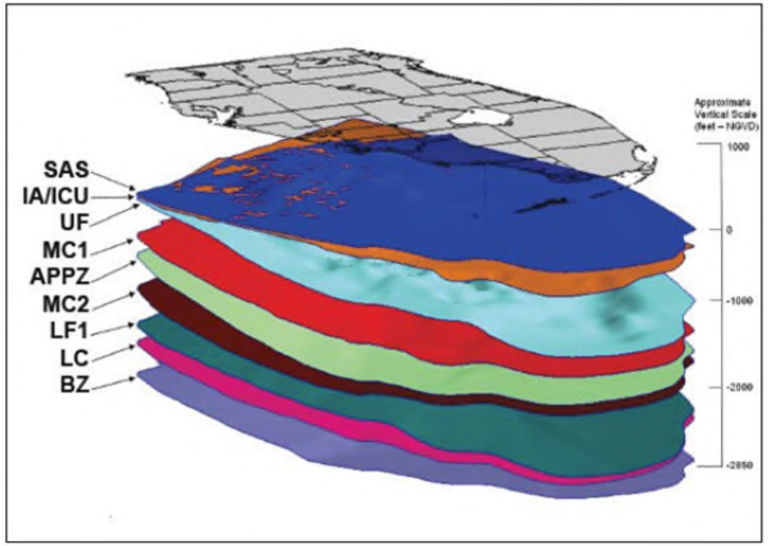
sfwmd.gov

ASR Ecological Risk Assessment History

- Original ERA completed in 2015 as part of the ASR Regional Study
- Utilized data from 2 ASR Pilot Facilities
  - Kissimmee River ASR (KRASR)
  - Hillsborough ASR (HASR)

CENTRAL AND SOUTHERN FLORIDA PROJECT

COMPREHENSIVE EVERGLADES RESTORATION PLAN



FINAL TECHNICAL DATA REPORT

AQUIFER STORAGE AND RECOVERY REGIONAL STUDY

MAY 2015

CENTRAL & SOUTHERN FLORIDA PROJECT

COMPREHENSIVE EVERGLADES RESTORATION PLAN

Regional Ecological Risk Assessment of CERP Aquifer Storage and Recovery Implementation in South Florida

U.S. Army Corps of Engineers
Jacksonville District

South Florida Water
Management District

ASR Ecological Risk Assessment History

ASR ERA Conclusions

- Low likelihood of risk to Lake Okeechobee and the Everglades
  - Highest - Larval fish due to impingement/entrainment
  - Low – Hg methylation
  - Limited toxicity
  - Minimal bioconcentration
- ASR systems should be constructed where sufficient dilution can occur

Photograph 3.1. Kissimmee River ASR Pilot Facility.

Photograph 3.2. Hillsboro ASR Pilot Facility.

ASR Ecological Risk Assessment History

- Comments received from NRC and PRP
  - Look at longer storage times and larger recovery volumes.
  - Toxicity testing with adjustments to water parameters.
  - Look at effects of hardness adjustments.
  - Additional *in situ* bioaccumulation studies.
  - More quantitative risk assessment.

Review of the Everglades Aquifer Storage and Recovery Regional Study

Committee to Review the Florida Aquifer Storage and Recovery Regional Study Technical Data Report

Water Science and Technology Board

Division on Earth and Life Studies

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Washington, D.C.
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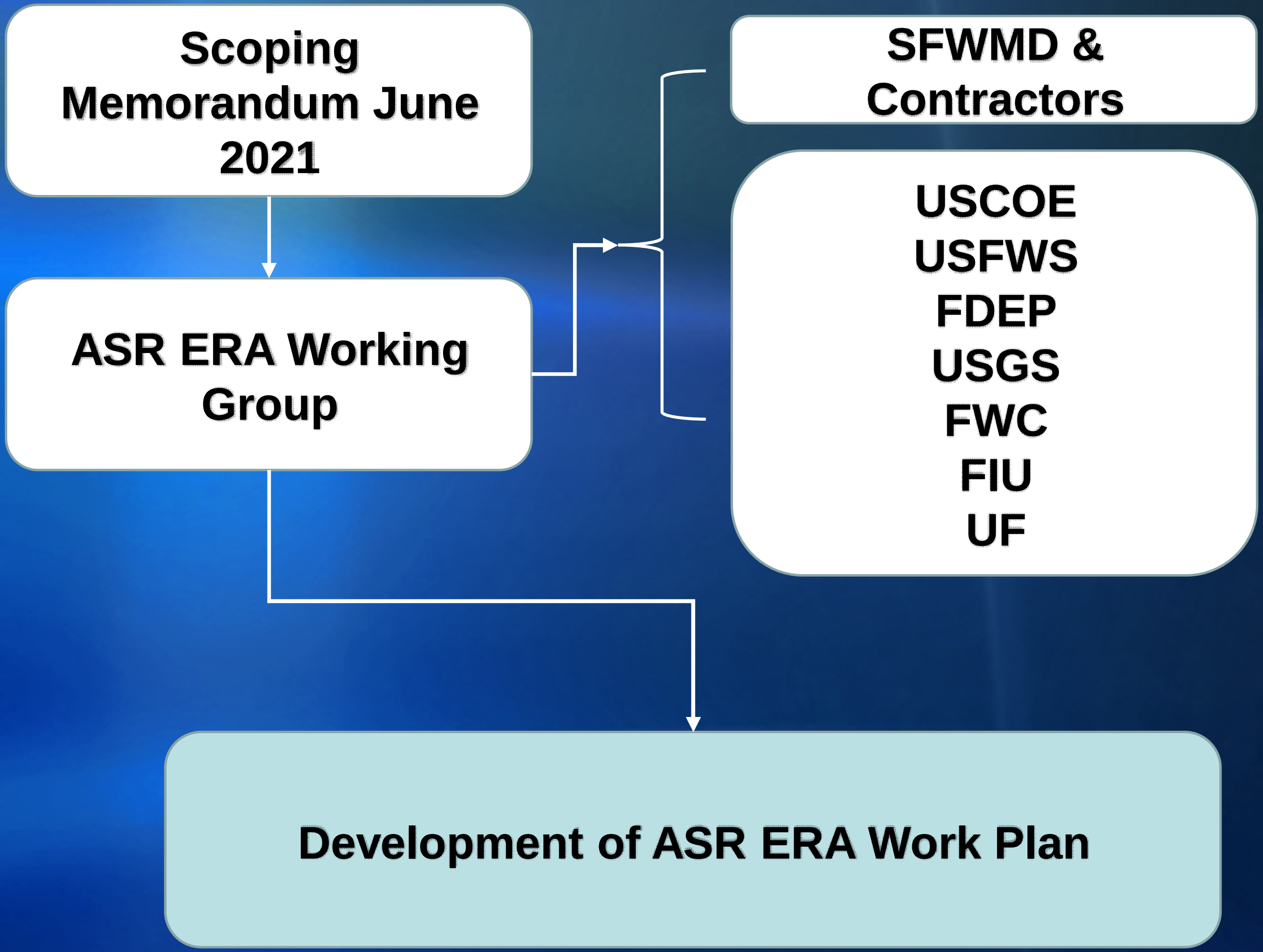
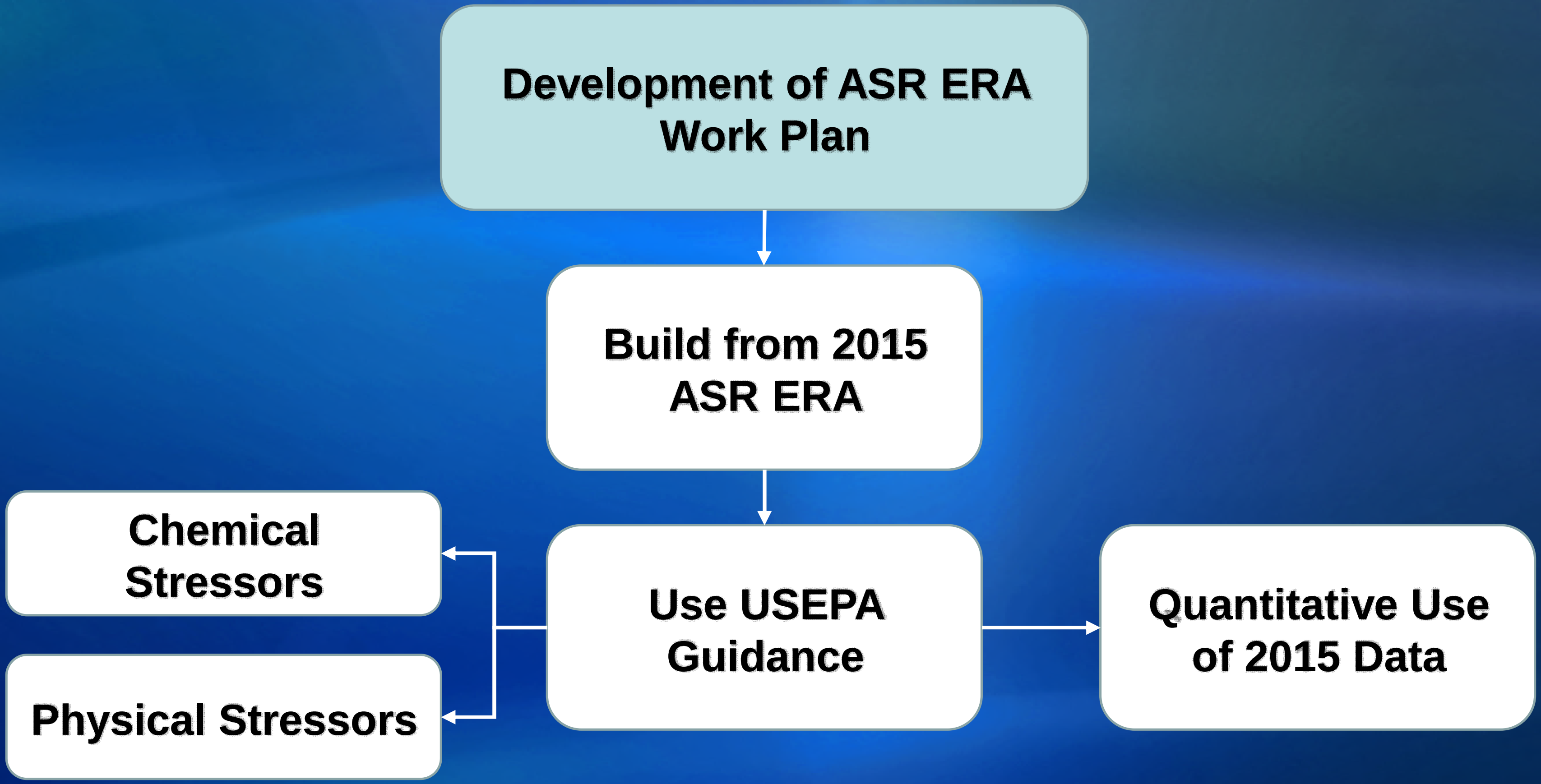
ASR Ecological Risk Assessment Path Forward

- Public process with multiple stakeholders
  - Many different approaches for analyses and data needs
  - Responsive to stakeholders, but as efficient and cost-effective as possible
  - Utilize comments from NRC and PRP



ASR Ecological Risk Assessment Path Forward



ASR Ecological Risk Assessment Path Forward

- Risk-Based Analysis of Historical ASR ERA Data
  - Quantitative Analysis of 2015 Data
    - Bioconcentration.
      - Aquatic-Feeding Wildlife
      - Fish and Mussels
    - Causal Analysis of Toxicity Testing

Ecological Risk-Based Analysis of Historical Bioconcentration and Toxicity Data for the Aquifer Storage and Recovery Quantitative Ecological Risk Assessment

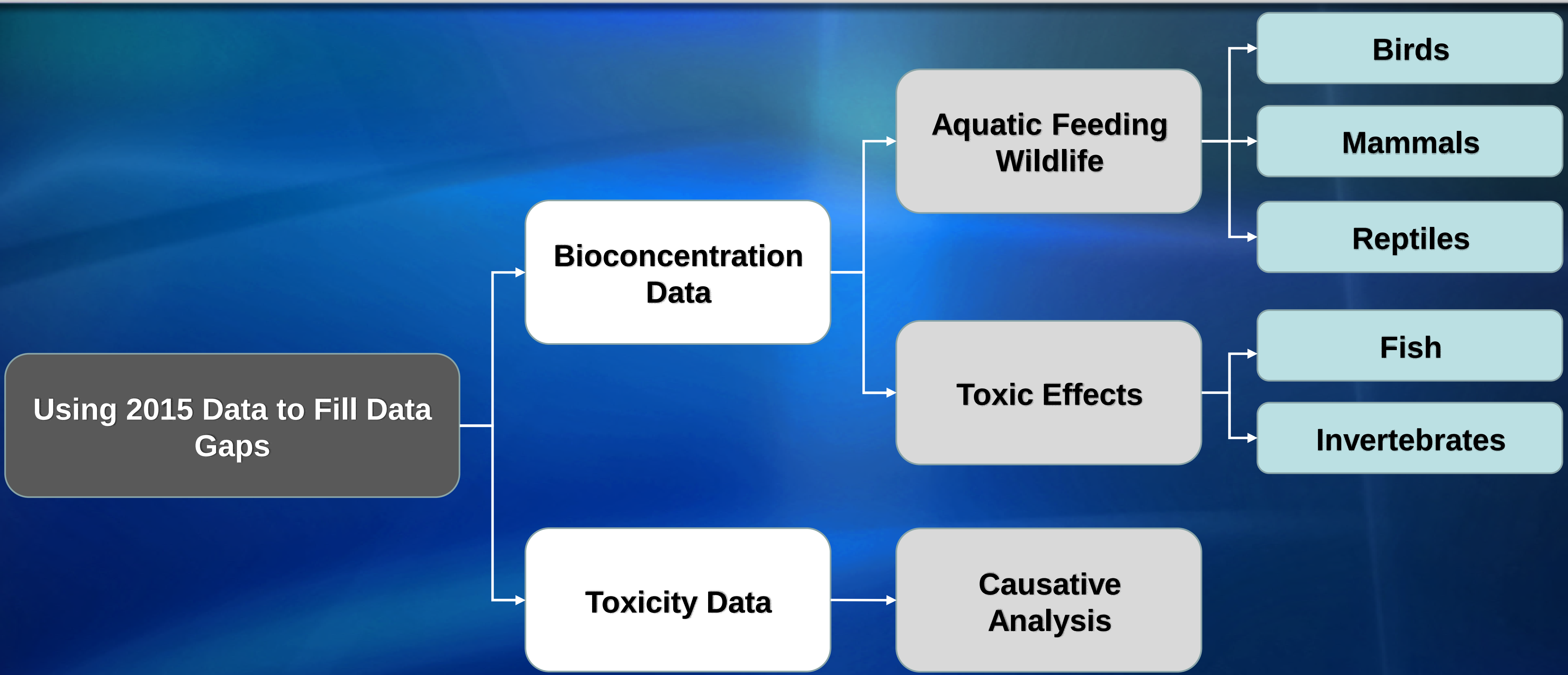
Prepared for:
South Florida Water Management District
P.O. Box 24682
West Palm Beach, Florida 33416

Prepared by:
Formation Environmental, LLC
2500 55th Street, Suite 200
Boulder, CO 80301

FORMATION ENVIRONMENTAL

DECEMBER 2021

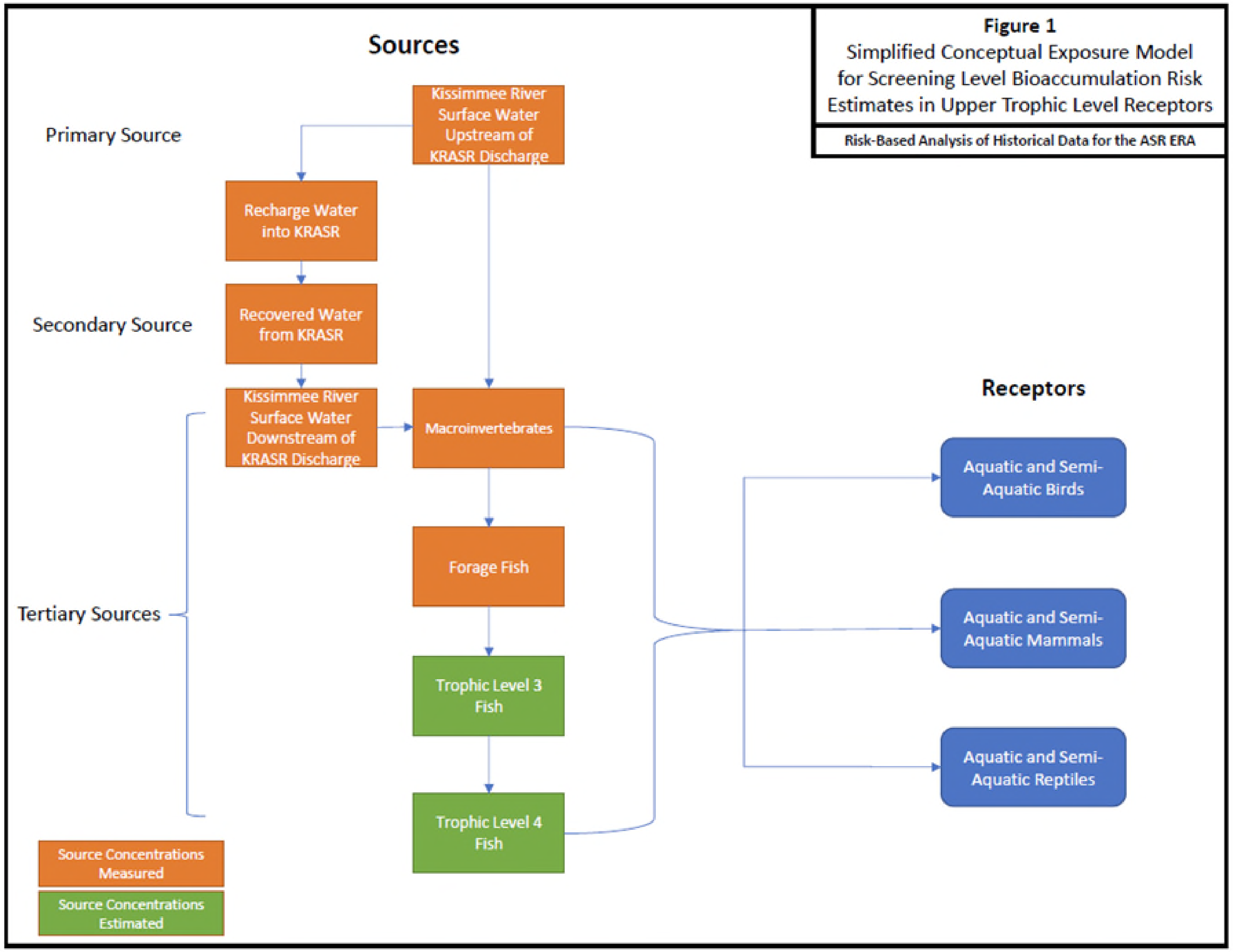
ASR Ecological Risk Assessment Path Forward



Historical Data Analysis

- Utilized available tissue data.
  - Conservative estimate of risk to birds, mammals, and reptiles feeding downstream of the ASR discharge.

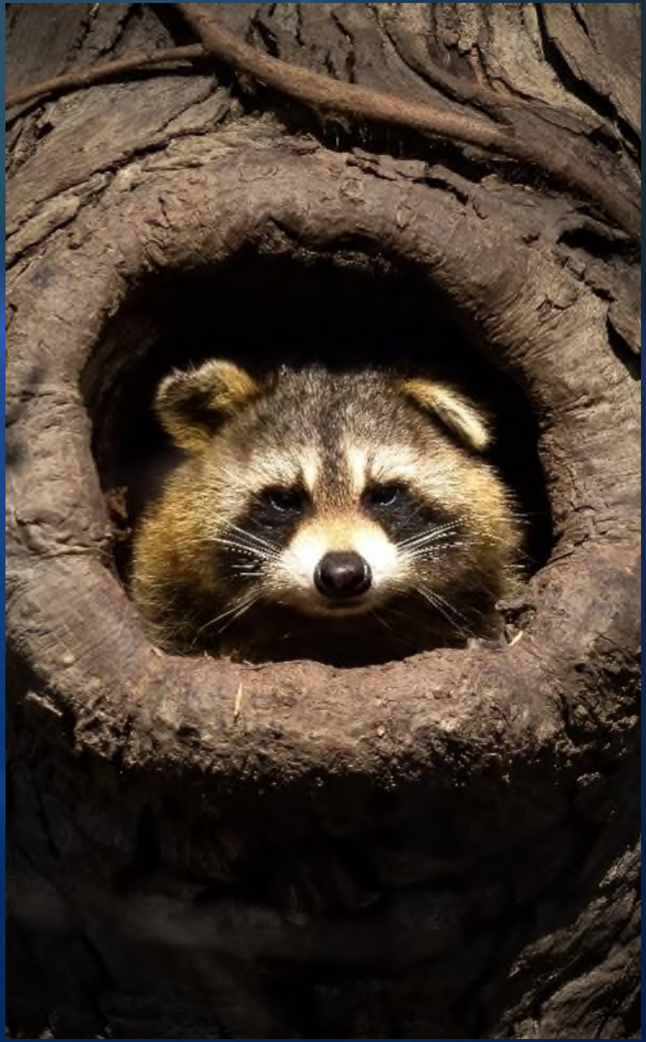
$$Exposure_{Total} = (SUF) * \frac{[(C_{water} * IR_{water}) + \sum(C_{prey} * IR_{prey})]}{BW}$$



Historical Data Analysis

- **Aquatic-Dependent Wildlife**
  - 10 bird species
  - 2 mammals
  - 1 reptiles
- **Screening-Level**
  - Maximum concentrations
  - No effect toxicity reference values used.
  - Radiological exposure screened using USDOE Level 1 Biota Concentration Guidelines

$$\mathrm{HQ} = Exposure_{total}/\mathrm{TRV}$$

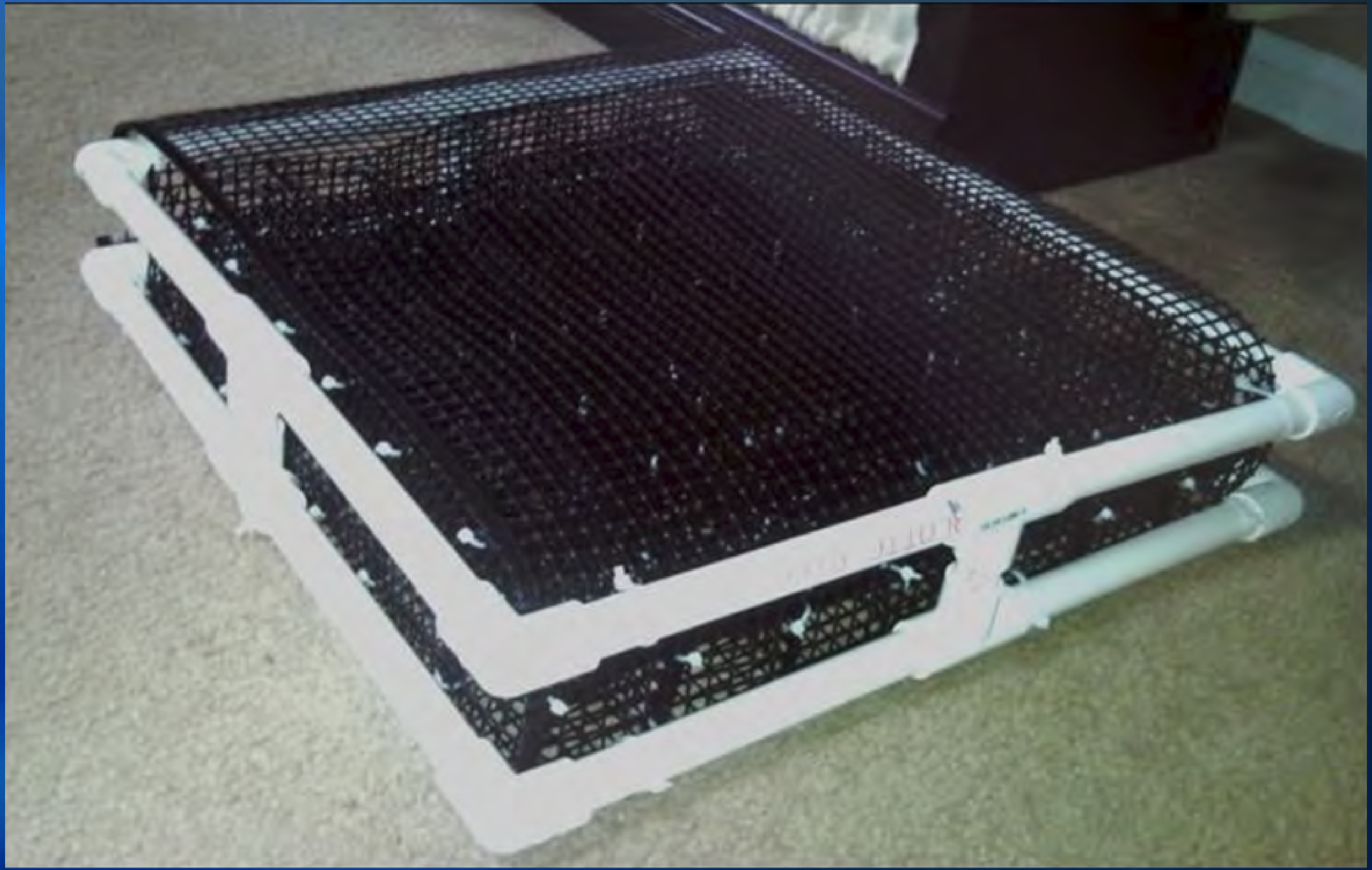


Historical Data Analysis

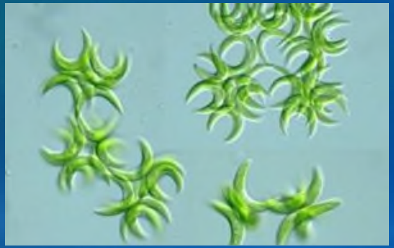
- No HQs > 1.
  - Likelihood of risk very low
  - Ra-226 and Ra-228 < Level 1 BCGs
  - Focus Wildlife ERA on bioaccumulative metals.

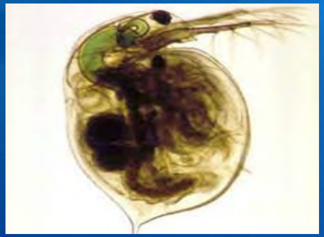
Historical Data Analysis

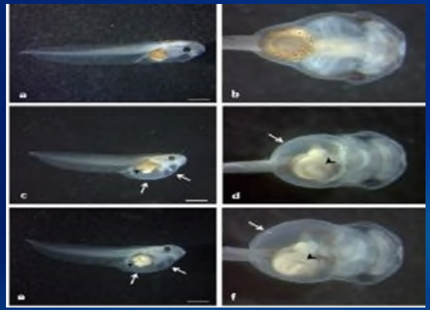
- Risk to Fish/Mussels Assessed
  - Max concentrations and no effect TRVs
  - Risks to fish *de minimis*.
  - Several metals had HQs > 1 for mussels.
    - Aluminum (upstream and downstream)
    - Manganese (all samples exceeded)
    - Molybdenum (upstream and downstream)
- Very low potential for risk to mussels and fish.
  - Should continue to be monitored in future studies.



Historical Data Analysis





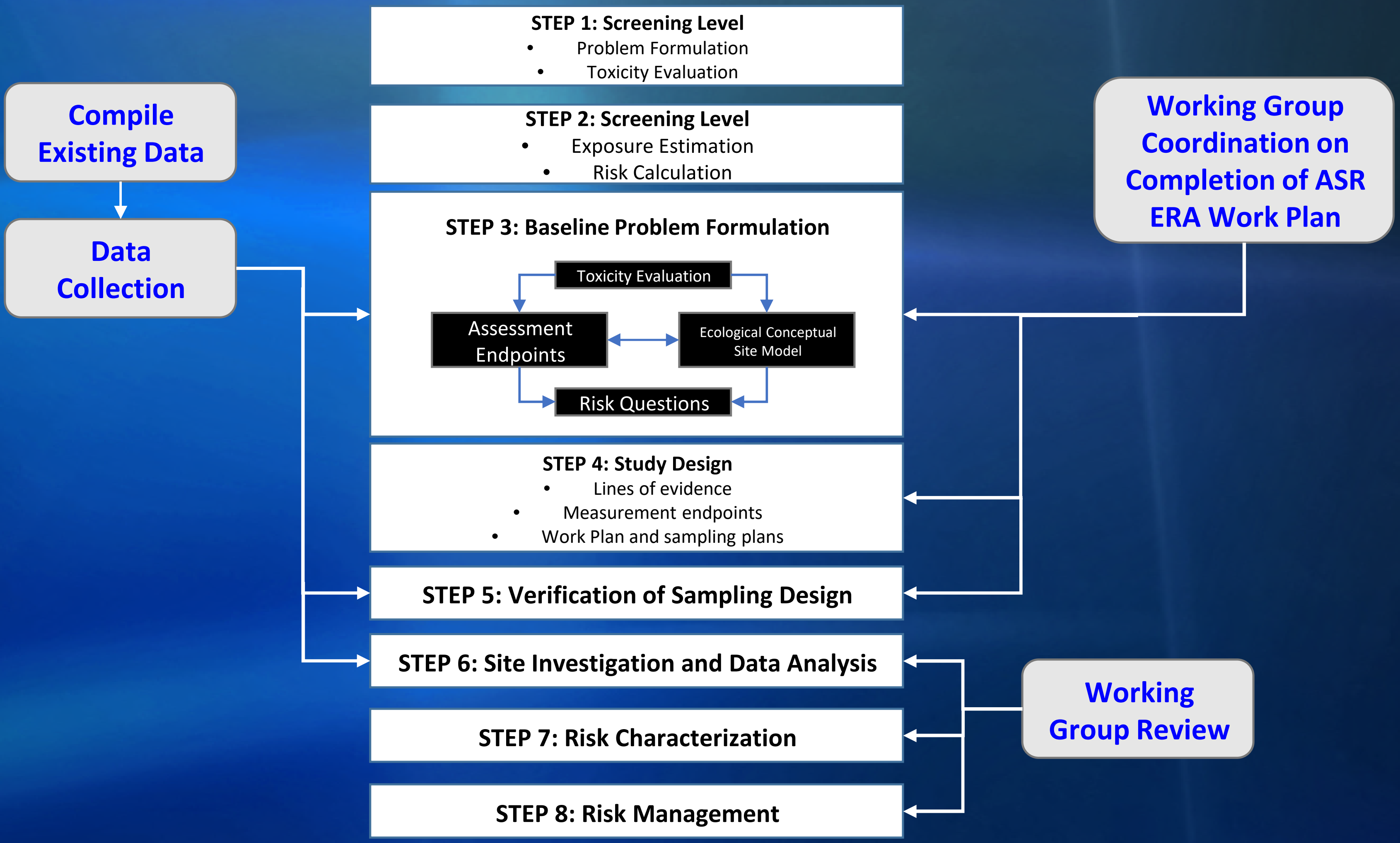



Causal Analysis of Toxicity Test Results

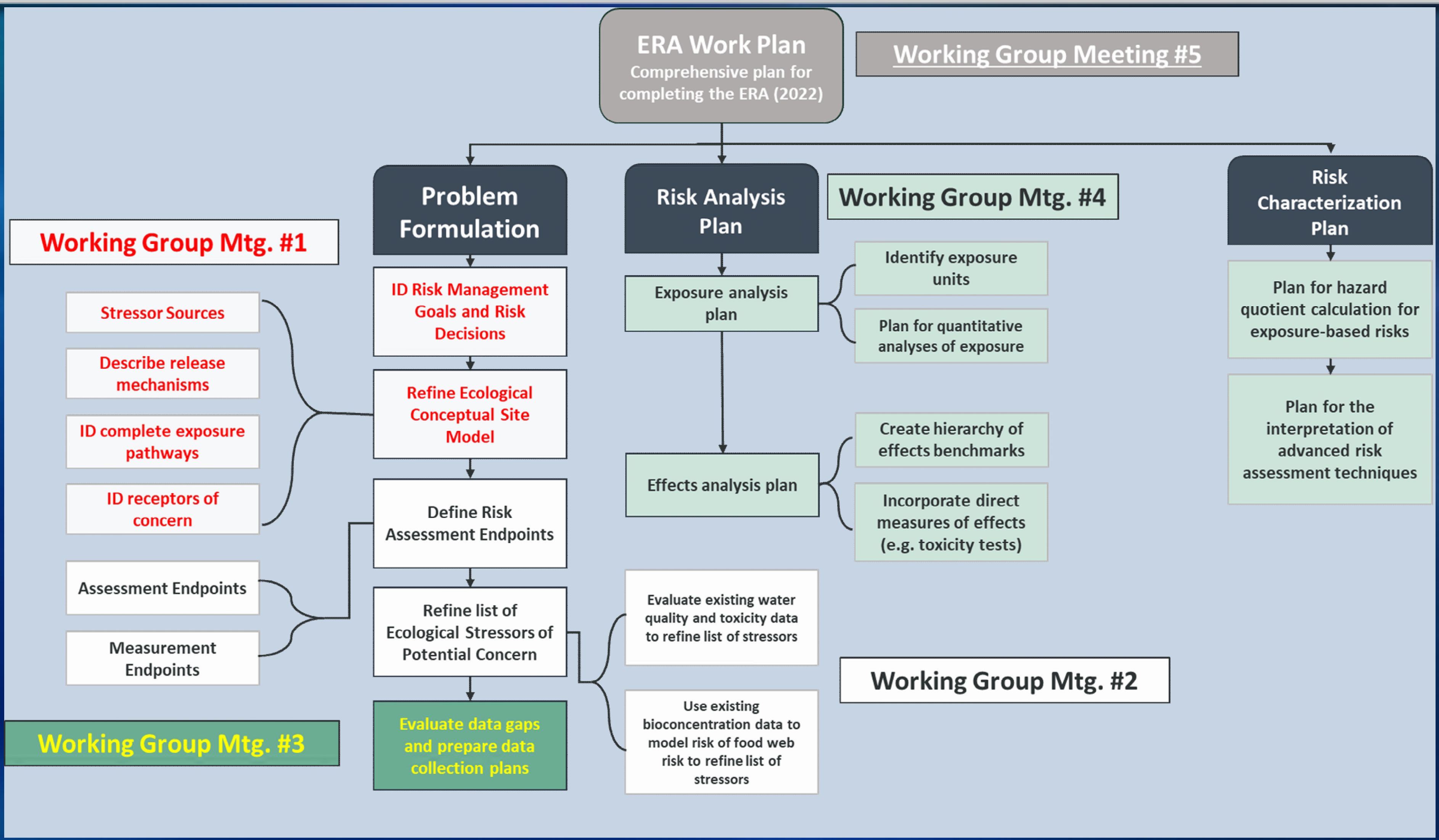
- 2015 ASR ERA only presented results of tests.
- Water collected at each location on date of toxicity test sample.
- Compare to water quality benchmarks (WQB) and toxicity test results.
  - Limited overlap of toxicity in sample and exceedance of WQB (4 of 80 tests).
  - Data did not support toxicity based on water quality parameters alone.
  - Recommend paired water analyses and toxicity tests for new data.

2022 ASR ERA Tasks

- **Development of a comprehensive ERA Work Plan**
  - Reassemble the Working Group
  - Step-wise process to build the Work Plan with input from stakeholders.
  - Incorporate 2021 analyses.
  - Currently beginning the problem formulation step.

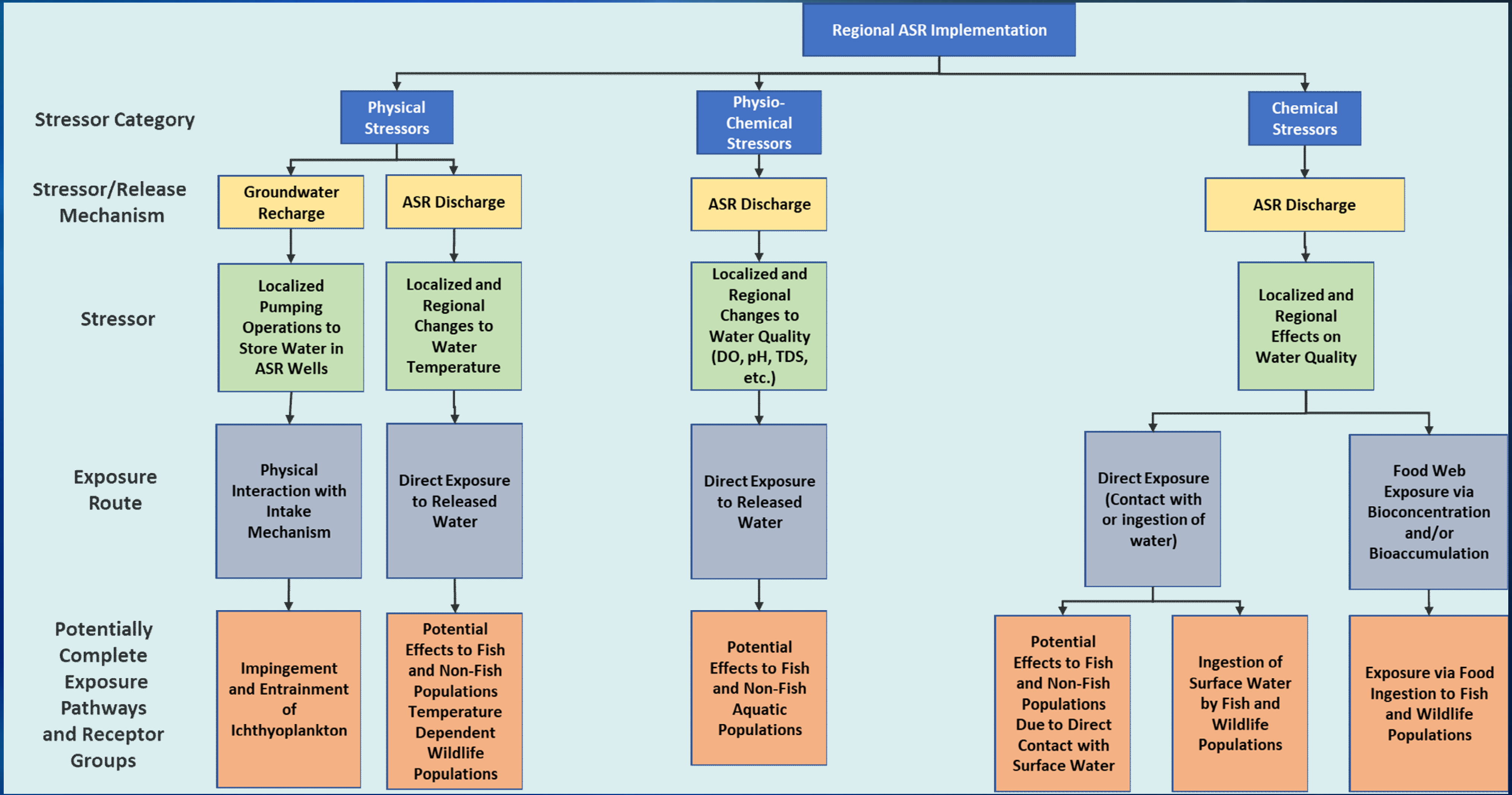


2022 ASR ERA Tasks – Work Plan Development



2022 ASR ERA Tasks – Work Plan Development

- Updated Ecological Conceptual Site Model
  - Stressors
    - Chemical
    - Physical
    - Physio-chemical.
  - Exposure pathways
  - Generic receptor groups (will be finalized in meeting #2)



2022 ASR ERA Tasks – Work Plan Development

➢Goals of the ASR ERA Work Plan

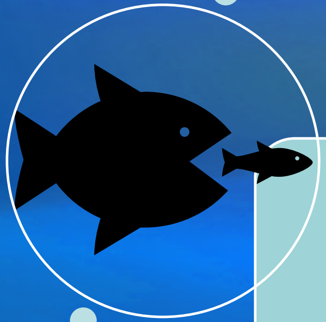
- Expand/Improve ERA
- Incorporate comments on 2015 ERA
- Consensus from Working Group
- Regional applicability
  - First ASR Well Cluster (C-38)
    - Vicinity of the discharge point
    - Potential risks also assessed regionally
  - Results should be scalable to future ASR Well Clusters
    - Similar Conditions/Similar Risk
    - Focus on unique attributes (if any) at future sites

Panel Discussion (5 min.)

ASR ERA –Pre-Operational Studies and Mobile Laboratory

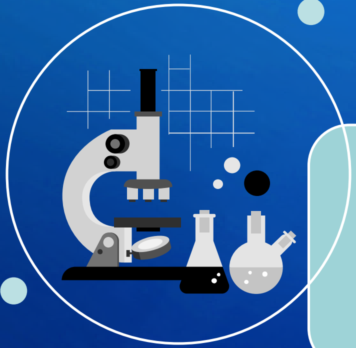
Presenter: Jennifer Mathia
Senior Biologist
Environmental Consulting and Technology, Inc.

2022 to 2024



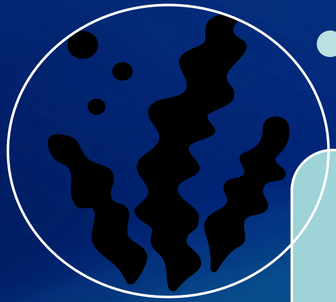
2024

>Mesocosm Studies



2023

>Pre-operational Studies
>Toxicity Studies
>Bioconcentration Studies



2022

>Pre-operational Studies
>Mobile Lab Construction
>ERA Work Plan Development

Pre-Operational Studies

- QA/QC
- General Data Collection
- Survey Areas
- Survey Initiation and Timing
- Water Quality
- Periphyton
- Submerged Aquatic Vegetation
- Benthic Macroinvertebrates
- Sediments
- Apple Snails
- Mussels
- Fish and Ichthyoplankton

Pre-Operational Studies

- QA/QC
  - Survey Specific Work Plans
  - Follow Programmatic Quality Assurance Plan (PQAP)
  - FDEP SOP or SFWMD specific, where appropriate

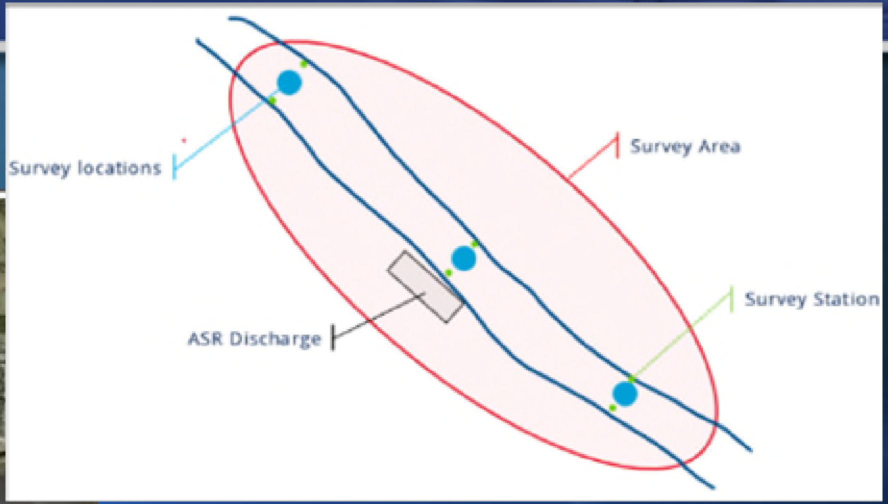
Pre-Operational Studies

General Data Collection

- Data will be collected to support the surveys and provide back up for peer review
  - Data logs
  - Field notebooks
  - SOPs
  - Methods
  - Data Forms
  - Calibration logs (YSI Pro DSS, Hach Chlorine Test kit CN-70)
- Each collection will include record of:
  - In-situ water quality
  - Temperature (air and water)
  - Weather (wind direction, wind speed, cloud cover, precipitation)
- Scientific Collector's Permit

Pre-Operational Studies

➢Monitoring Sites



Pre-Operational Studies

- Schedule
  - Semi-annual minimum frequency
  - Focused sampling during peak growing season/spawning season

Table 4. Proposed sampling frequencies for 2022-2023 sampling period.

	July	August	September	October	November	December	January	February	March	April	May	June
Water quality (grab sample analysis per Appendix A)												
Periphyton												
SAV												
Benthic Macros												
Sediment												
Apple Snails												
Mussels												
Fish Population												
Fish tissue												
Ichthyoplankton												

Pre-Operational Studies

➢Water Quality

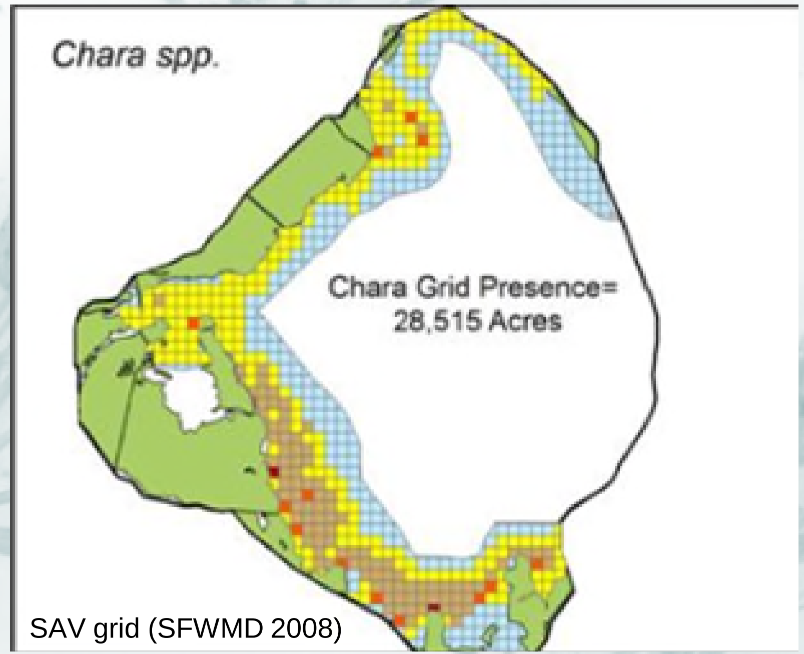
- SFWMD current water quality program is extensive
- No separate water quality study for ASR ERA proposed
- Water quality will be collected in parallel with each study described next to characterize water at time sampling
- Analyzed for metals and nutrients in laboratory
- QA/QC sample collections will follow DEP-SOP FS 2100 and PQAP
- Field measurements

Pre-Operational Studies

- Periphyton
  - FIU Institute of Environment Periphyton Analysis Laboratory
  - Field Surveys
    - Epiphytic evaluated using periphytometers
    - Metaphyton grabs
  - Data Analysis
    - Taxonomy, cell density, abundance, ash-free dry mass, chlorophyll-a
    - Shannon-Weiner diversity index, taxa richness, evenness
    - Chemical and nutrient analysis (descriptive statistics)

Pre-Operational Studies

- **Submerged Aquatic Vegetation (SAV)**
  - Canals are poor habitat
  - Lake Okeechobee heavily studied
  - Field Studies
    - Desktop Assessment
    - Reconnaissance Surveys
    - Mapping and Characterization Field Surveys
  - Data Analysis
    - Frequency of occurrence, density, abundance
    - Statistical analyses



SAV grid (SFWMD 2008)

Pre-Operational Studies

- Benthic Macroinvertebrates
  - Desktop Review
  - Field surveys
    - Hester-Dendy per FDEP SOP FS-7430
    - 28-day deployment
    - Deployed concurrent with periphytometers
  - Data Analysis
    - Taxonomy
    - Taxa richness, Shannon-Weiner Diversity, Pielou's evenness, EPT
    - Statistical analyses

Source: Wisconsin DNR

Pre-Operational Studies

- Sediment
  - Field sampling
    - Three grabs per sample station
    - Sediment cores proposed, with ponar dredge as contingency
    - Sediment depth, water column depth, water quality
  - Data Analysis
    - Metals, nutrients, pH, grain size, water content, ash content
    - Statistical Analyses

Pre-Operational Studies

- Apple Snails
  - Important relationship to snail kite
  - Field surveys
    - Tissue collection
    - Submitted intact to laboratory
  - Data analysis
    - Metals analysis
    - Statistical analysis

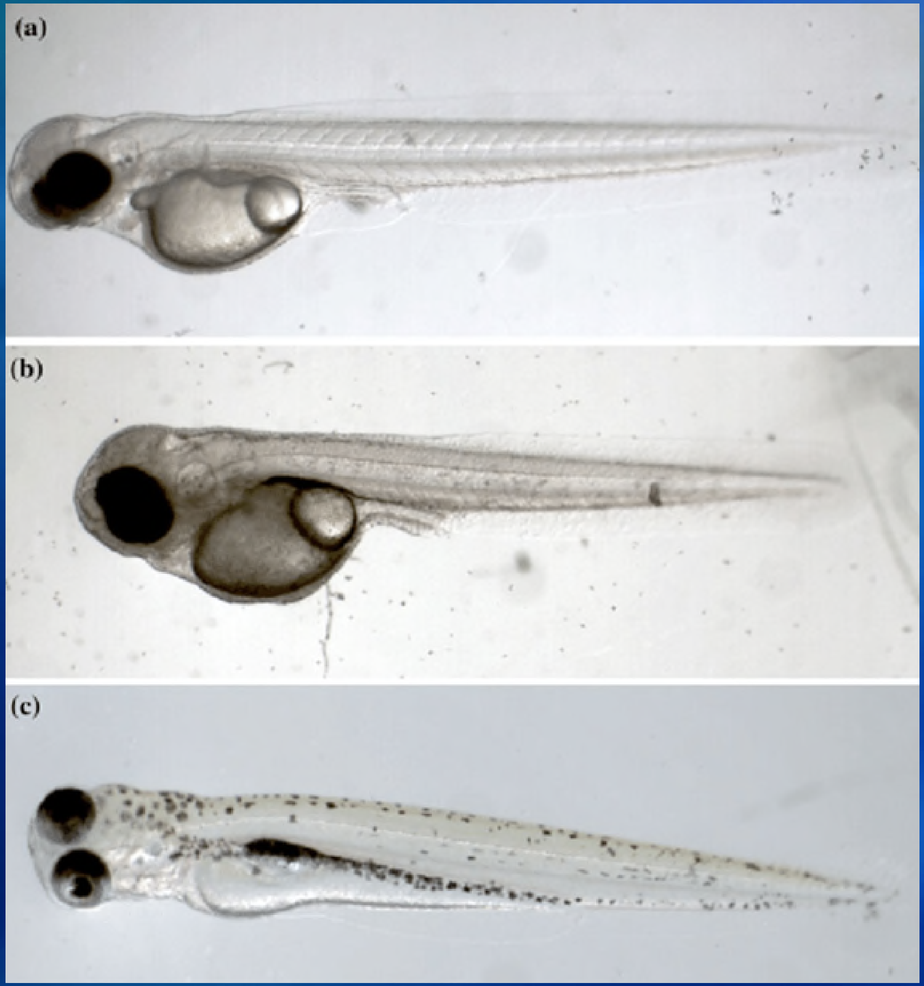
Pre-Operational Studies

- Mussels
  - Sensitive to bioconcentration in regional ASR ERA studies
  - Field Surveys
    - Native Florida mussels (*Elliptio jayenis*) targeted
    - Mussel tissue collection
    - 30 mussels per sample station
    - Shucked prior to shipping
  - Data Analysis
    - Tissues analyzed for metals
    - Statistical analysis

Pre-Operational Studies

- Fish
  - Desktop Assessment
  - Field Surveys
    - Canal focused
    - Fish Community Characterization
    - Fish Tissue Collection
      - Three trophic levels/feeding guilds (i.e., bluegill, crappie, and largemouth bass)
      - Analyzed for metals

Pre-Operational Studies

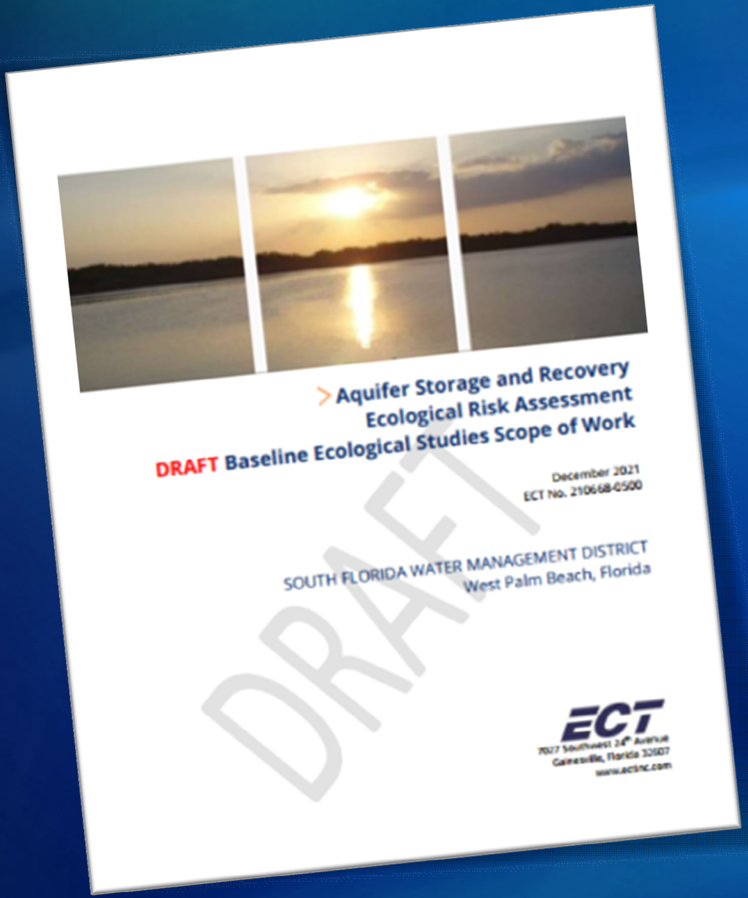


- Ichthyoplankton
  - Entrainable size organisms
  - Field Surveys
    - Plankton tows
      - 0.3-mm mesh plankton net with 1 L cod end
      - Target spawning period of local fish (March to June)
      - Three depths
    - Qualitative Assessment of nursery habitats along shoreline

Pre-Operational Studies

- Fish and Ichthyoplankton
  - Data Analysis
    - Taxa richness, Shannon-Weiner diversity index, Pielou's evenness
    - Catch-per-unit-effort (CPUE)
    - Metals tissue concentrations
    - Descriptive statistics
    - ANOSIM
    - Ordination diagrams

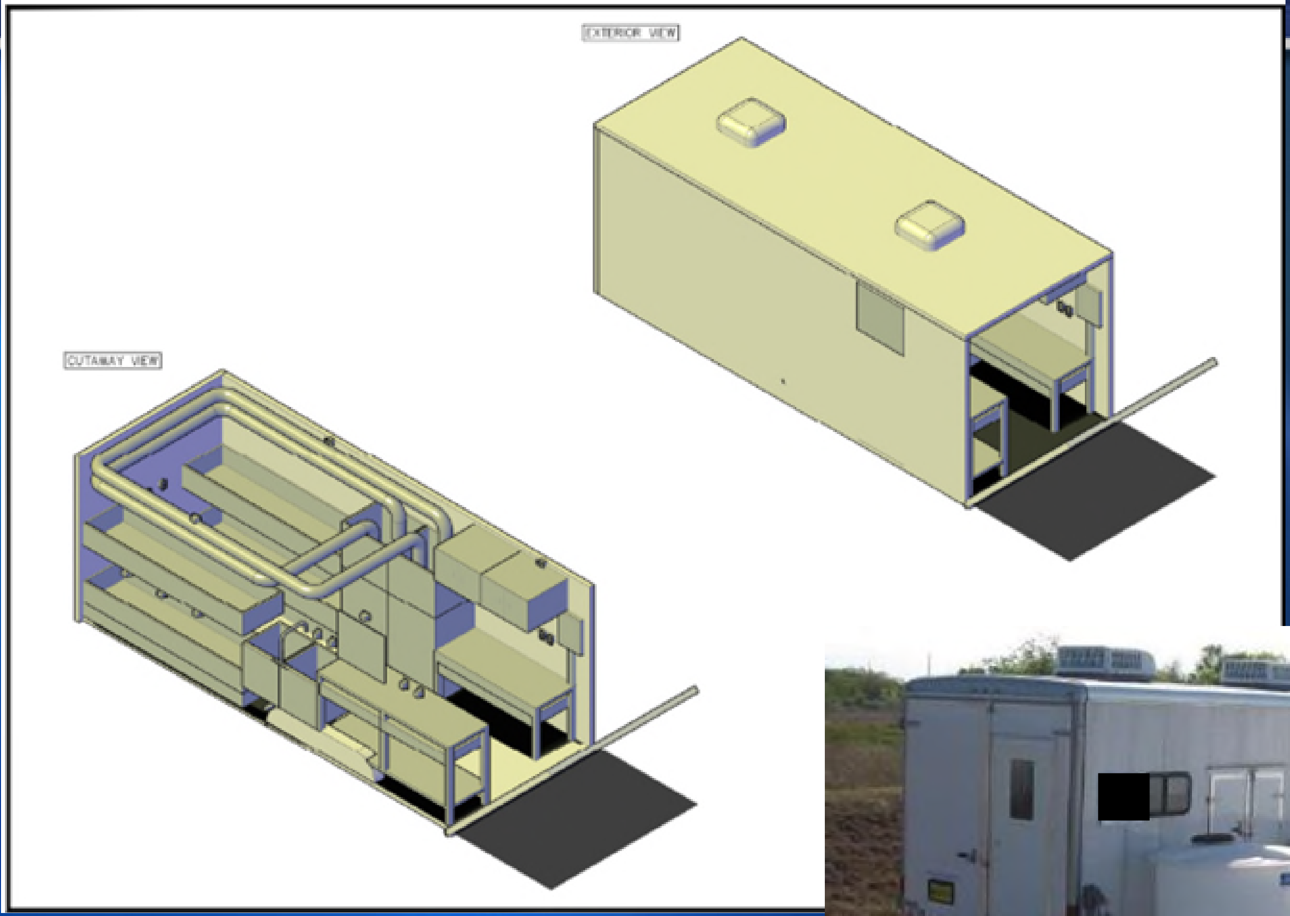
Pre-Operational Studies



- Data Management and Reporting
  - Bi-monthly progress reports following field collections
  - Survey specific annual reports
  - Comprehensive pre-operational report for C-38 ASRs
  - Data provided as reports, graphs, electronic, databases, ArcGIS, etc.

Mobile Laboratory

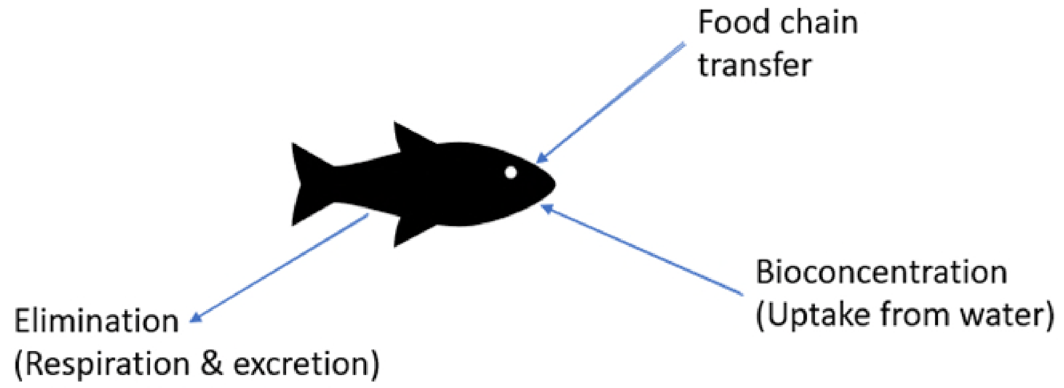
- Designed for future on-site bioconcentration studies



Bioconcentration Studies

- Bioconcentration vs bioaccumulation
- Test organisms
  - Bluegill (*Lepomis macrochirus)*-Osage Farms
  - Freshwater mussel (*Elliptio jayenis)*-Lake McMeekin
  - Pretreatment
- Water quality
  - Grab samples
  - Metals and nutrients
  - Ambient conditions

Bioaccumulation and Bioconcentration Process



Bioaccumulation = bioconcentration + food chain transfer – (elimination + growth dilution)

Bioconcentration Studies

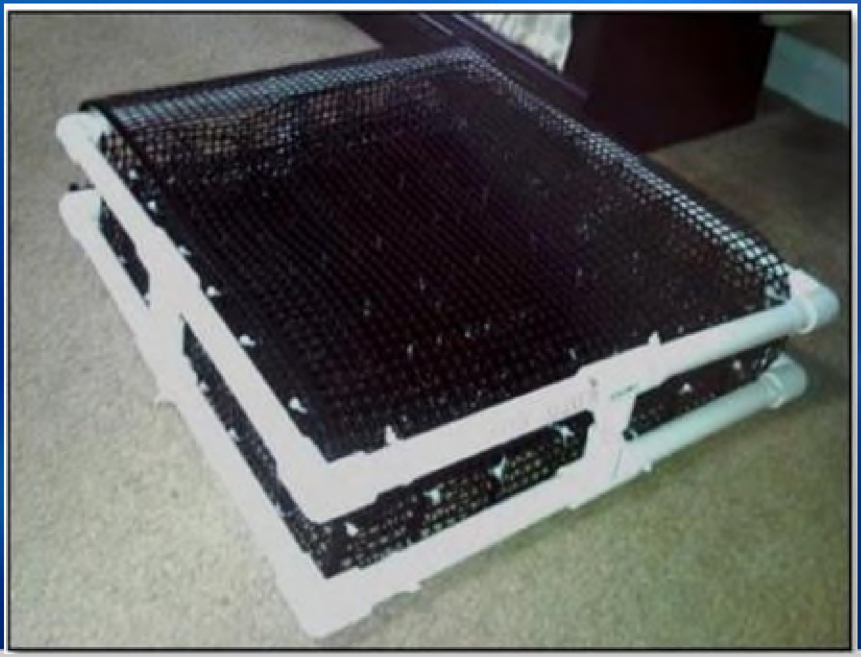
- ASTM method “Standard Guide for Conducting Bioconcentration Test with Fishes and Saltwater Bivalve Mollusks, ASTM: E 1002-94” used as guide
- Mobile laboratory
  - Construction to be completed late 2022
  - Flow through
  - 2 different water supply options for three different treatments:
    - Background surface water or recharge (BSW)
    - Recovered ASR Water (RCV)
    - 50/50 mixture of BSW and RCV (MW)

Bioconcentration Studies

- Study recharge and recovery cycles
- Fish and Mussels
- Monitoring
  - Water quality
  - Mortality
  - Anomalies
- Tissue Analysis
  - Metals

Bioconcentration Studies

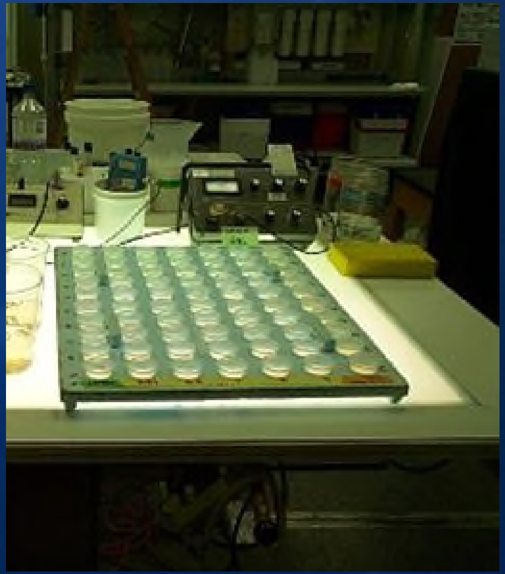
- In-situ Bioaccumulation
  - Sample survey areas, locations, and sample stations per baseline studies
  - Mussels
  - Periphyton
  - Data analysis follows pre-operational studies



Toxicity Studies

➢Ecotoxicity Test

- Tests
  - 7-day *Ceriodaphnia* survival and reproduction study
  - 21-day *Daphnia magna* survival and reproduction study
  - 7-day fathead minnow embryo-larval survival and teratogenicity study
  - FETAX (frog embryo assay)
  - 96-hour bannerfin shiner test
  - 96-hour *Ceriodaphnia* test
- Recharge and Recovery
- Multiple cycles of varying durations

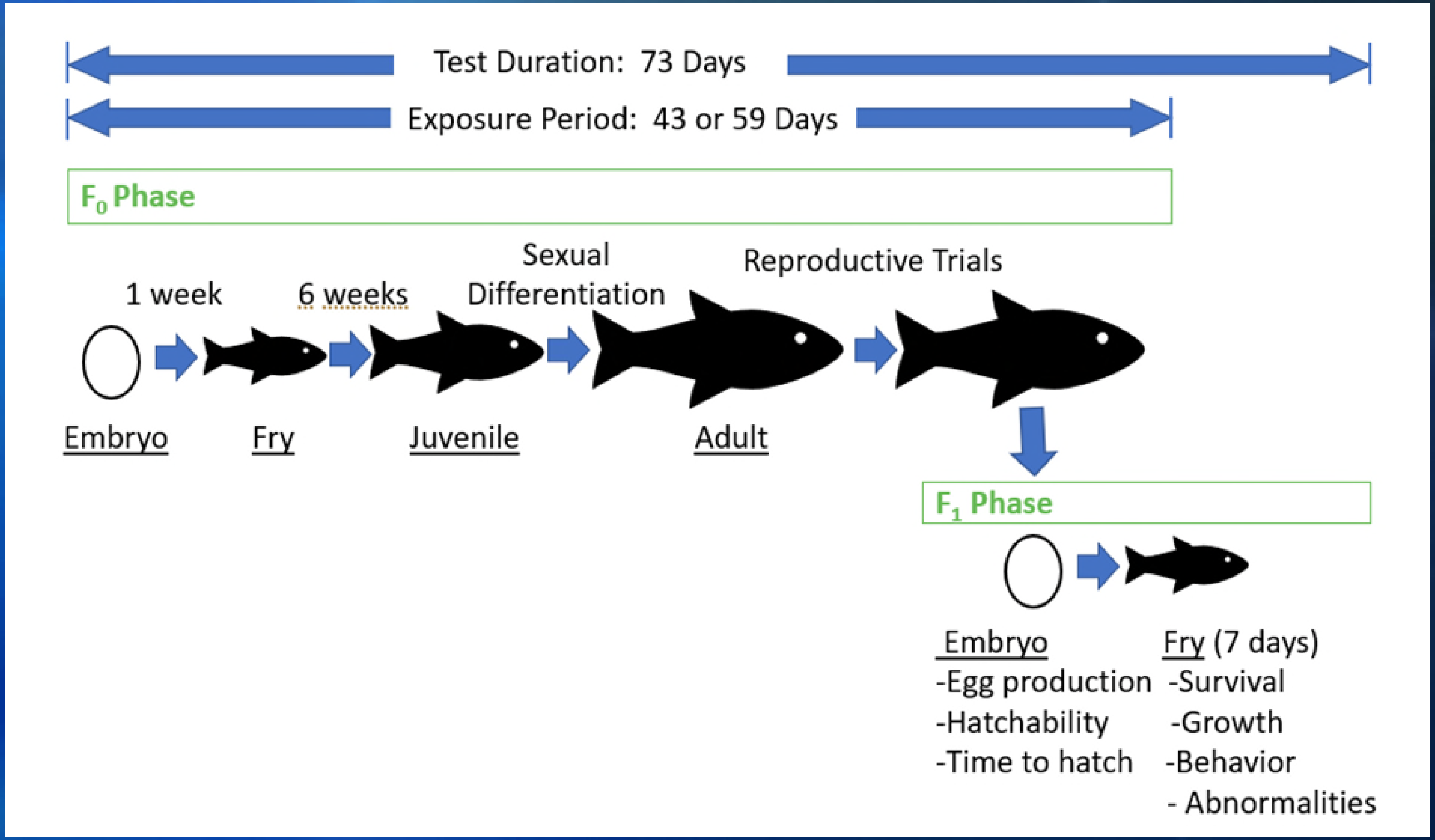


Toxicity Studies

- NDPES and CERP Permits
  - Additional toxicity testing will likely be required as part of the NPDES and CERP permits for operation of the ASR wells.
  - Whole Effluent Toxicity Testing

Toxicity Studies

- **Longer-Term chronic Toxicity Study**
  - **Fathead minnow (*Pimephales promelas*)**
  - **Evaluate reproduction success**



Panel Discussion
(5 min.)

Break
2:00 PM – 2:15 PM

Aquifer Storage and Recovery Programmatic Quality Assurance Plan

Presenter: Steven Elliott
Chemist
Stantec

What is a Quality Assurance Project Plan?

- QAPPs describe *HOW* project elements are done
- The EPA has established basic guidelines for QAPP development
- The steps include:
  - Project Management
  - Data Generation and Acquisition
  - Assessment and Oversight
  - Data Validation and Usability

Figure 1-1. ASR Wellfields and Treatment System Locations

What is a "Programmatic" QA Plan?

- The ASR PQAP uses a broader approach and tries to address all anticipated activities
- Individual project Work Plans will either reference procedures detailed in the PQAP or will have to provide sufficient detail about variances or items not addressed in the PQAP.
- The PQAP is designed to be a "living" document

Work Plan Development

- Work Plans that address water quality, biological, and ecological data collection and management must:
  - Define project scope and purpose
  - Reference standardized procedures and guidelines
  - Justify design strategy and sampling locations
  - Discuss DQOs
  - Define parameters and analytical requirements
  - Reference or define equipment and procedures

Criteria

- USEPA Primary and Secondary Drinking Water Standards
- Florida MCLs for drinking water and CTLs for groundwater and surface water
- Additional Permit parameters

Table 1-1. ASR Science Plan Groundwater and Surface Water Parameters and Applicable Criteria

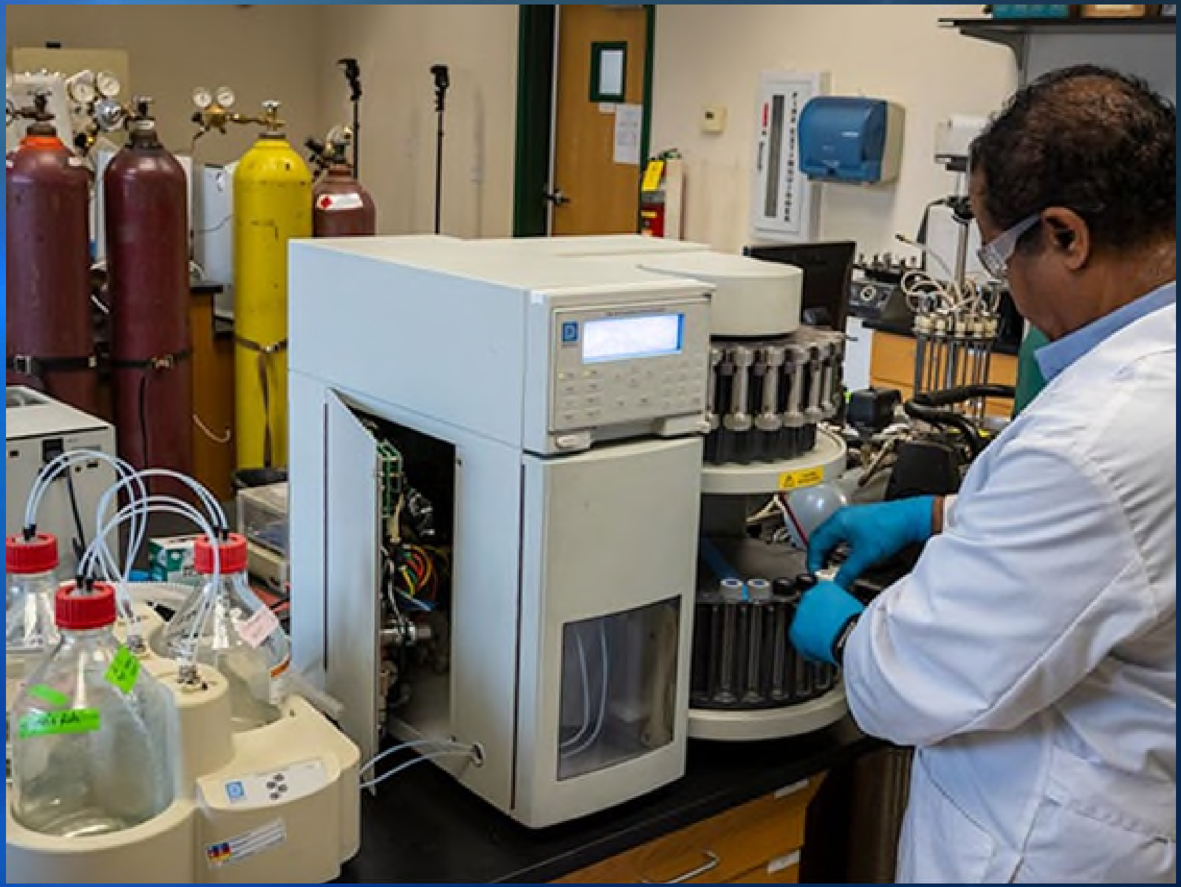
Parameter	FDEP DW MCLs[1]	FDEP CTLs (ug/L)[2]		USEPA Drinking Water Standards (ug/L)[3]	Recommended Project MDL (ug/L)
		GW	SW (fresh)	Primary	
Volatile Organic Compounds (VOCs)					
Benzene	1	1	71.28	5	1
Carbon tetrachloride	3	3	4.42	5	3
Chlorobenzene	100	100	17	100	17
1,2-Dibromo-3-chloropropane	--	0.2	--	0.2	0.2
1,2-Dichlorobenzene (o-DCB)	600	600	99	600	99
1,4-Dichlorobenzene (p-DCB)	75	75	3	75	3
1,1-Dichloroethane	--	70	--	--	70
1,1-Dichloroethylene	7	7	--	7	7
1,2-Dichloroethane	3	3	37	5	3
cis-1,2-Dichlorethylene	70	70	--	70	70
trans-1,2-Dichlorethylene	100	100	11000	100	100
Dichloromethane (methylene	5	5	1580	5	5

Field Sampling

- Forms and Logs
- Equipment requirements, calibration, decontamination
- Quality Control Samples
- Sample Collection Techniques
  - Groundwater
  - Surface Water
  - Sediment
  - Tissue
- Preservation and Holding Times
- Chain of Custody

Chemical Analysis

- Laboratory Certification
- Detection and Reporting Limits
- Quality Control Requirements
- Reporting Requirements
- Storage Requirements



Data Assessment

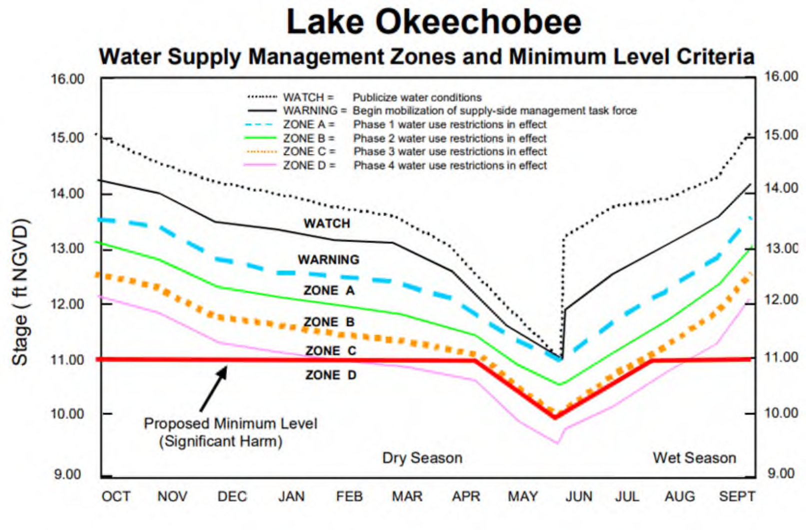
- Literature Assessment
- Field Data Validation
- Laboratory Data Assessment
  - Validation
  - Data Usability Summaries
  - ADaPT

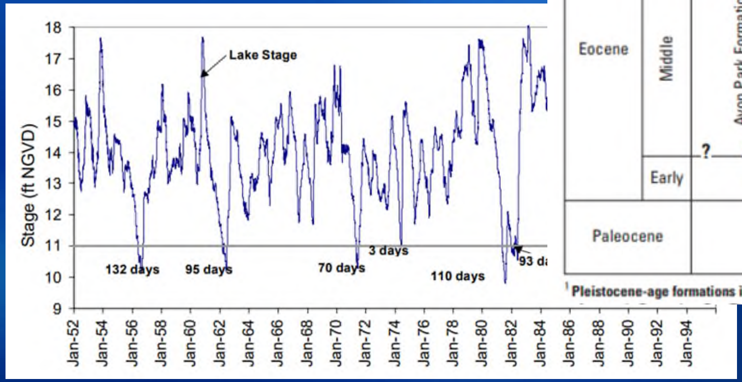
Well Construction

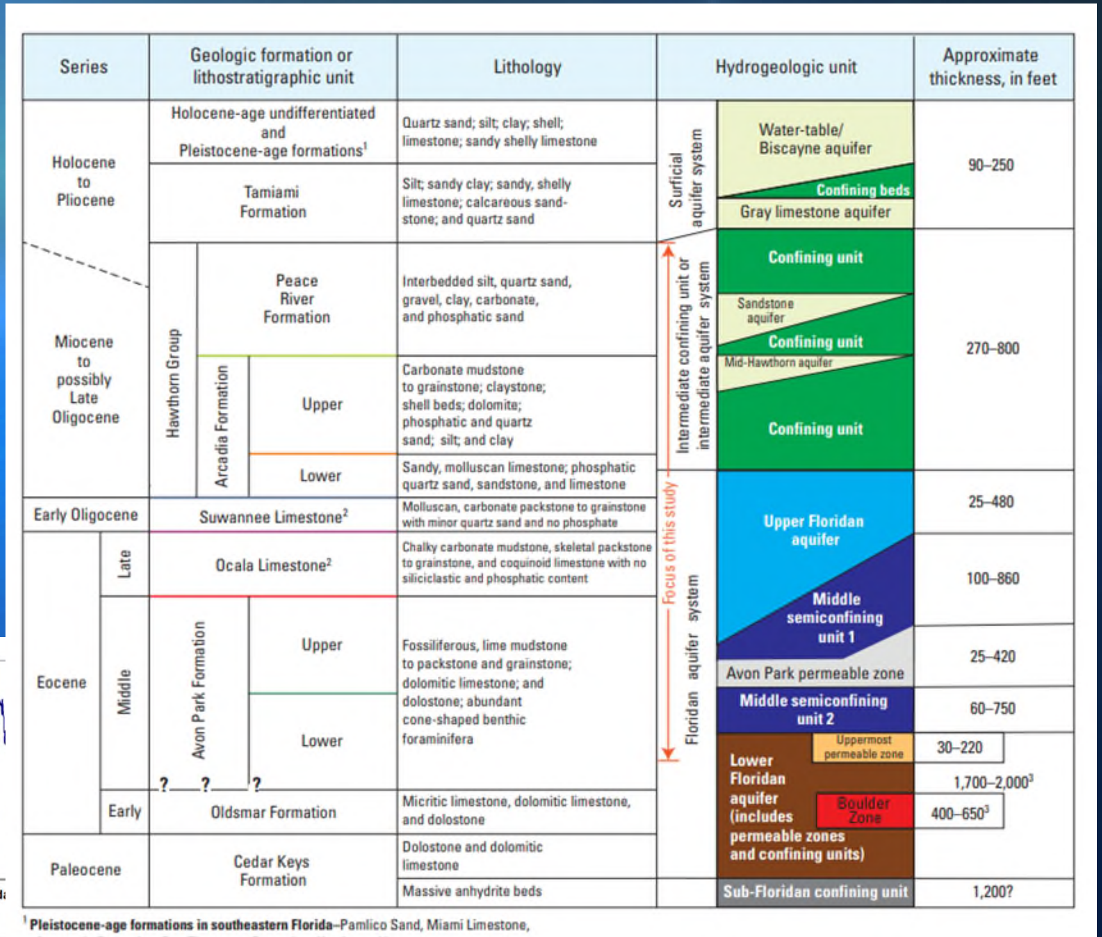
- ASR Well Construction and Testing
- Continuous Coring
- Post-Construction Pump Tests
- Construction Oversight

Hydrogeological Monitoring

- Surface geophysical surveys
- Tracer testing
- Pathogen inactivation studies
- Nutrient reduction studies







Series		Geologic formation or lithostratigraphic unit			Lithology	Hydrogeologic unit		Approximate thickness, in feet
Holocene to Pliocene		Holocene-age undifferentiated and Pleistocene-age formations[1]			Quartz sand; silt; clay; shell; limestone; sandy shelly limestone	Surficial aquifer system	Water-table/ Biscayne aquifer; Confining beds	90–250
		Tamiami Formation			Silt; sandy clay; sandy, shelly limestone; calcareous sand-stone; and quartz sand		Gray limestone aquifer	
Miocene to possibly Late Oligocene		Hawthorn Group	Peace River Formation		Interbedded silt, quartz sand, gravel, clay, carbonate, and phosphatic sand	Intermediate confining unit or intermediate aquifer system	Confining unit; Sandstone aquifer; Confining unit; Mid-Hawthorn aquifer	270–800
			Arcadia Formation	Upper	Carbonate mudstone to grainstone; claystone; shell beds; dolomite; phosphatic and quartz sand; silt; and clay		Confining unit	
				Lower	Sandy, molluscan limestone; phosphatic quartz sand, sandstone, and limestone			
Early Oligocene		Suwannee Limestone[2]			Molluscan, carbonate packstone to grainstone with minor quartz sand and no phosphate	Floridan aquifer system	Upper Floridan aquifer	25–480
Eocene	Late	Ocala Limestone[2]			Chalky carbonate mudstone, skeletal packstone to grainstone, and coquinoid limestone with no siliciclastic and phosphatic content		Middle semiconfining unit 1	100–860
	Middle	Avon Park Formation		Upper	Fossiliferous, lime mudstone to packstone and grainstone; dolomitic limestone; and dolostone; abundant cone-shaped benthic foraminifera		Avon Park permeable zone	25–420
				Lower			Middle semiconfining unit 2	60–750
		?	?	?			Lower Floridan aquifer (includes permeable zones and confining units); Uppermost permeable zone	30–220; 1,700–2,000[3]
	Early	Oldsmar Formation			Micritic limestone, dolomitic limestone, and dolostone		Boulder Zone	400–650[3]
Paleocene		Cedar Keys Formation			Dolostone and dolomitic limestone			
					Massive anhydrite beds		Sub-Floridan confining unit	1,200?

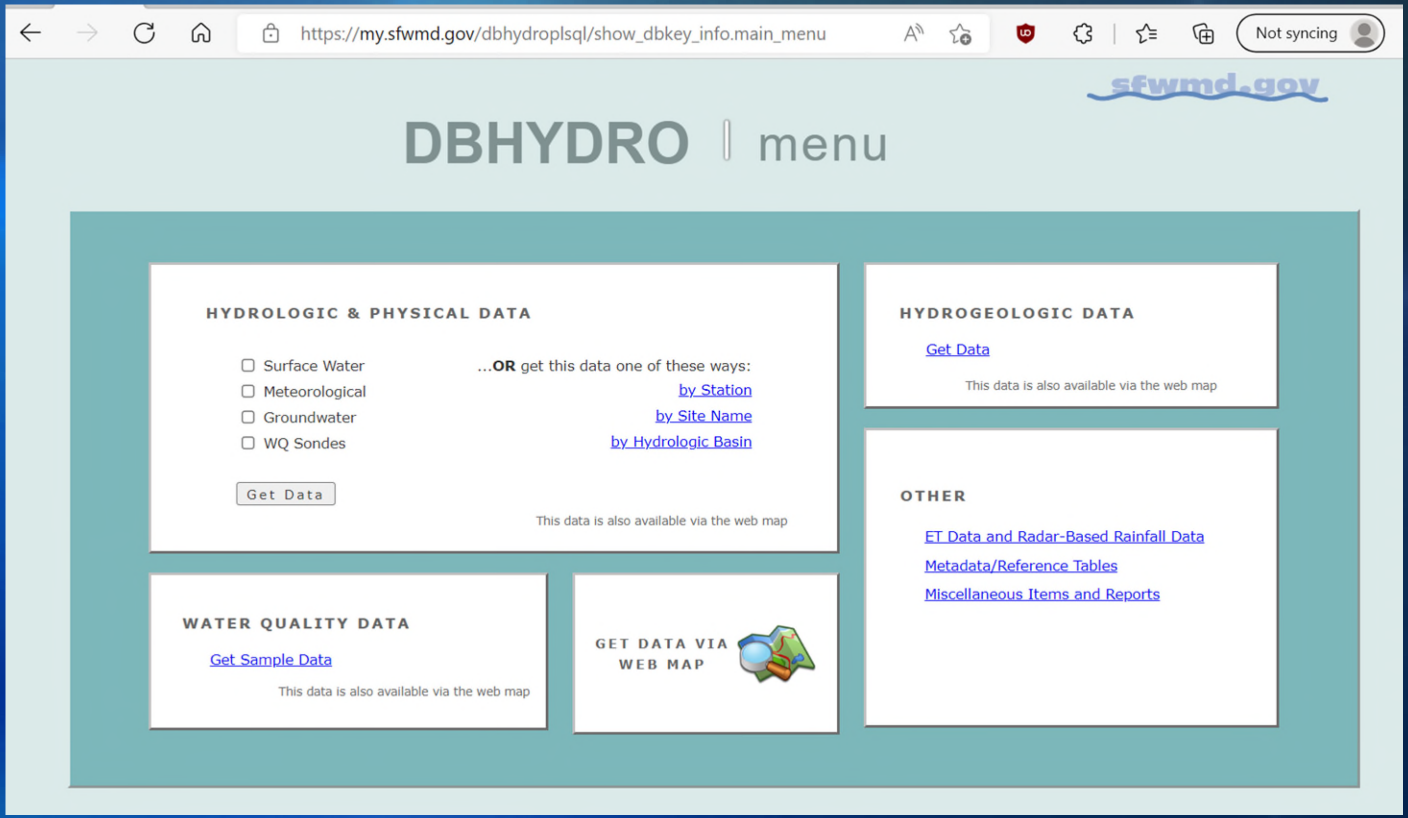
[1] **Pleistocene-age formations in southeastern Florida**–Pamlico Sand, Miami Limestone,

Ecological Monitoring

- Mobile Lab Construction
- Operational Considerations
- Ecotoxilogical Testing
- Bioconcentration Studies
- Lake Okeechobee Environmental Model
- Baseline Ecological Studies
- Mesocosm Studies

Data Management

- Storage
- Custody
- Security
- Access
- Archiving



Audits

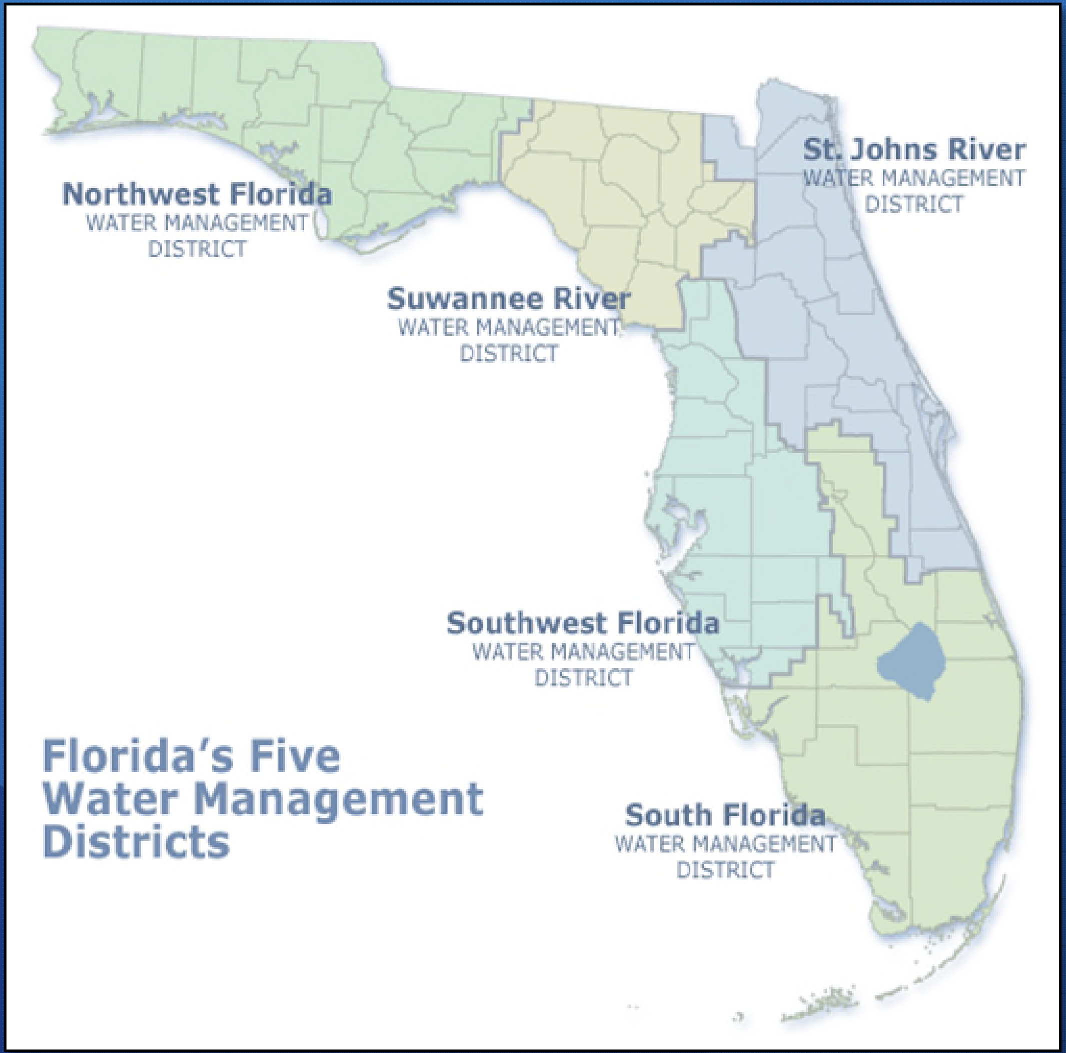
- Field Audits
  - FDEP Audit Checklists
- Laboratory Audits
- Data Management Audits
- Corrective Actions

Conclusion

- The PQAP is designed to guide future Work Plans
- A “living” document
- Covers:
  - Potential parameters and criteria
  - Sampling
  - Analysis
  - Well construction and oversight
  - Hyrogeological Modeling
  - Ecological Assessment

Panel Discussion (5 min.)

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT



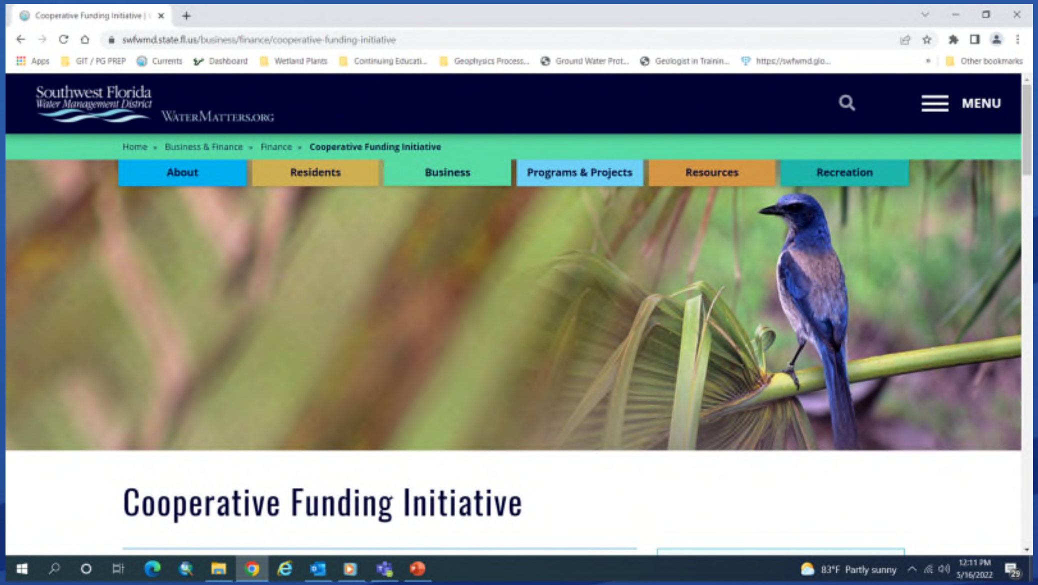
Recharge Projects in the SWFWMD

Sammy Smith
Hydrogeologist II
Water Resources Bureau
Water Supply Section

June 15, 2022

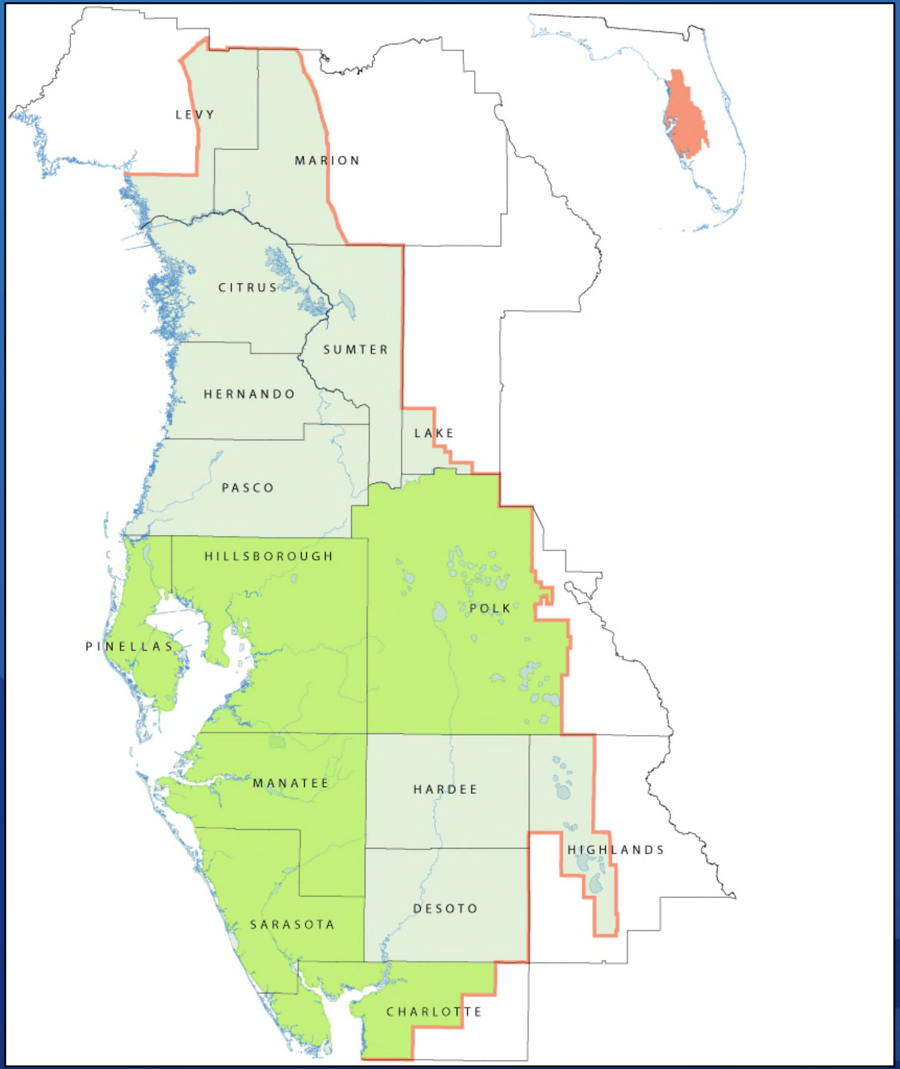
Cooperative Funding Initiative

- This program allows local governments and private entities (within our District) to share costs for projects that assist in creating sustainable water resources, provide flood protection and enhance conservation efforts.
- Do Projects Align with District Strategic Plan?
- The CFI covers up to 50% of total project cost



Presenter: Sammy Smith

CFI Recharge Projects



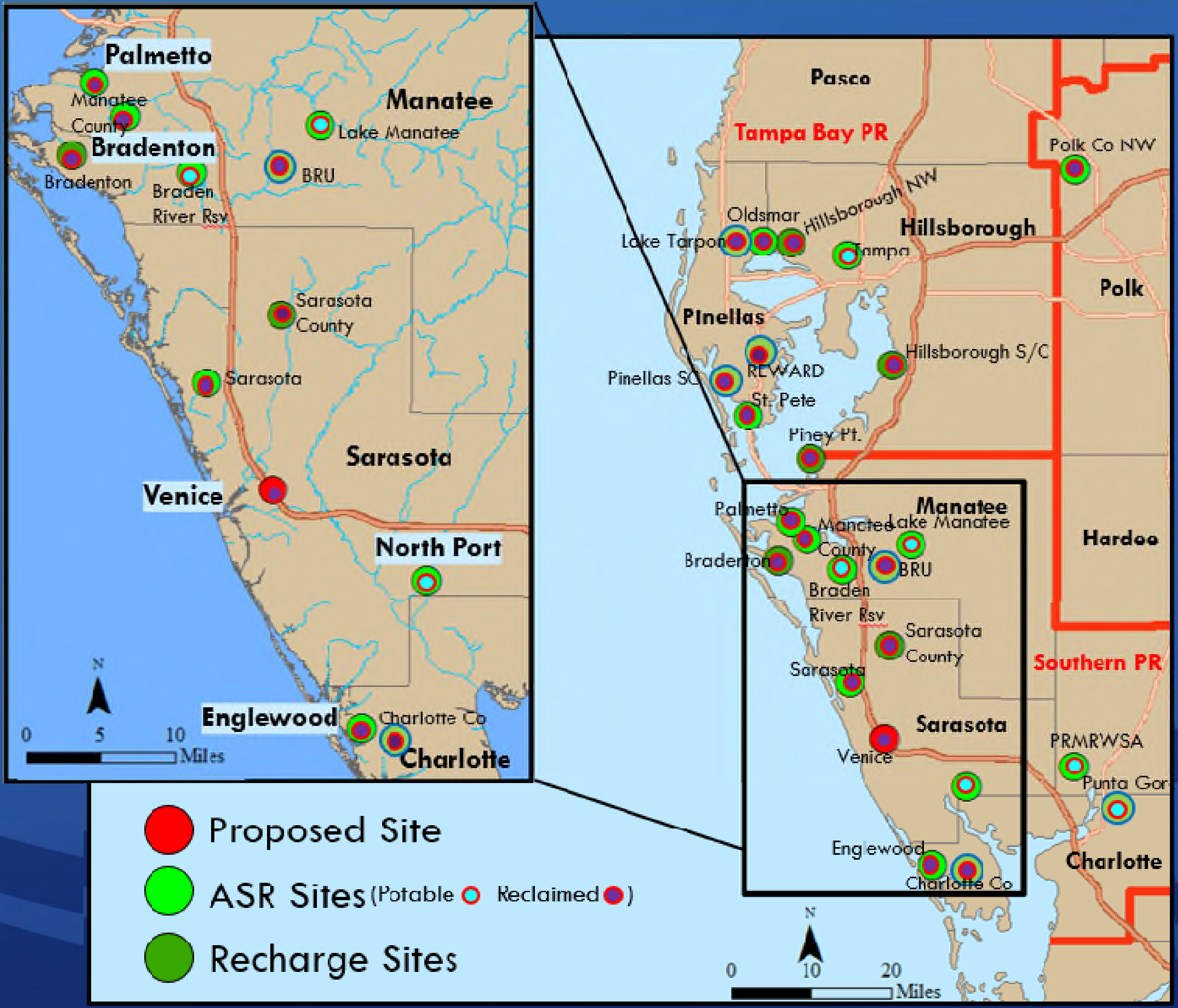
Direct Recharge:

- Q246 (City of Tampa)
- Q088 (Hillsborough County)
- Q142 (Pinellas County)
- Q159 (Sarasota County)
- N855 (Hillsborough County)
- N287 (Hillsborough County)
- N665 (City of Clearwater)

Aquifer Storage & Recovery:

- Q050 (City of Venice)
- Q142 (Pinellas County)
- N833 & K120 (City of North Port)
- N398 (City of Oldsmar)
- N435 & K114 (City of Bradenton)
- L608 (City of Palmetto)
- N024 (Polk County)
- K269 (Sarasota County)
- K509 (Hillsborough County)
- P787 & K424 (City of St. Petersburg)
- K257 (City of Englewood)
- F007 (Manatee County)

Presenter: Sammy Smith



Presenter: Sammy Smith

N833 – The City of North Port (ASR)

Presenter: Sammy Smith

N833 – The City of North Port (ASR)

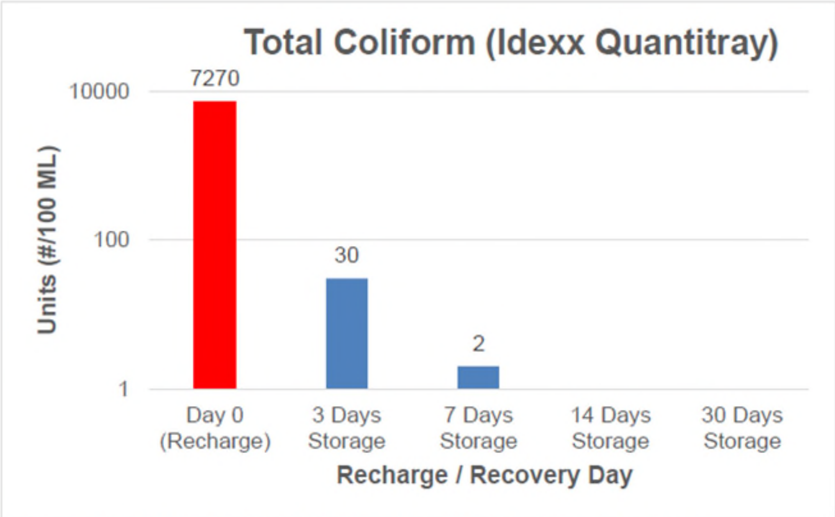


Figure 1. Cycle Test 6C ASR-1 Well Total Coliform Results.

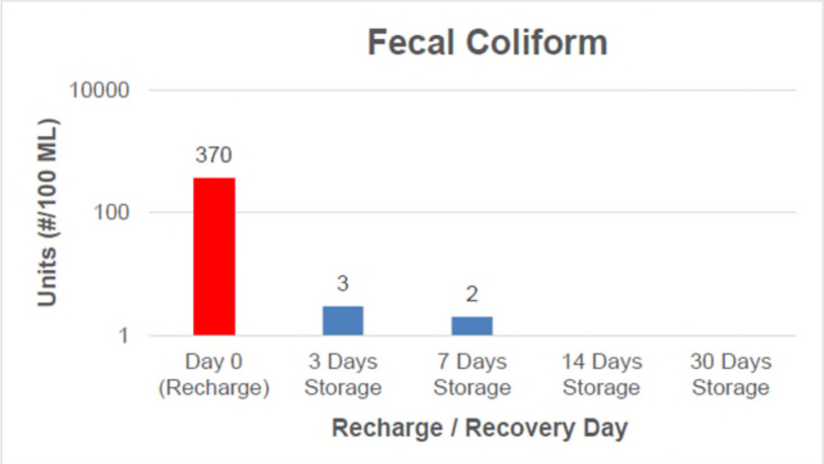


Figure 2. Cycle Test 6C ASR-1 Well Fecal Coliform Results.

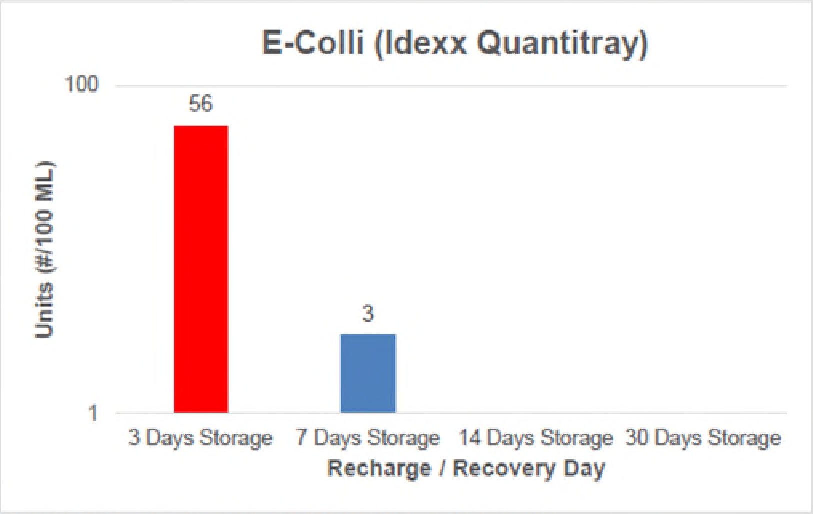


Figure 3. Cycle Test 6C ASR-1 Well E-Coli Results.

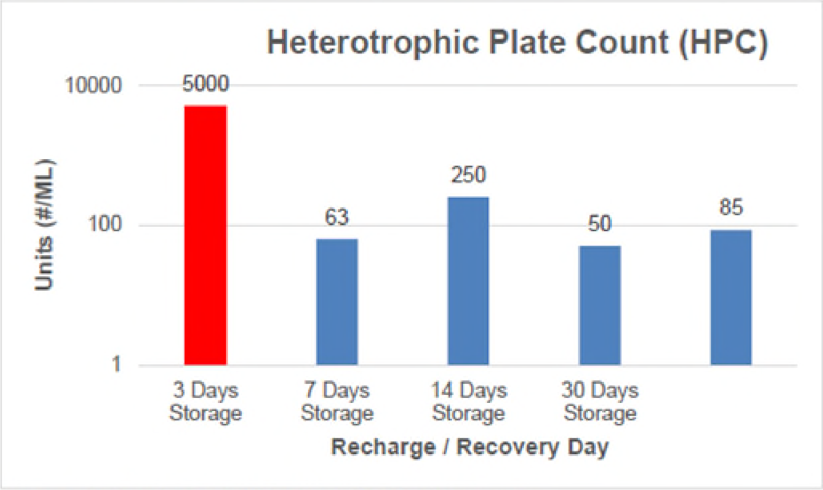


Figure 4. Cycle Test 6C ASR-1 Well HPC Results.

Presenter: Sammy Smith

N833 – The City of North Port (ASR)

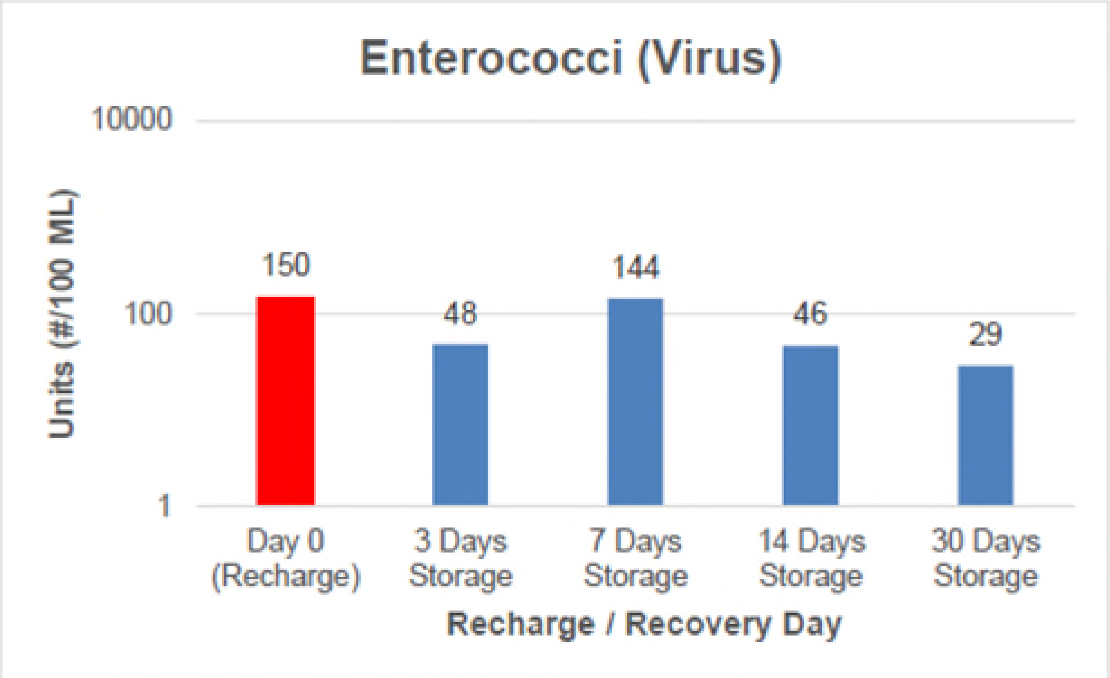


Figure 5. Cycle Test 6C ASR-1 Well Virus Results.

Presenter: Sammy Smith

Q142 – Chesnut Park AR/ASR (Pinellas County)

Scope:

30% design/TPR of an ASR system to store and recover excess surface water from Lake Tarpon, as well as an AR system designed to help restore water level elevations in the NTBWUCA and aid in aquifer freshening.

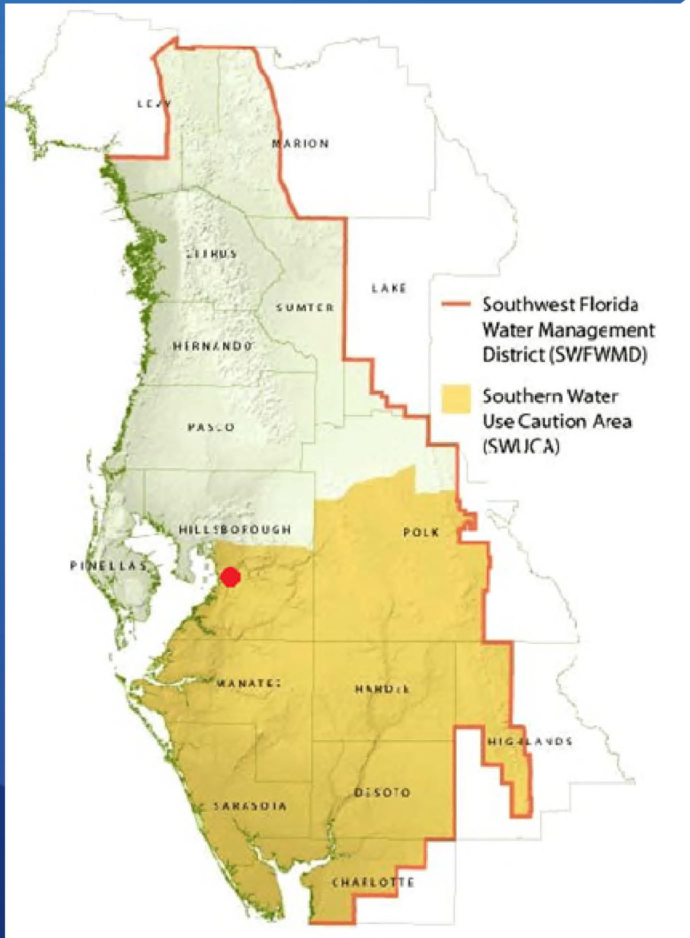
Shared intake structure for both wells

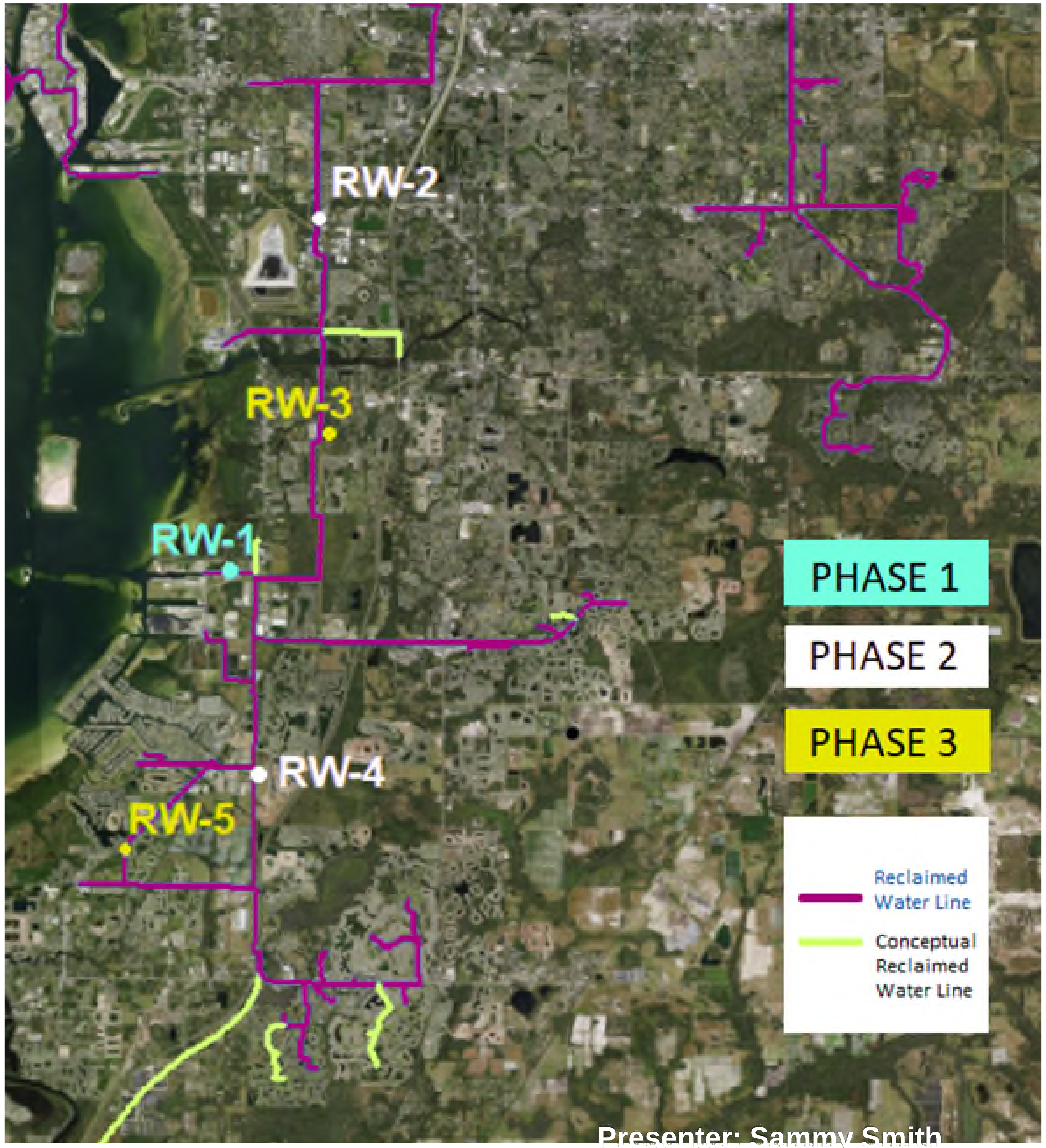
Minimum 5-year total recovery quantity of 300MG for the ASR portion

1 BG minimum recharge volume over a 5-year period for the AR portion

Presenter: Sammy Smith

N287/N855
SHARP (Hillsborough County)

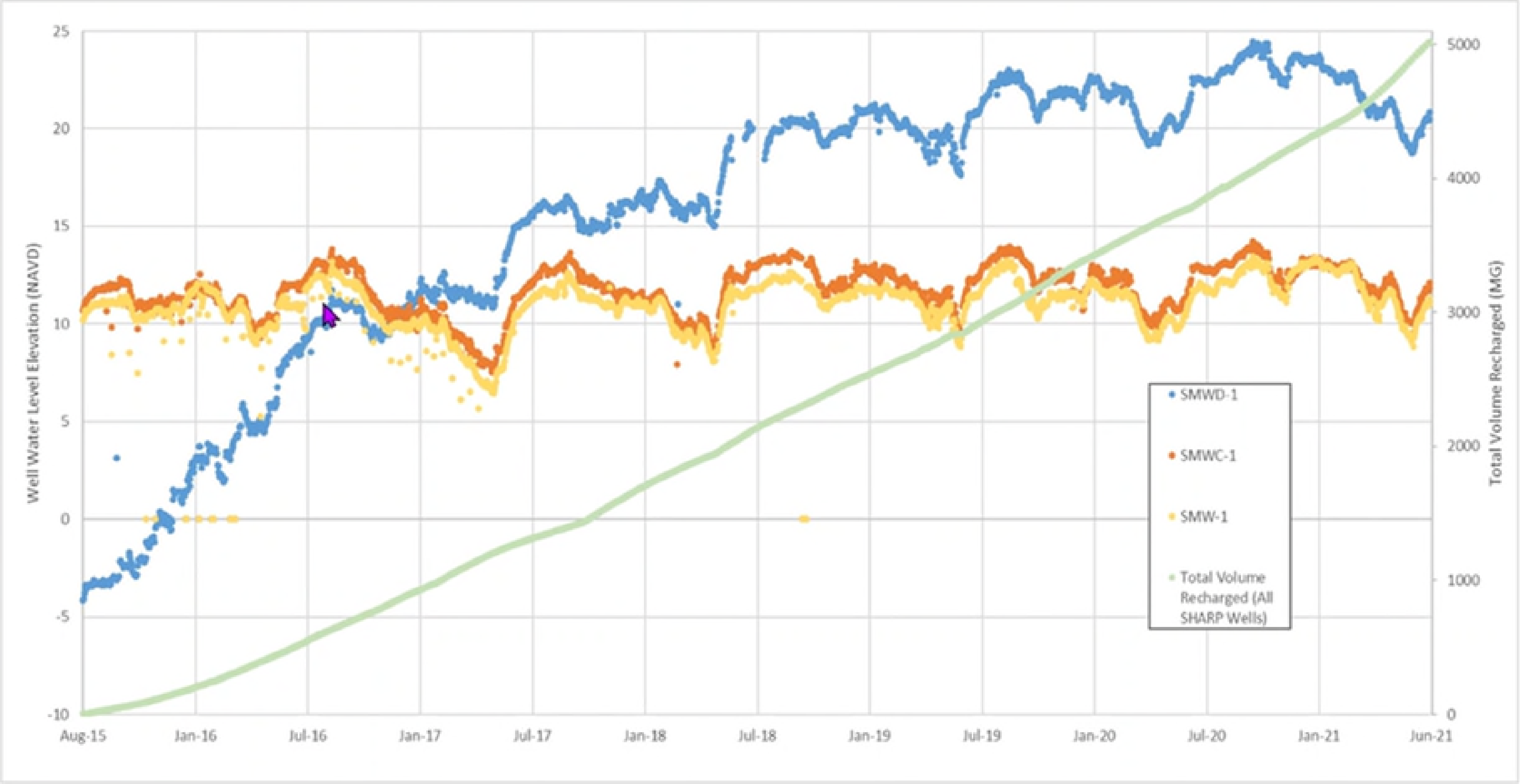




Presenter: Sammy Smith

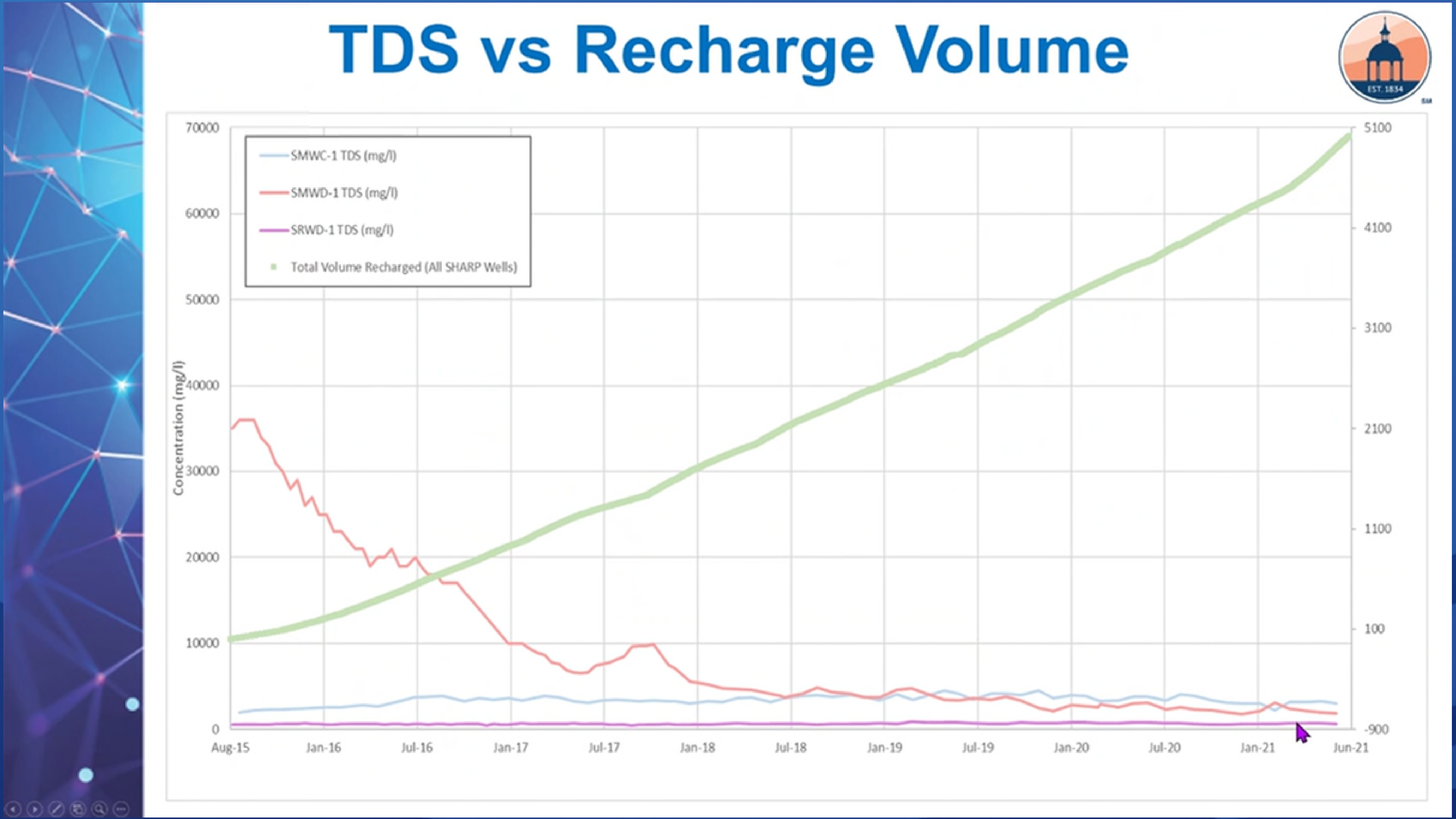
N287/N855 - SHARP (Hillsborough County)

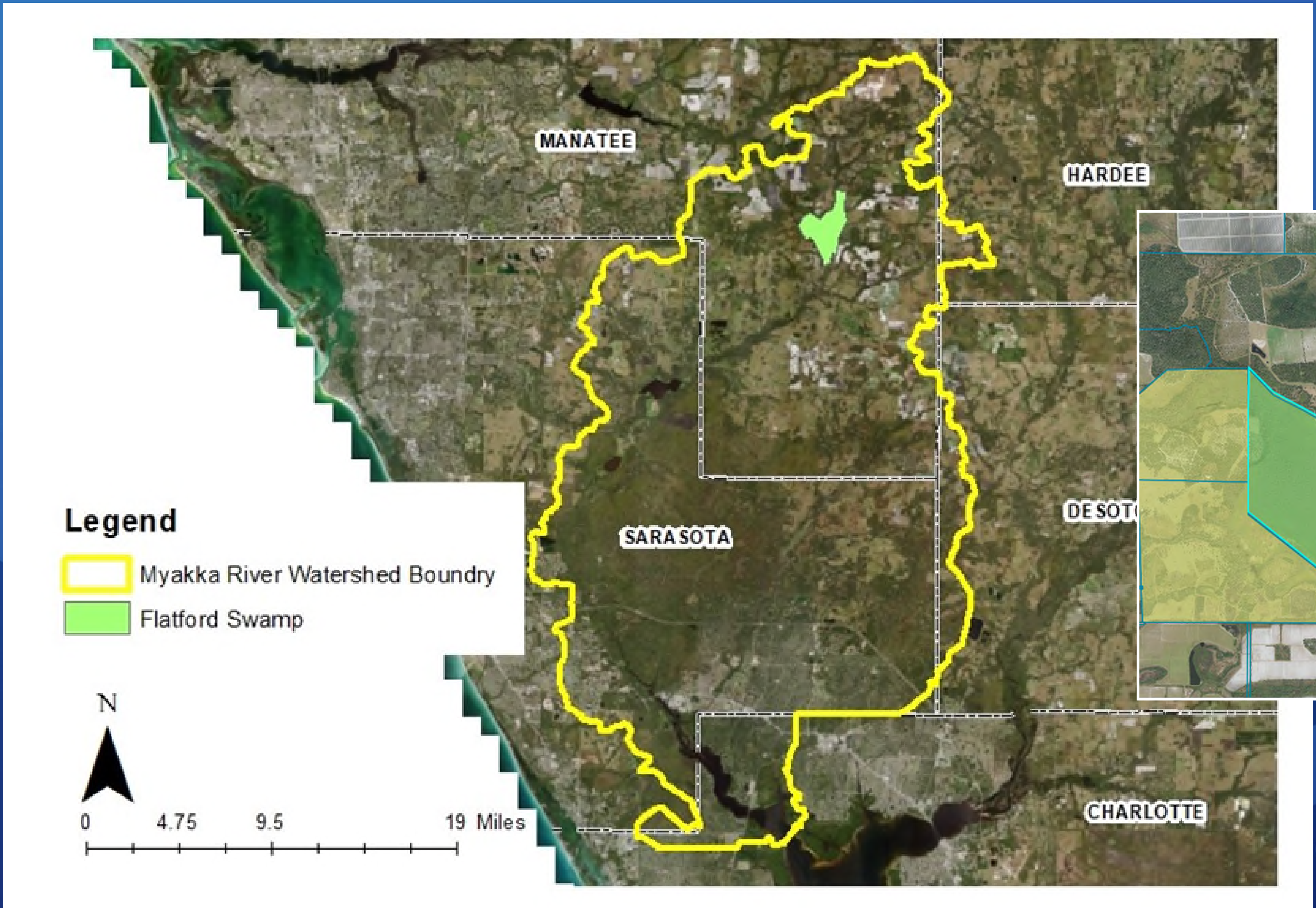
Groundwater Level vs Recharge Volume

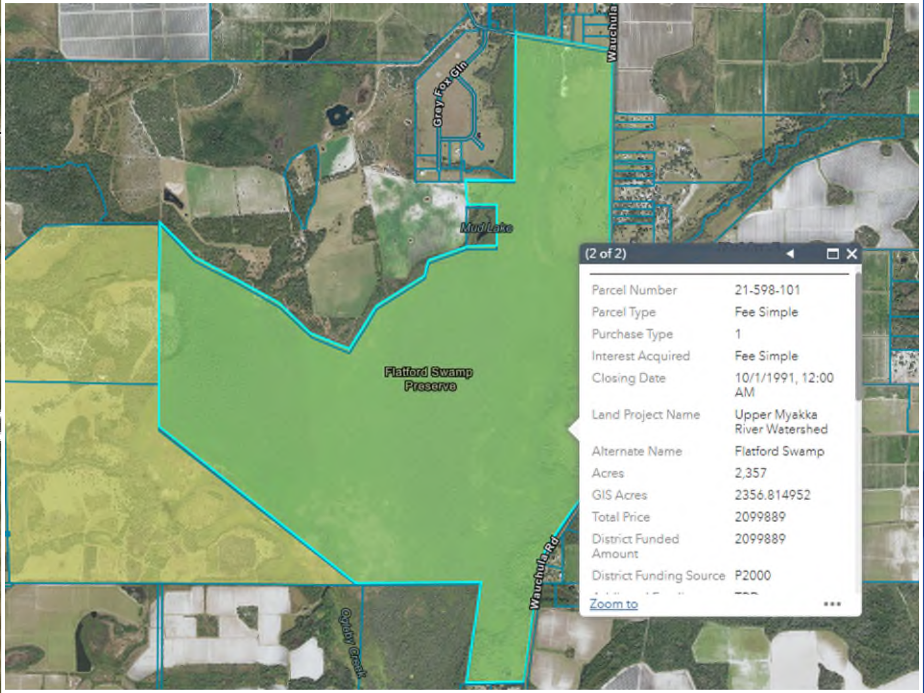


Presenter: Sammy Smith

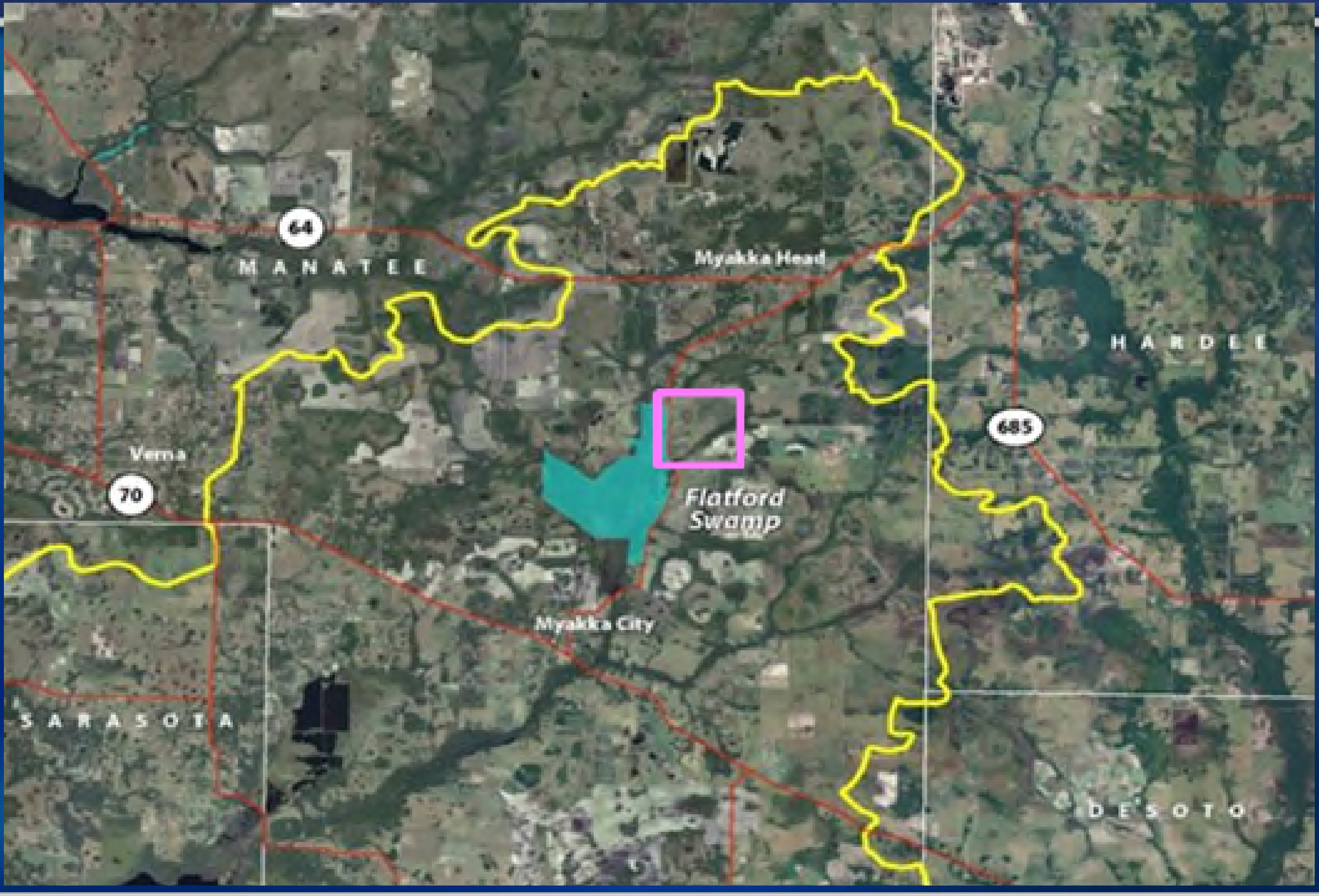
N287/N855 - SHARP (Hillsborough County)

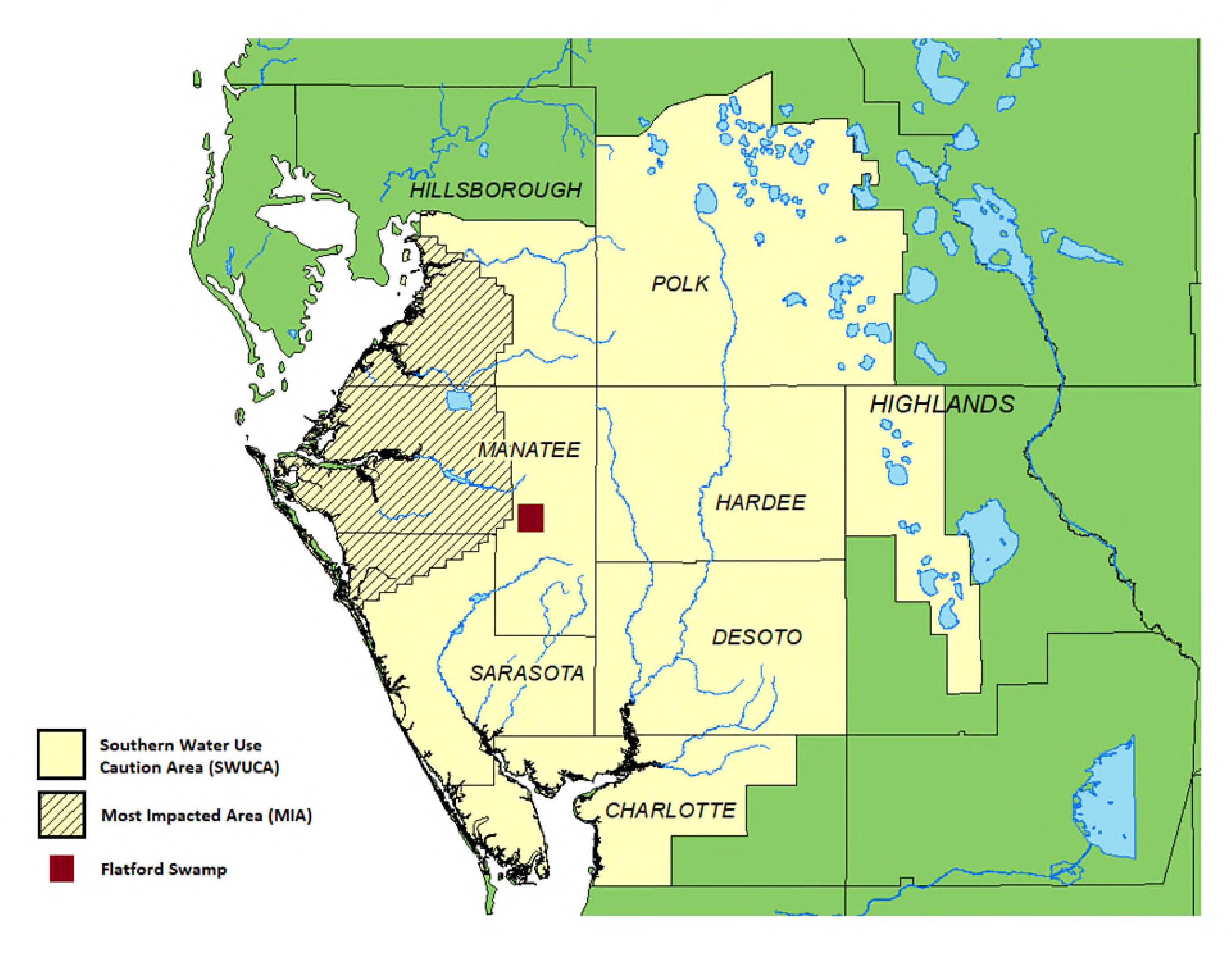




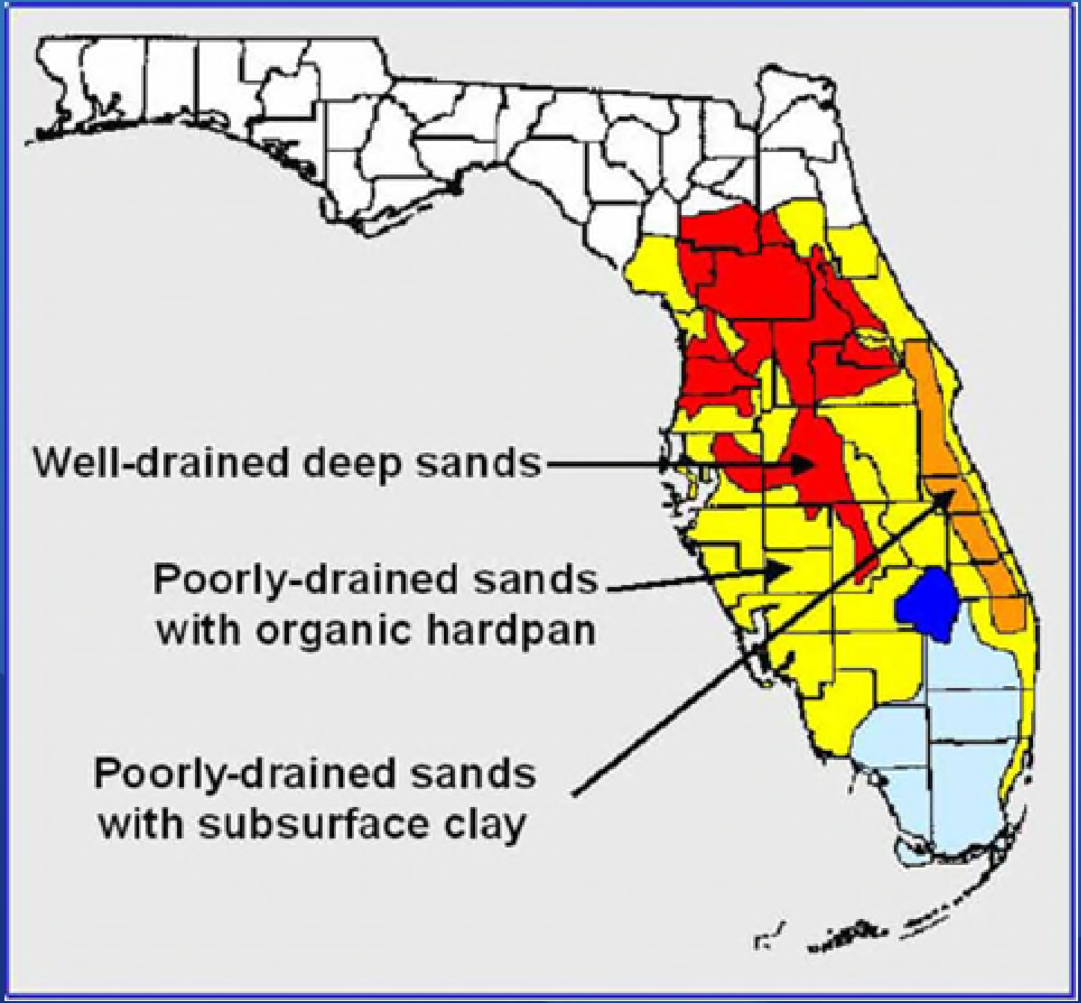


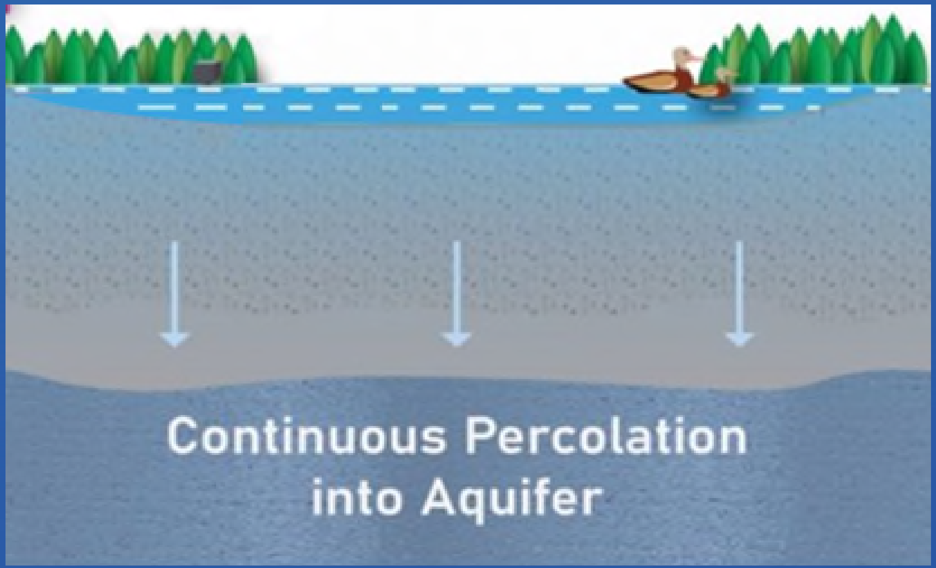
Presenter: Sammy Smith

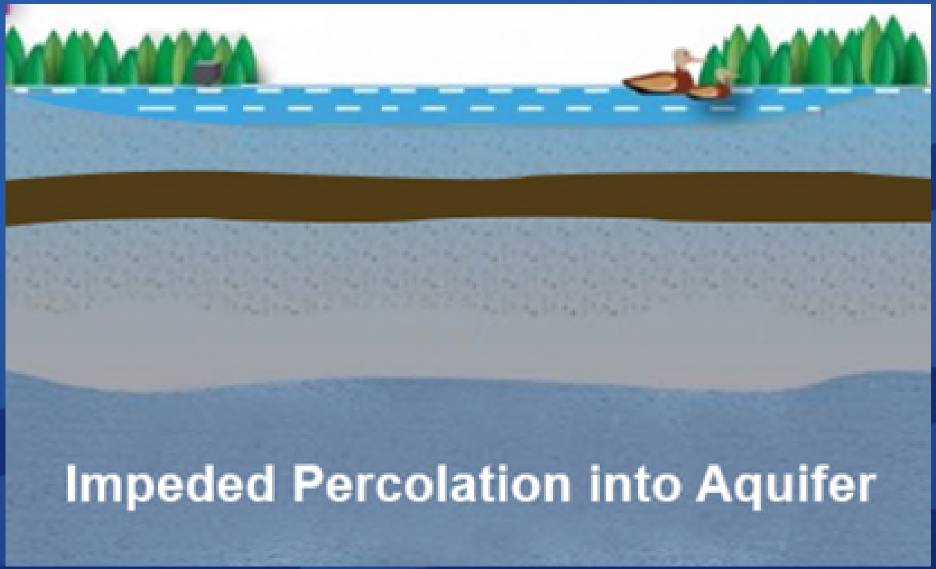

64
MANATEE
Myakka Head
HARDEE
685
Verna
70
Flatford Swamp
Myakka City
SARASOTA
DESOTO


HILLSBOROUGH
POLK
HIGHLANDS
MANATEE
HARDEE
DESOTO
SARASOTA
CHARLOTTE
Southern Water Use Caution Area (SWUCA)
Most Impacted Area (MIA)
Flatford Swamp

Geomorphology (Hardpan):



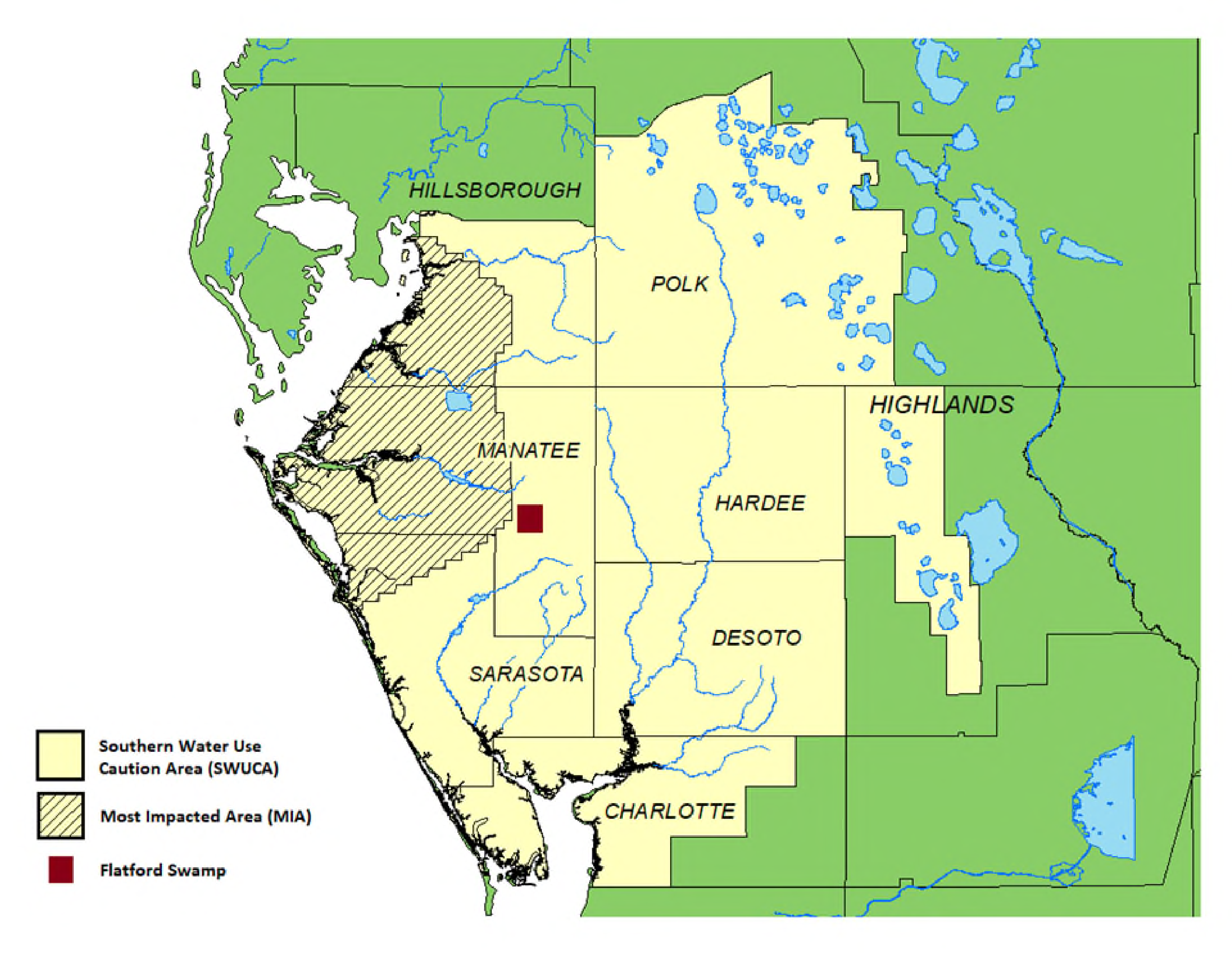


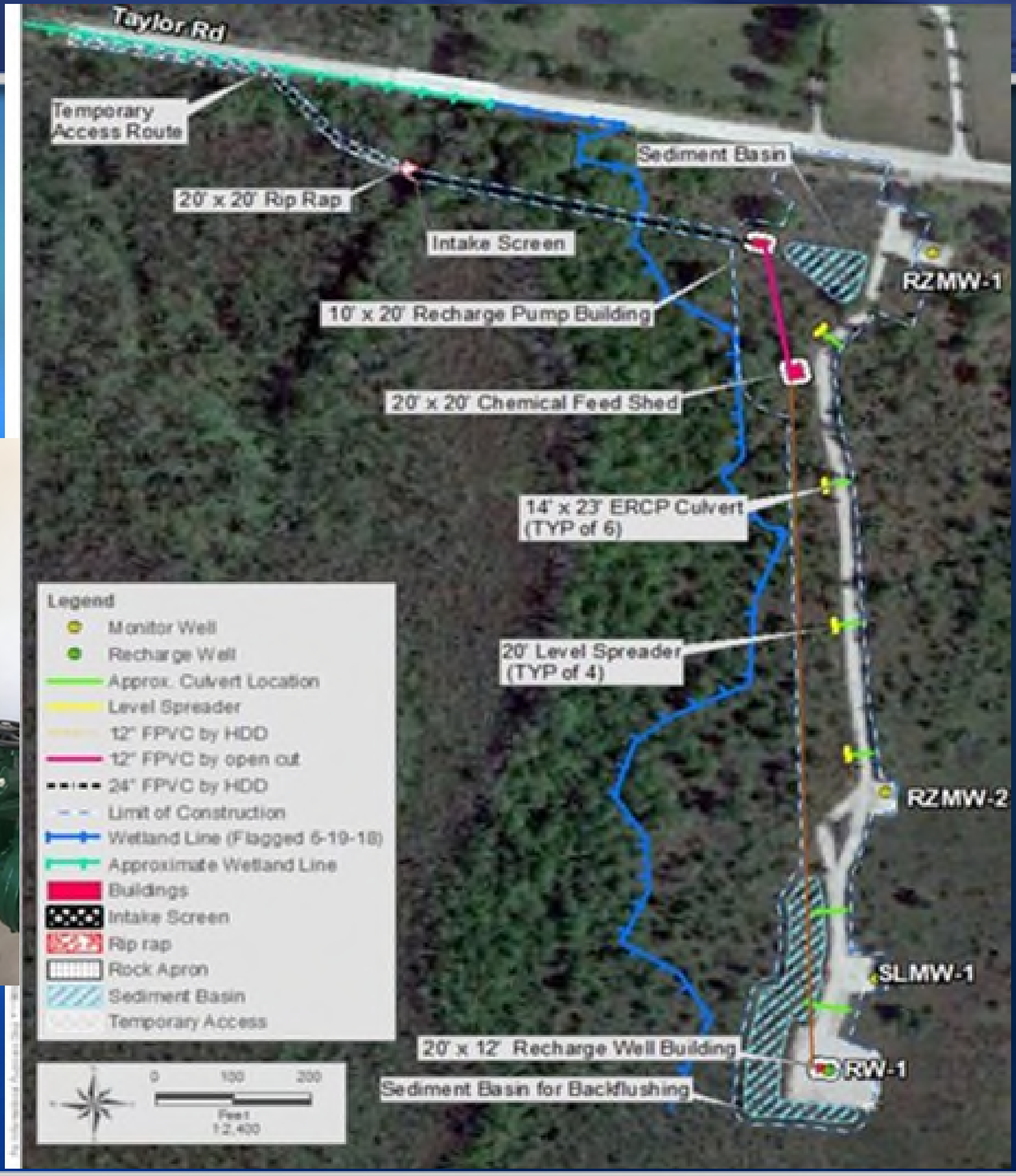


Presenter: Sammy Smith

Multiple Benefits

- Trend back toward historic hydroperiod
- Improve aquifer level in the Southern Water Use Caution Area (SWUCA)
- Saltwater Intrusion (mitigation)




Taylor Rd
Temporary Access Route
Sediment Basin
20' x 20' Rip Rap
Intake Screen
RZMW-1
10' x 20' Recharge Pump Building
20' x 20' Chemical Feed Shed
14' x 23' ERCP Culvert (TYP of 6)
20' Level Spreader (TYP of 4)
RZMW-2
SLMW-1
20' x 12' Recharge Well Building
RW-1
Sediment Basin for Backflushing
Legend
Monitor Well
Recharge Well
Approx. Culvert Location
Level Spreader
12" FPVC by HDD
12" FPVC by open cut
24" FPVC by HDD
Limit of Construction
Wetland Line (Flagged 6-19-18)
Approximate Wetland Line
Buildings
Intake Screen
Rip rap
Rock Apron
Sediment Basin
Temporary Access
0 100 200
Feet
1:2,400

Panel Discussion
3:00 PM – 3:30 PM

Public Comment
3:30 PM – 3:40 PM

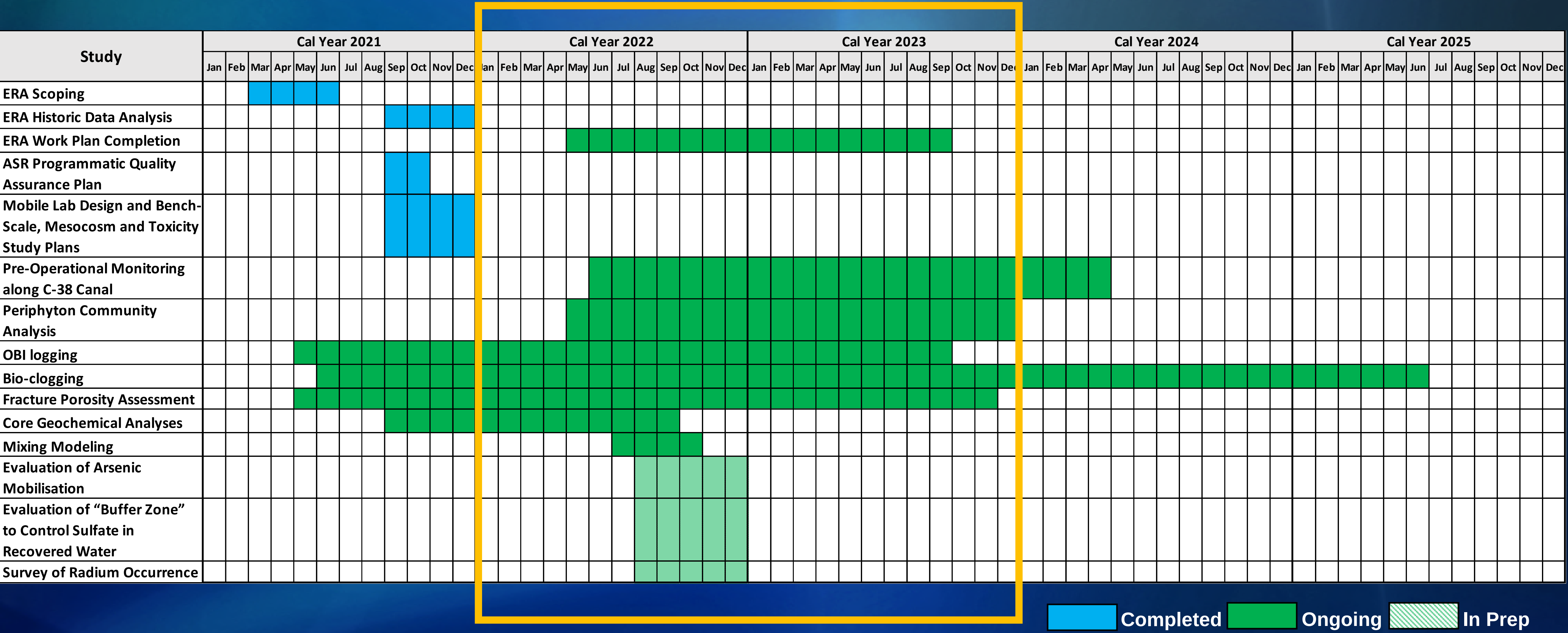
Closing Remarks and Expected Progress Over the Next Year

Presenter: Anna Wachnicka, Ph.D.
Lead Scientist/ASR Science Plan Project Manager

Contributor: Robert Verrastro, PG and Elizabeth Caneja

South Florida Water Management District, West Palm Beach, FL

Expected Progress Over the Next Year



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

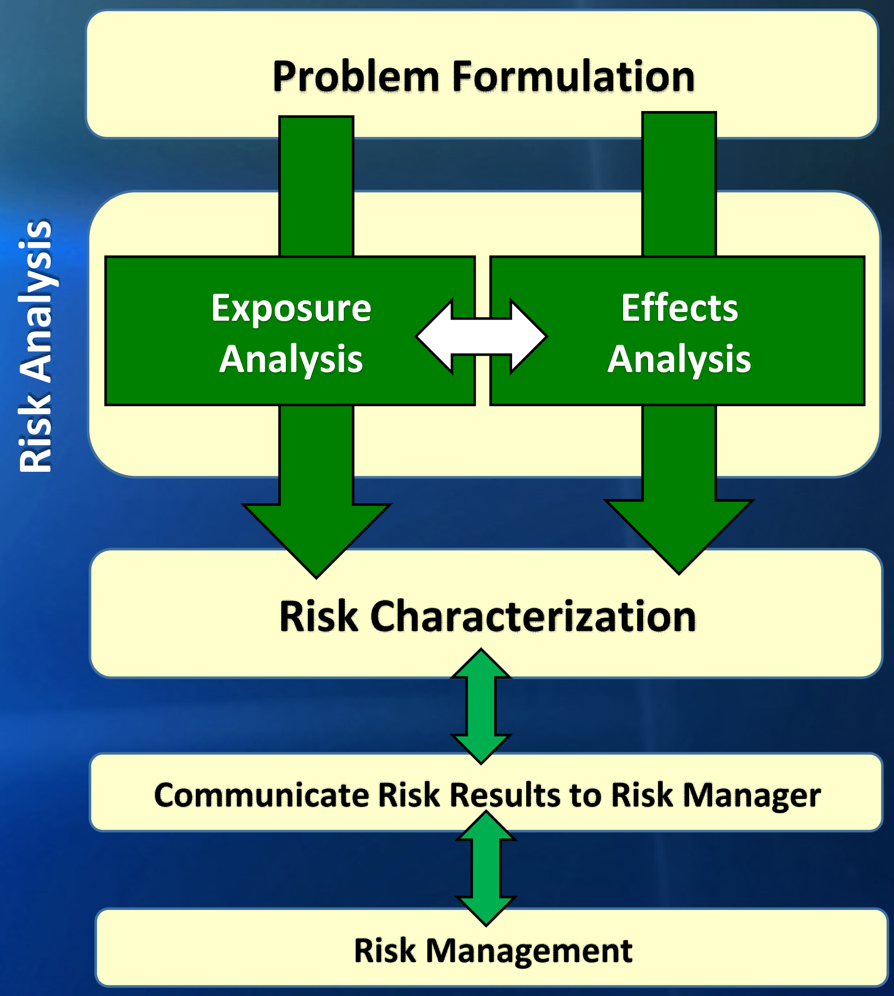
Phase 3: Data Collection

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

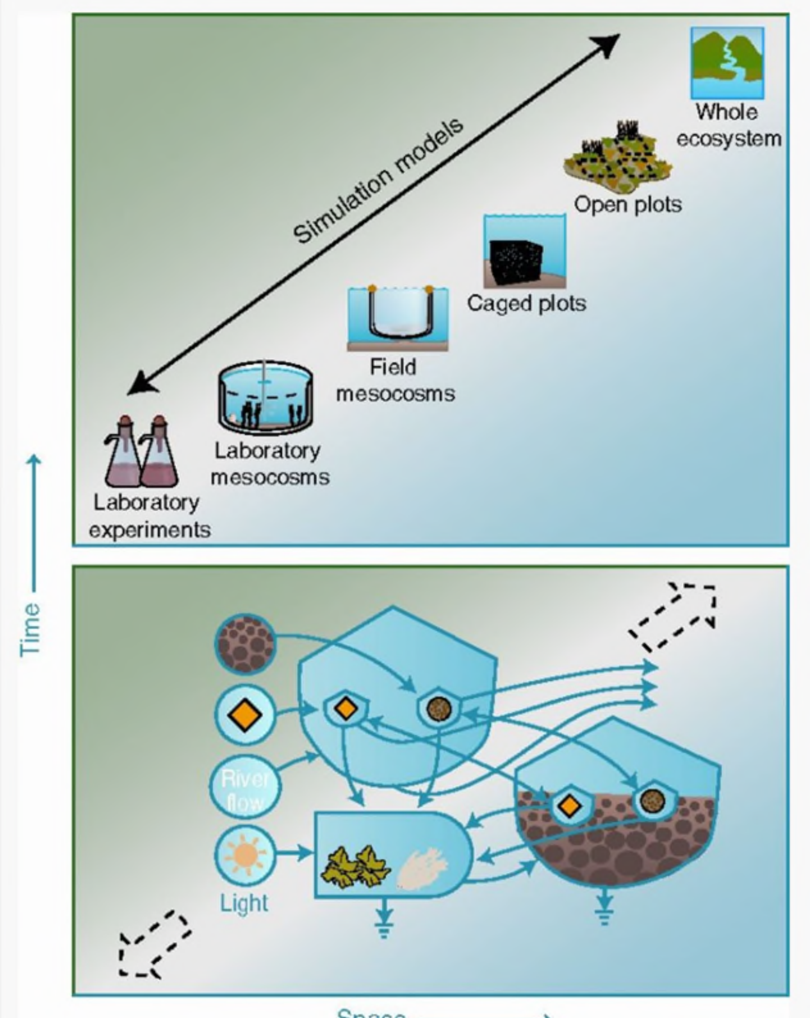
Phase 4: Quantitative Ecological Risk Assessment

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

EPA Ecological Risk Assessment Framework



Enclosed Experiments and Field Studies



Petersen et al., 2008

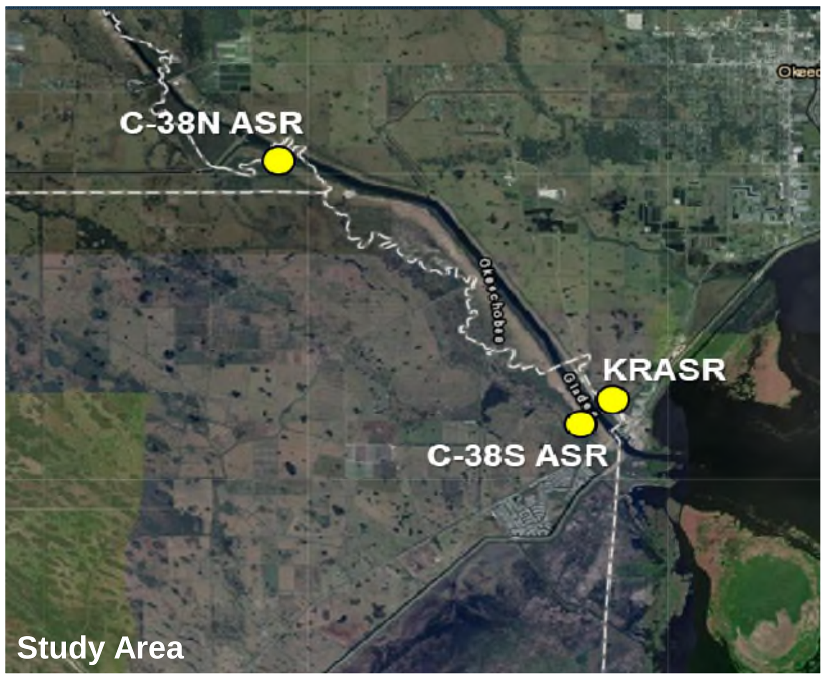
Toxicity, bioaccumulation and changes in community structure studies will be conducted at different temporal and spatial scales

Studies will be designed based on additional modeling (landscape, hydrological) scenario outcomes

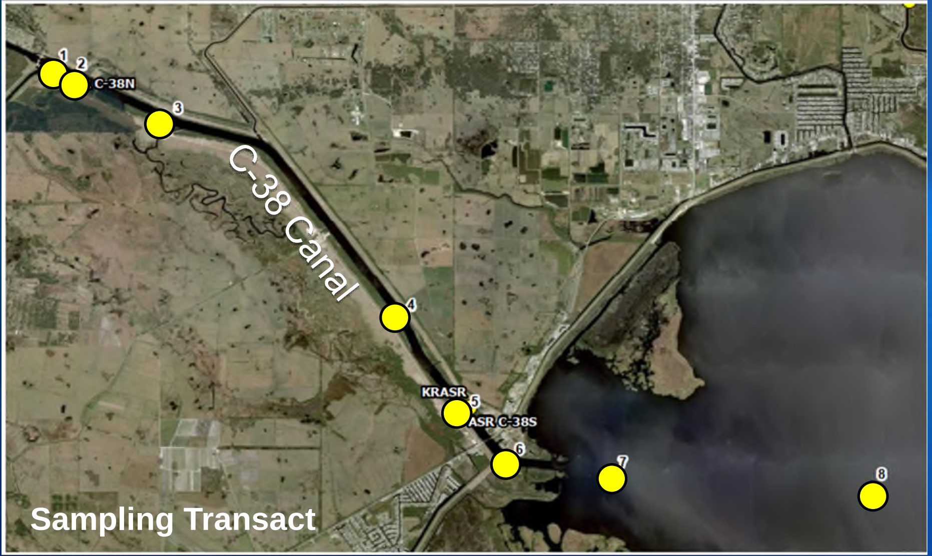
Simulation models will use data from the studies (bench-scale, mesocosms, field) to predict responses to different spatial and temporal scales

Bench-Scale Chronic Toxicity Tests and Bioconcentration Studies

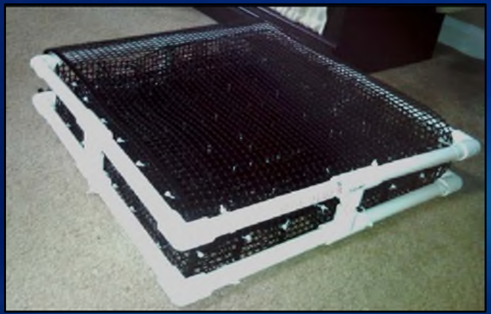
- Construction of mobile, temperature-controlled lab in 2022
- Lab experiments under variety of conditions using source, recovered and mixed water in 2023 - 2024
- Bioconcentration Studies
  - At multiple ASR locations (C-38 KRASR first in 2022 – 2024)
  - Accumulation of contaminants within tissue of selected organisms
- Bench-Scale toxicity Testing in 2023
  - Laboratory controlled setting
  - Chronic tests (Survival, Growth, Reproduction)



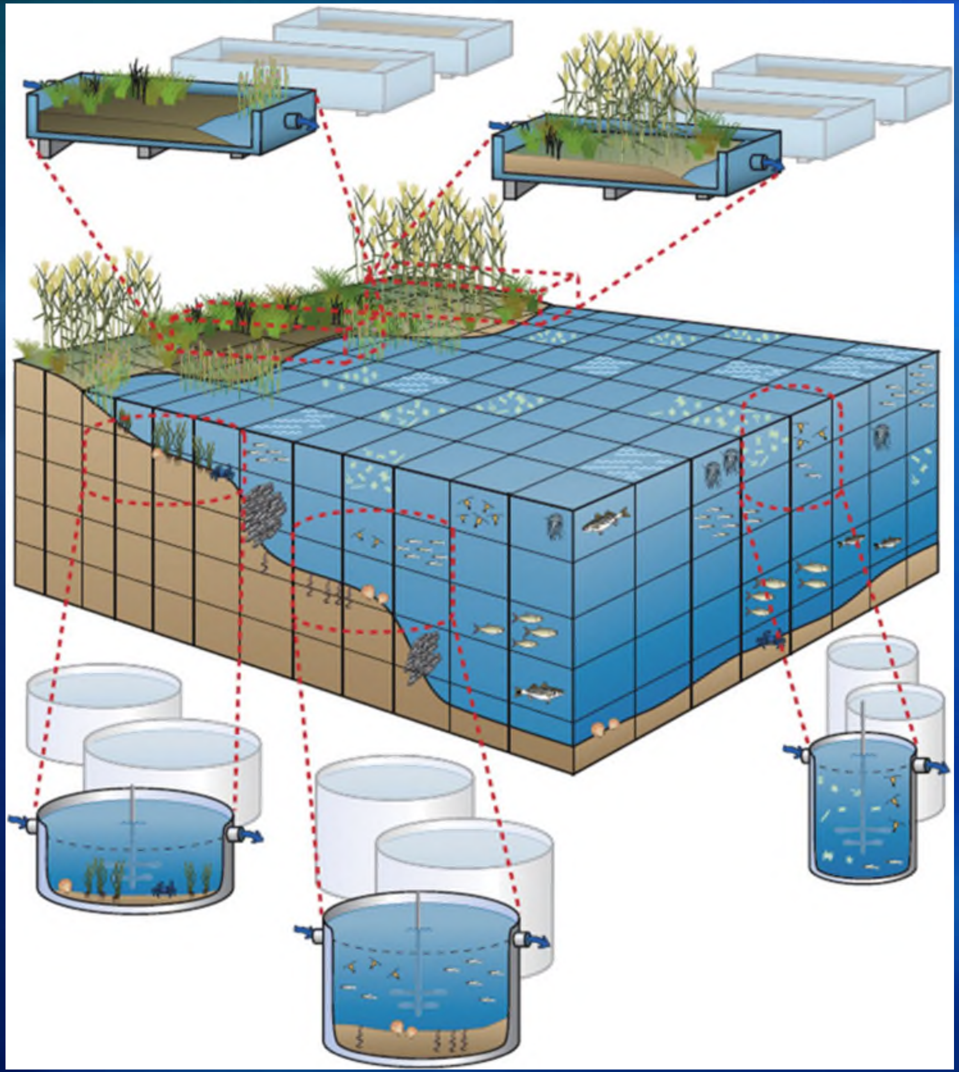
Long-Term Pre- and Post-Operational Monitoring



- 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-year Post-Operational monitoring once cycling begins (2023 - 2026)
- Examples of Planned Monitoring: periphyton, caged mussels, invertebrates, fish



Field Mesocosm Experiments

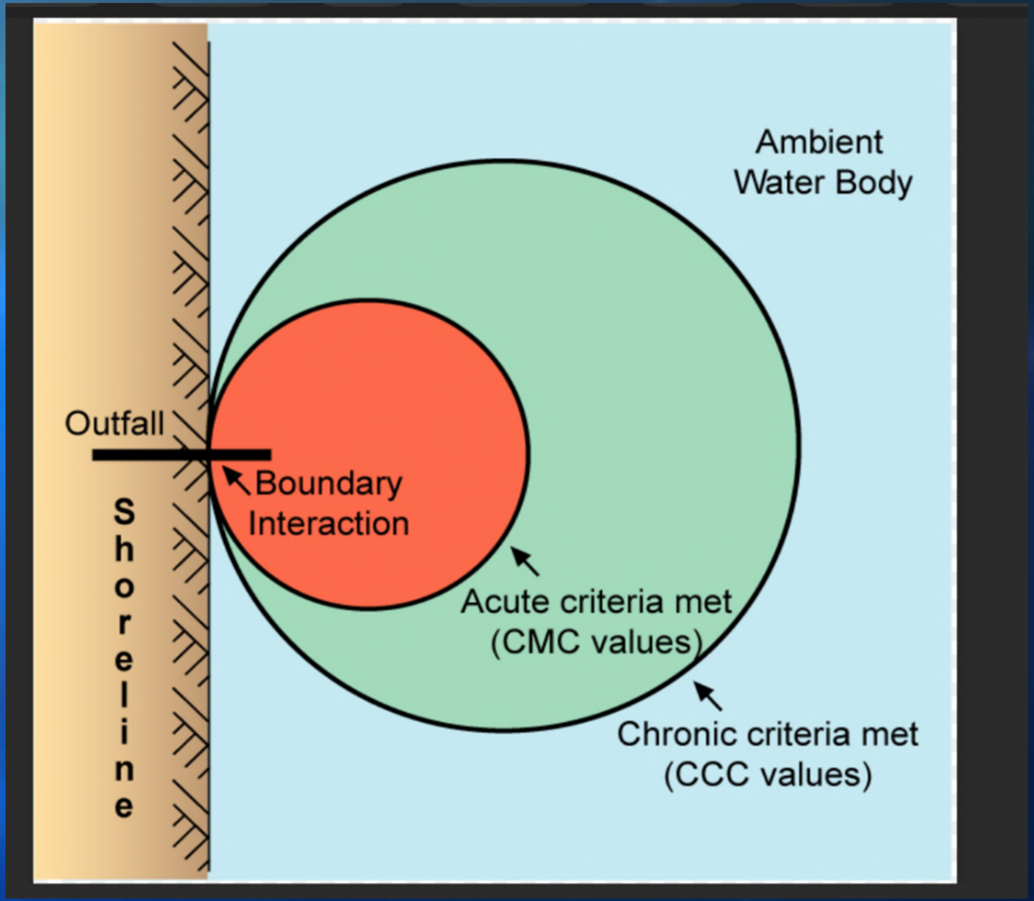


- Construction of mesocosm facility at KRASR in 2023 for conducting bioaccumulation experiments in 2024 - 2025
- Experiments designed in light of the fact that water from ASR operations will be recovered during dry, low-flow conditions
- Planned Studies
  - Effect of changes in water hardness on soft water Everglades organisms
  - Effect of recovered water on freshwater community structure and bioaccumulation (e.g. periphyton, vegetation)

Mixing Zone Modeling (2022)

Modeling Goals

- Support SFWMD ASR permitting
- Support ASR Ecological Risk Assessment
- Support ASR outfall design/blending/pre-treatment and engineering specifications



Ecological Risk Assessment Support

- Evaluate Discharge Scenarios
- Evaluate Blending Recovered Water and River Water

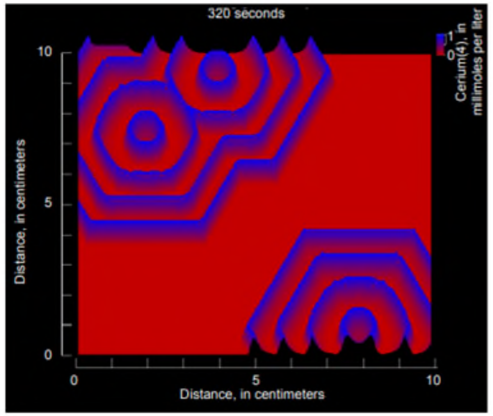
Predictive Evaluation of Arsenic Mobilization

- Mineral components will be “reacted” with treated surface water
- Utilizing core analysis from FGS and newly-completed wells
- Benchtop analysis using PHREEQC version 3.2

USGS
science for a changing world

Description of Input and Examples for PHREEQC Version 3—A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations

Chapter 43 of
Section A, Groundwater
Book 6, Modeling Techniques

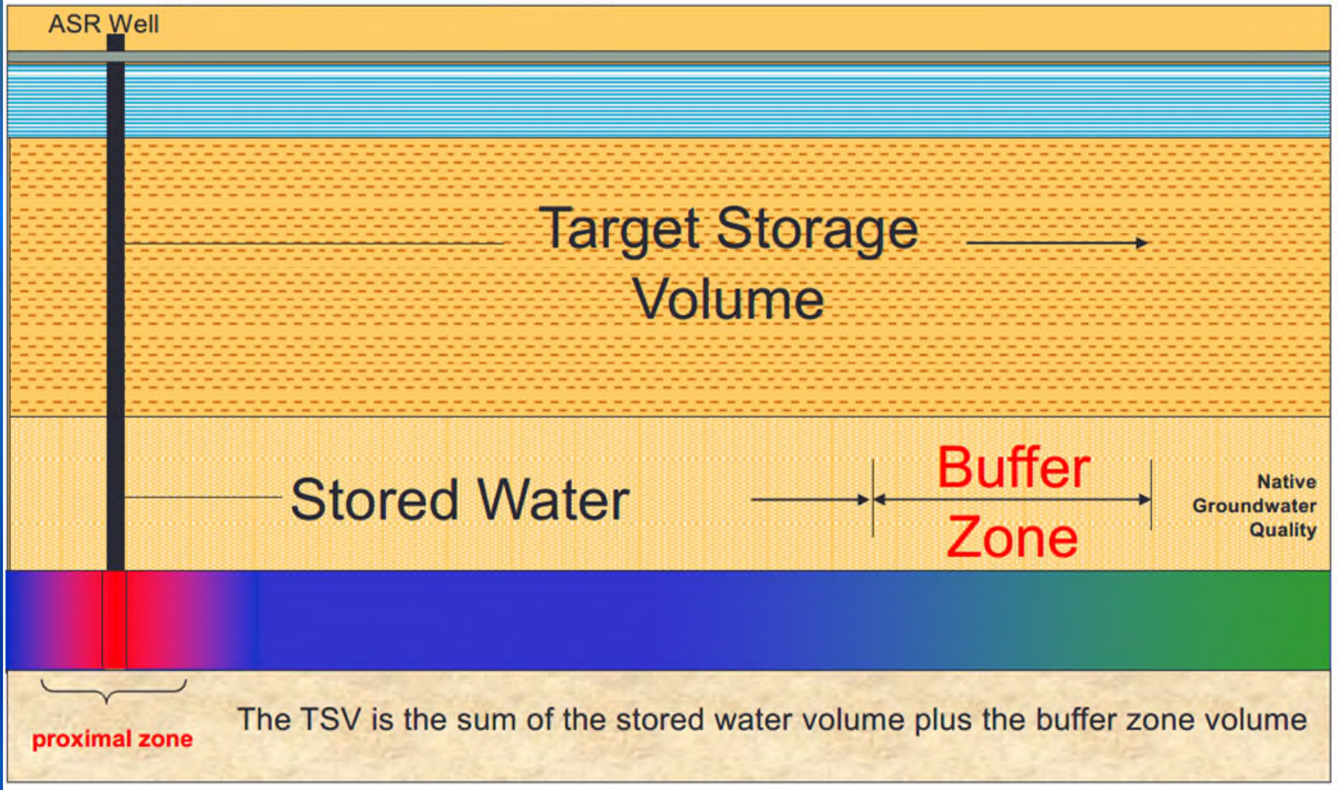


Techniques and Methods 6–A43

U.S. Department of the Interior
U.S. Geological Survey

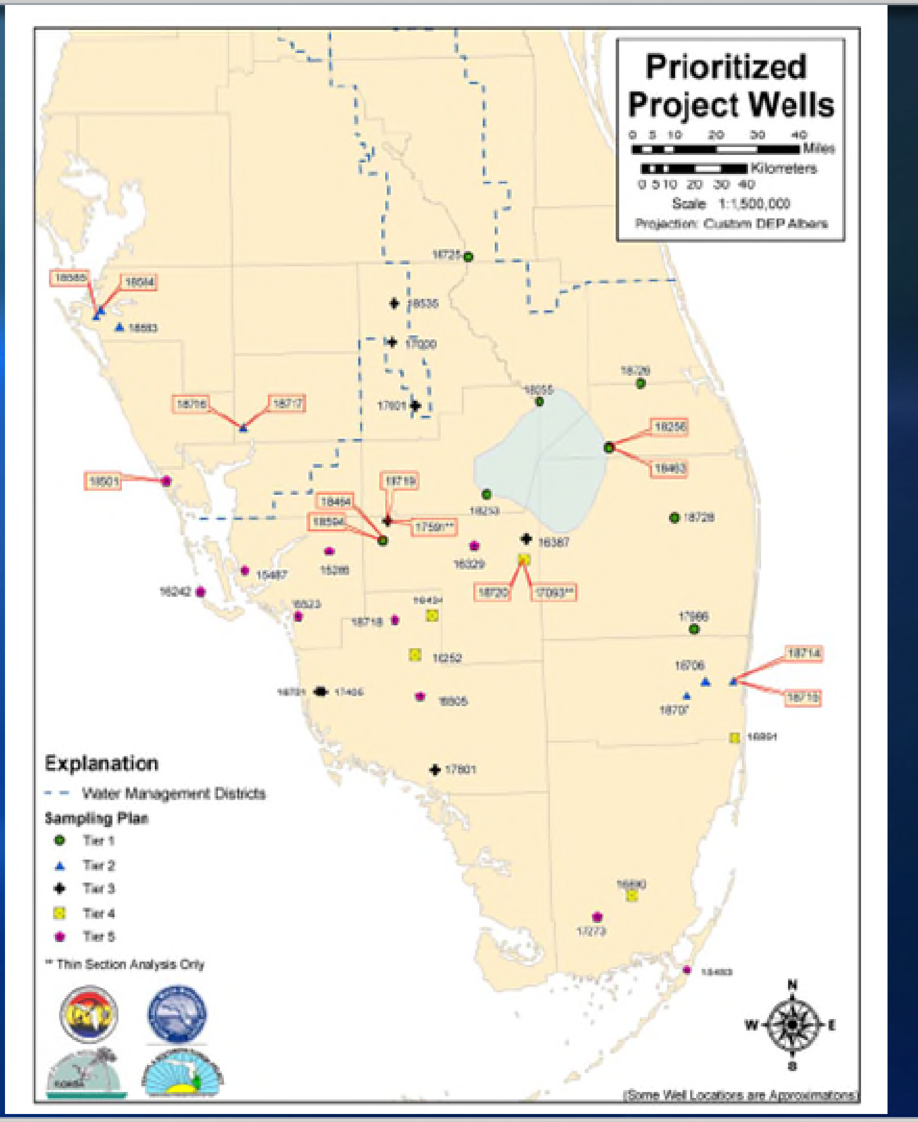
Evaluation of "Buffer Zone" to Control Sulfate in Recovered Water

- Mixing zone model will be developed to approximate sulfate concentrations in the bubble
- Calibration using data from KRASR cycle testing
- Operational strategies can be tested to maximize recovery while minimizing sulfate



Survey of Radium Occurrence in Native UFA and APPZ

- Utilizing isotopic lithologic and groundwater quality data from existing and previous monitoring networks
- Maps will be developed to designate areas of further evaluation in vicinity of LOWRP
- Will be augmented with data from newly constructed test wells



Expectations from Peer Review Panel and ASR Science Plan Next Steps

- Each panelist to prepare a memorandum – June 30th
- Chair to compile memos into the 2022 Peer Review Panel Report – July 15th
- SFWMD/USACE to revise the Draft 2022 ASR Science Plan Report – August 30th
- Reconvene with the Peer Review Panel – early September
- Release Draft Report for 30-day public review – mid- September through mid-October
- Finalize Comment/Response Matrix and release Final 2022 ASR Science Plan in November 2022

Thank You!

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