Adapting to Rising Salinity in the Floridian Aquifer

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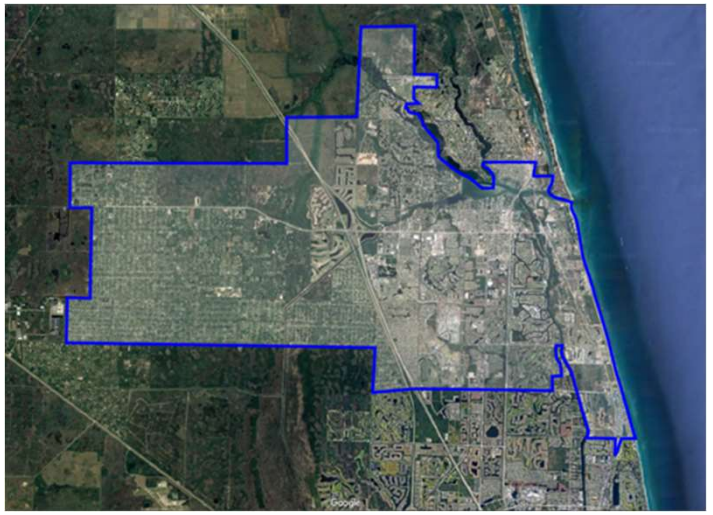
Outline

- Introduction to Jupiter Water Utilities
- FAS Wellfield Monitoring and Rehabilitation
- Wellfield Expansion
- FAS Wellhead Repairs and Re-design
- RO Plant Process Improvements

Background

- Town of Jupiter Water Utilities
  - Jupiter, FL (SE coastal region)
  - Blended water supply
    - Reverse Osmosis
    - Nanofiltration
    - Anion Exchange
  - 30 MGD capacity
  - Population served: ~90,000



SYSTEM DESCRIPTION

- Water Supply
  - 2 groundwater sources
  - Floridan aquifer
    - Deep, brackish wells
    - High in TDS and dissolved gases
  - Surficial aquifer
    - Shallow, fresh groundwater
    - High in hardness, TOC, color and iron

Floridan aquifer water supply well

Surficial aquifer water supply well

Overview of Treatment

Facility Designed to Produce 30 MGD

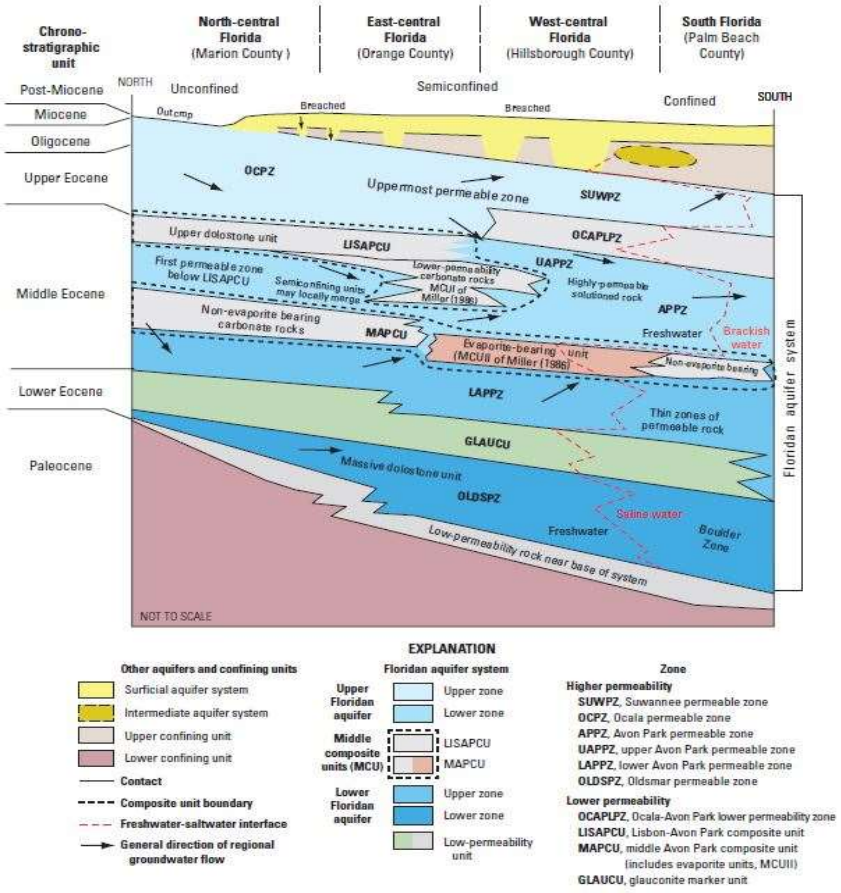
13.7 MGD Reverse Osmosis Process
Constructed in 1990
Expanded in 1996 & 2005

1.8 MGD Anion Exchange Process
Constructed in 2000

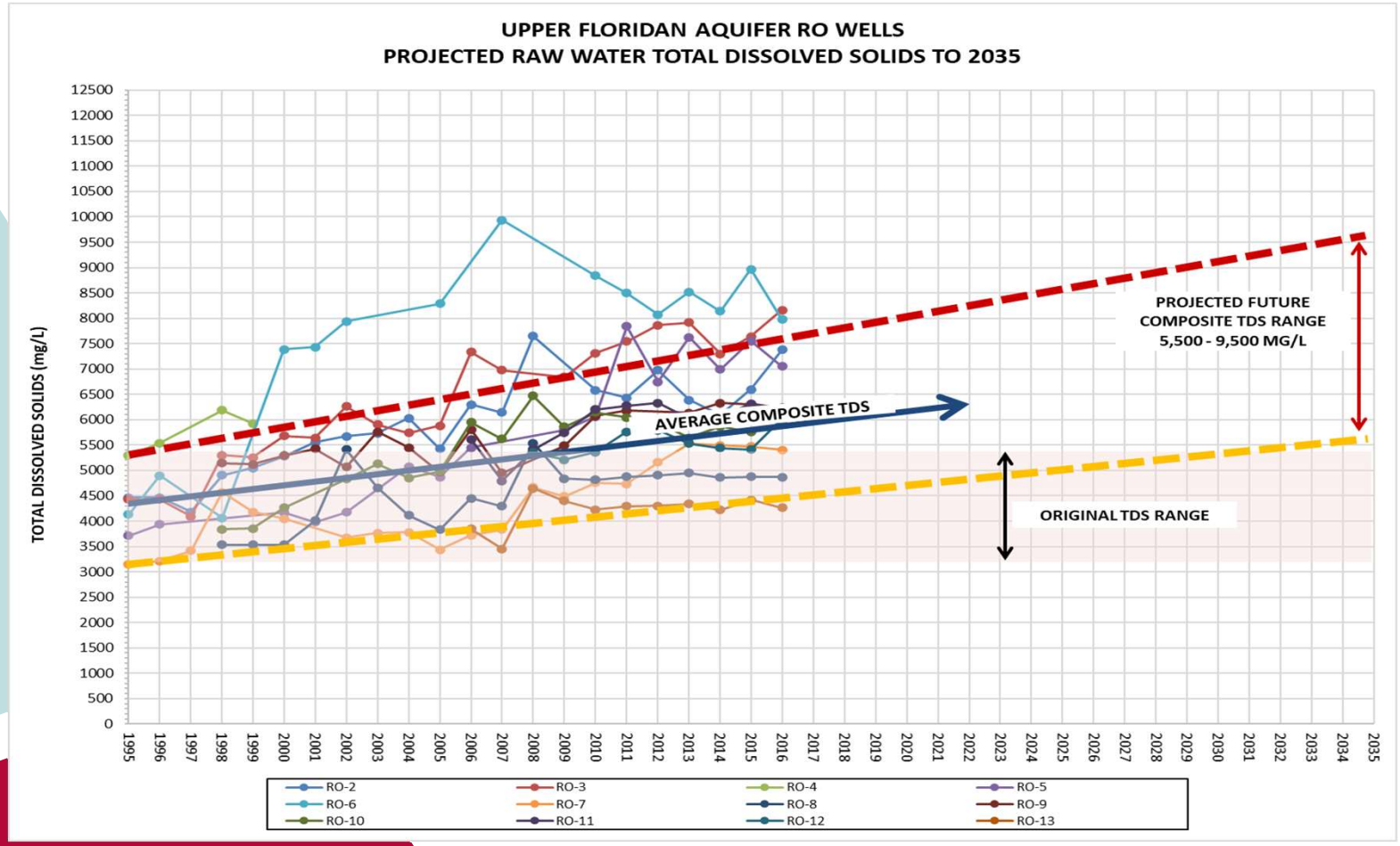
14.5 MGD Nanofiltration Process
Constructed in 2010

The UFA in South Florida

- Confined Carbonate Aquifer
- Top of Aquifer Between ~800 ft and 1100 ft.
  - ~ 500-700 feet thick brackish water zone
  - Artesian with Static WL's +20-30 Feet ALS.
- Brackish Water Quality
  - Chloride Concentration ~500-8000mg/L



Degrading FAS Water Quality



UFA WQ Degradation in S FL Wells

- WQ degradation over time due to:
  - Vertical intrusion of poorer WQ from above, below and laterally.
  - Over pumping
  - Wellfield Interference.
  - High Drawdown
  - Declining Well Performance
- What to do about WQ Degradation:
  - Decrease pumping rates
  - Add more wells.
  - Rehabilitation, acidization deepen borehole, deepen casing (liner), back plugging.

UFA Wellfield Testing Program

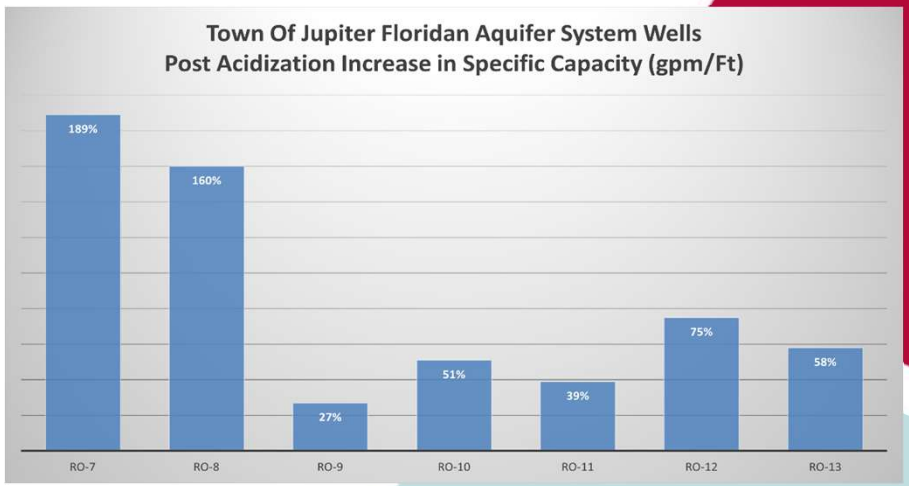
- Annual water quality and well performance testing started in 2014.
- Identified wells with performance and water quality changes.
- Recommendations to reduce the rate of WQ degradation and improve well performance included:
  - Well Rehabilitation/Acidization
  - Reducing pumping rates (from ~2.0 to 1.0-1.5 MGD/Well)
  - Wellfield Expansion (increase number of wells)

UFA Well performance

- Well Perf. Degradation = Reduced Raw Water Capacity
- Specific Capacity = GPM/Ft. of Drawdown (DD)
- < Specific Capacity = > DD
- > DD = Lower Pumping Rate
- Individual well pumping rates reduced from 1.5-2.0 MGD to 1.0-1.5 MGD
- Total Raw Water Cap. reduced from ~20.5 to 16.0 MGD.
- Acidization of UFA wells increases specific capacity and reduces DD.

UFA Well Rehab. (Acidization)

- Acidization Program (2016-2021).
- Acidized 9 Wells using between 10,000-20,000 gallons 32% HCl per Well
- Increased Well Specific Capacities by 27% -189%
- Post Acidization Pumping Water Levels at or above land surface at pumping rates between 1.0 and 2.0 MGD.

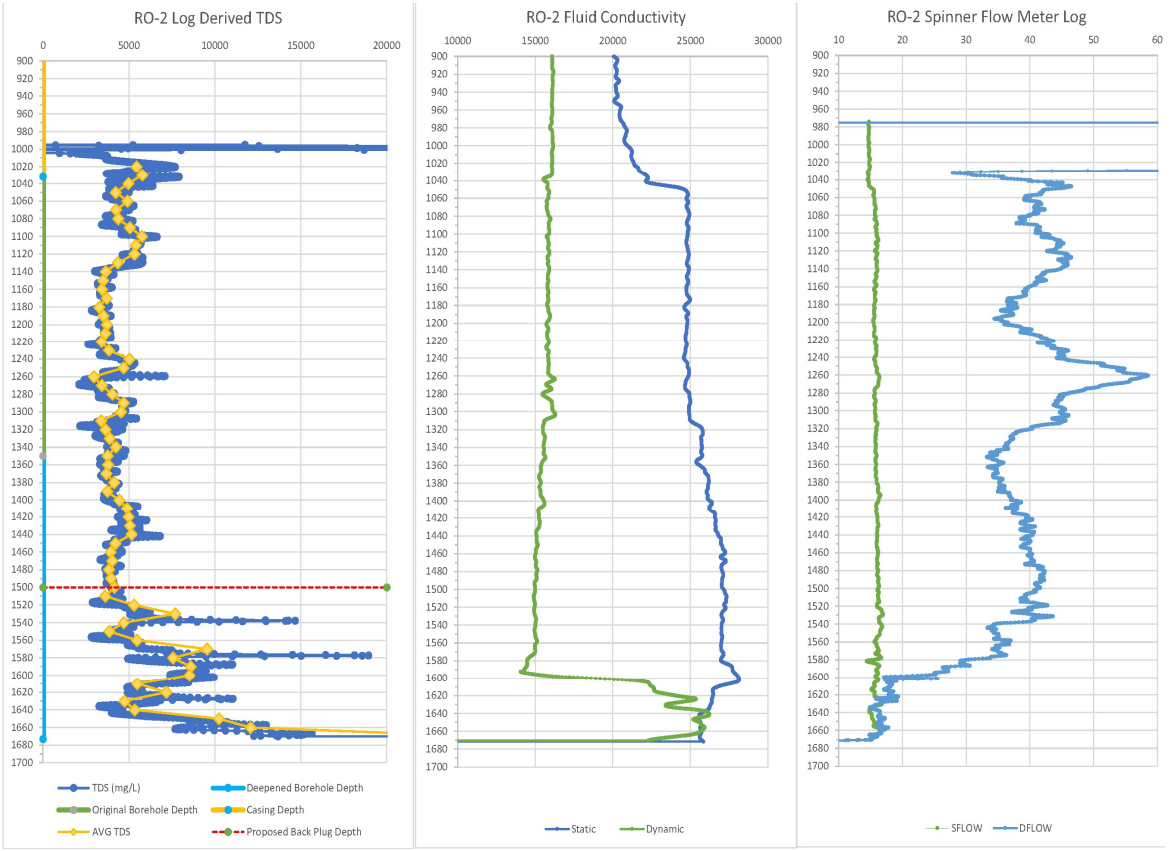


UFA Well Rehab. (Back Plugging)

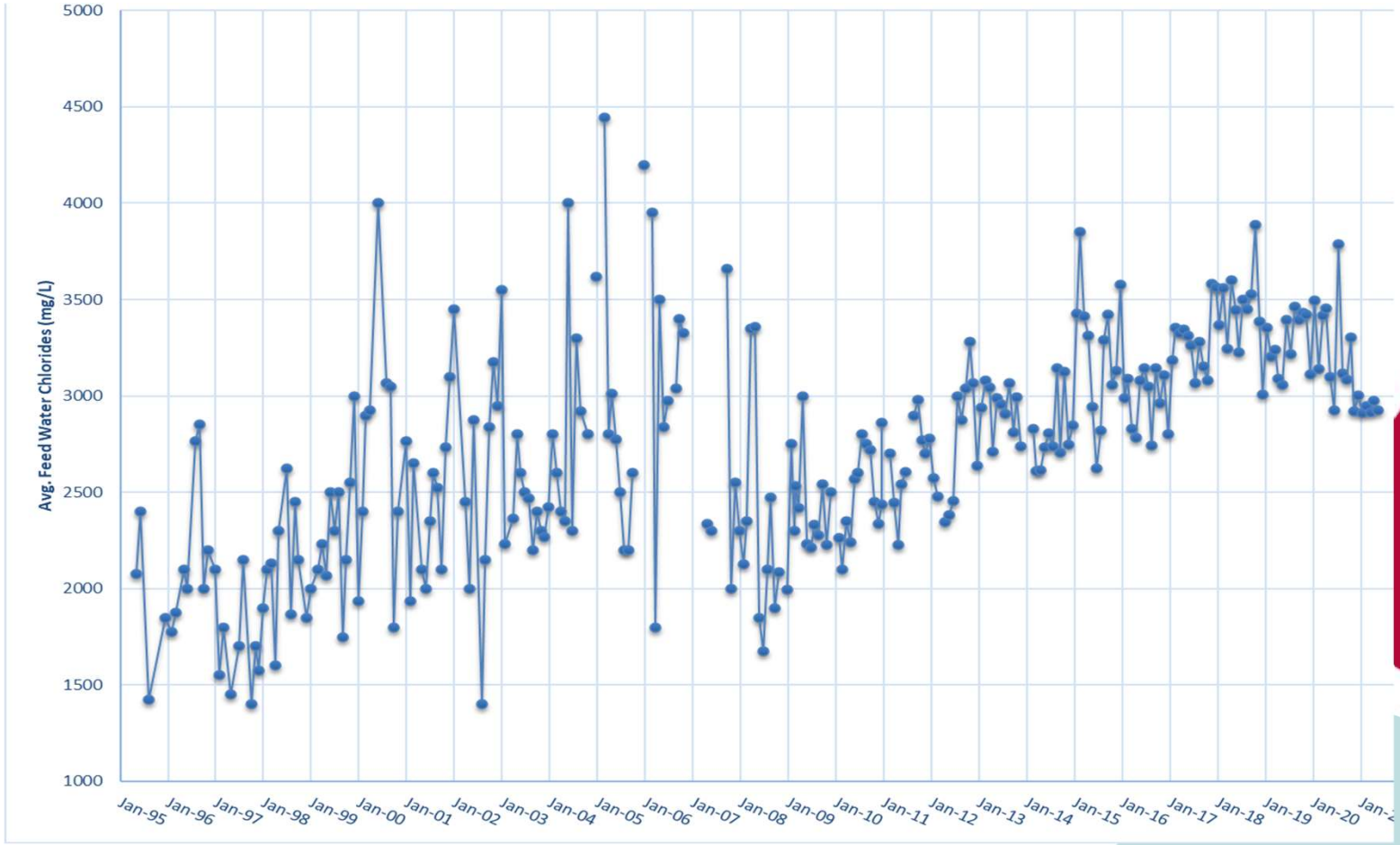
- RO-2 & RO-3: longest serving and historically some of the best producing wells.
- Deepened in 1997.
- Between 1997 and 2020 Chlorides increased by ~260% (2020 TDS ~5000-5500 mg/L)
- Current membranes could not handle RO-2 & Ro-3 raw water resulting in ~3 MGD raw water loss from existing wells!

UFA Well Rehab. (Back Plugging)

- Pre Rehab pump testing investigation: TDS higher at lower pumping rates.
- Geophysical logging investigation: TDS higher & majority of flow at bottom of borehole.
- Results: RO-2 TDS and specific capacity reduced by ~54% by ~29%.
- Results: RO-3 TDS and specific capacity reduced by ~38% by ~53%.
- Rehab effort reclaimed 2 MGD of treatable raw water capacity from existing wells!



UFA Well Rehab. (Water Quality)



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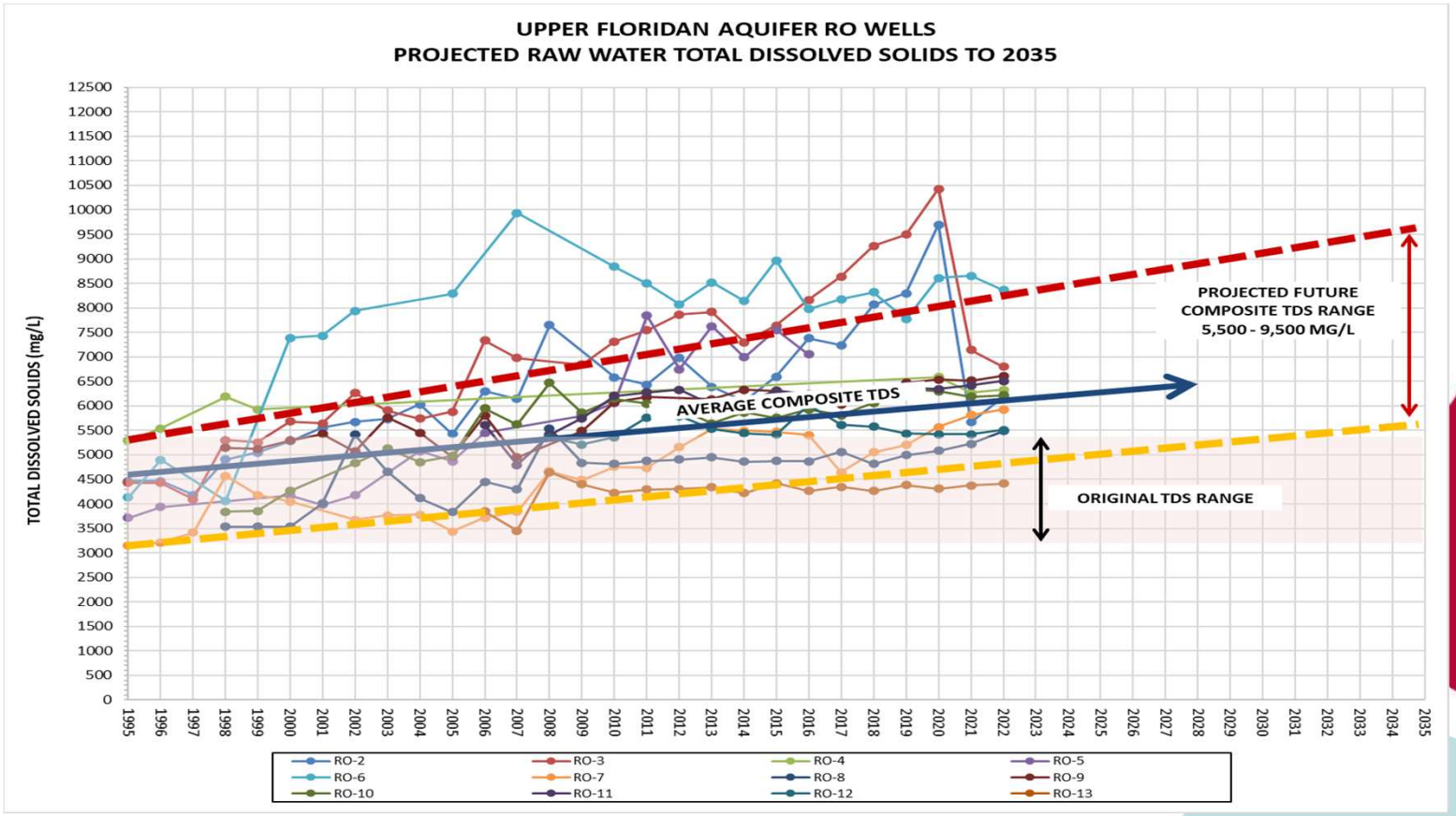
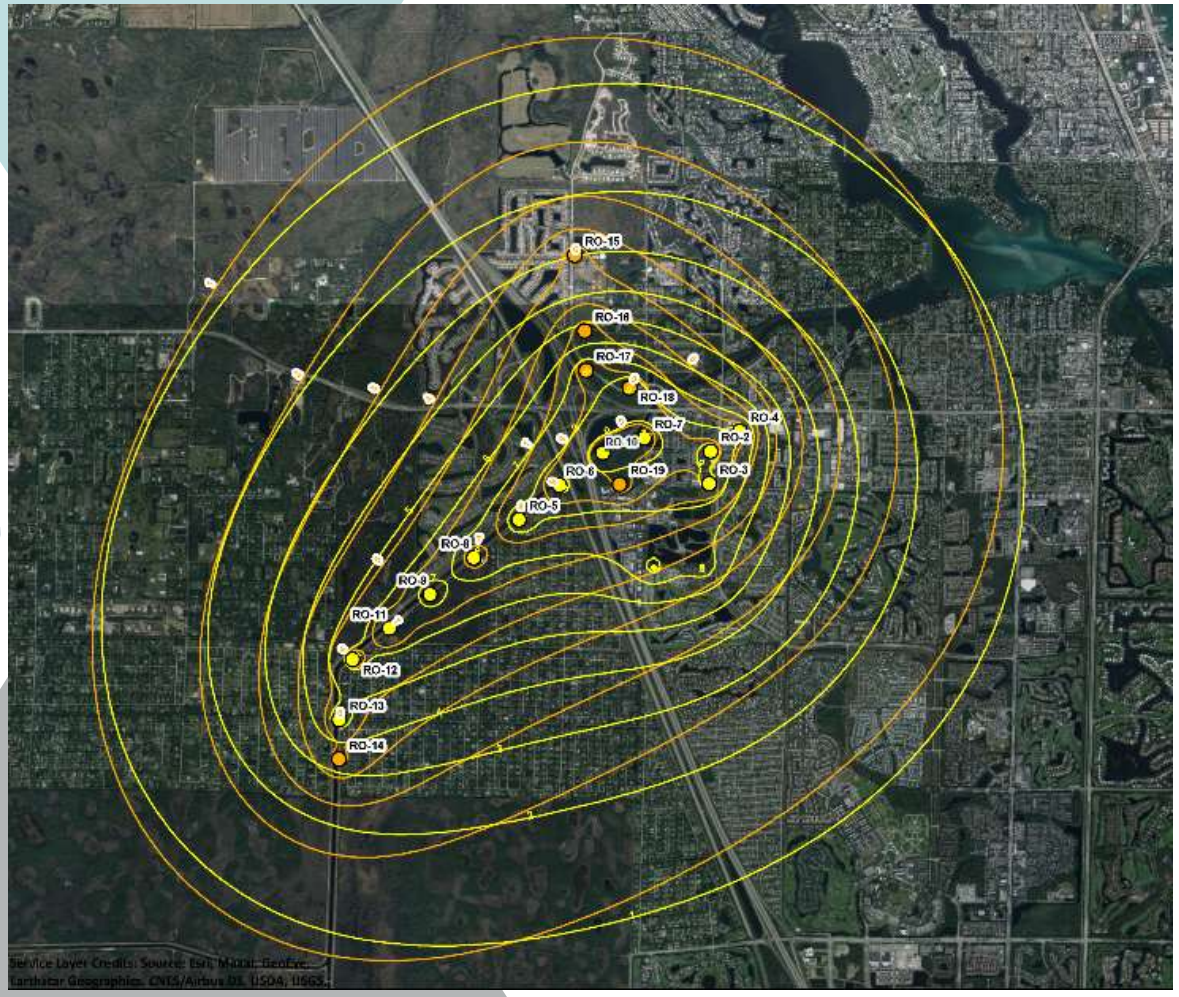


FAS Wellfield Expansion



Legend

- Modified Locations of Proposed FAS Wells
- Location of Existing FAS Wells
- Model-Predicted Drawdown in FAS with Currently Permitted 16 FAS Wells Pumping 18.5 MG (1-ft Cl)
- Model-Predicted Drawdown in FAS with 18 FAS Wells Pumping 18.5 MGD (1-ft Cl)

0 2,600 5,200 Feet

Original FAS Wellhead Design (FRP Well Casing)

- First Generation Well Design
- Constructed in late 1980s to early 1990s
- FRP Casings and carbon steel surface casings

Original FAS Wellhead Design (PVC Well Casing)

- Second Generation Well Designs
- Certa-Lok PVC Casings and carbon steel surface casings

Wellhead Deterioration (FRP Well Casing)

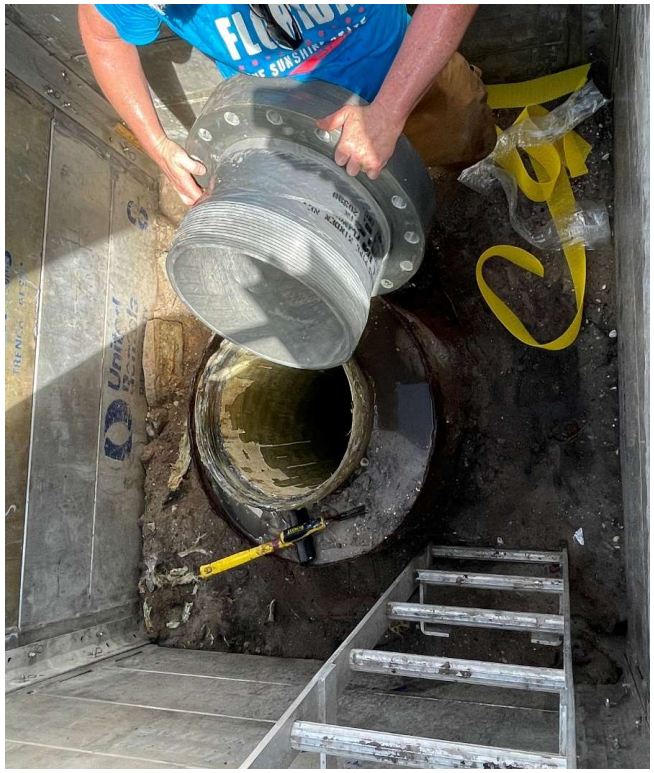
- Deterioration of FRP
- Evidence of casing leak

Wellhead Deterioration (PVC Well Casing)

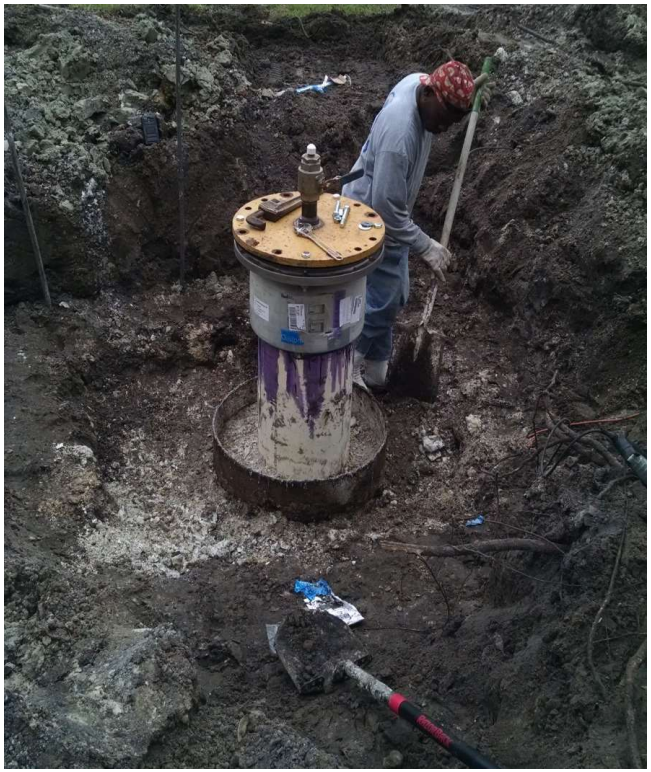
- PVC Casing Deterioration

Wellhead Repair/Redesign

FRP Casing Repair



FRP Casing Repair



PVC Casing Repair

Wellhead Repair/Redesign

New well casing

New surface casing

Wellhead Repair/Redesign

Well pad reinforcement with gusset plate to surface casing

Wellhead support table and flushing tee

Wellhead Repair/Redesign

Vertical Turbine Pump Application

Horizontal End Suction Pump Application

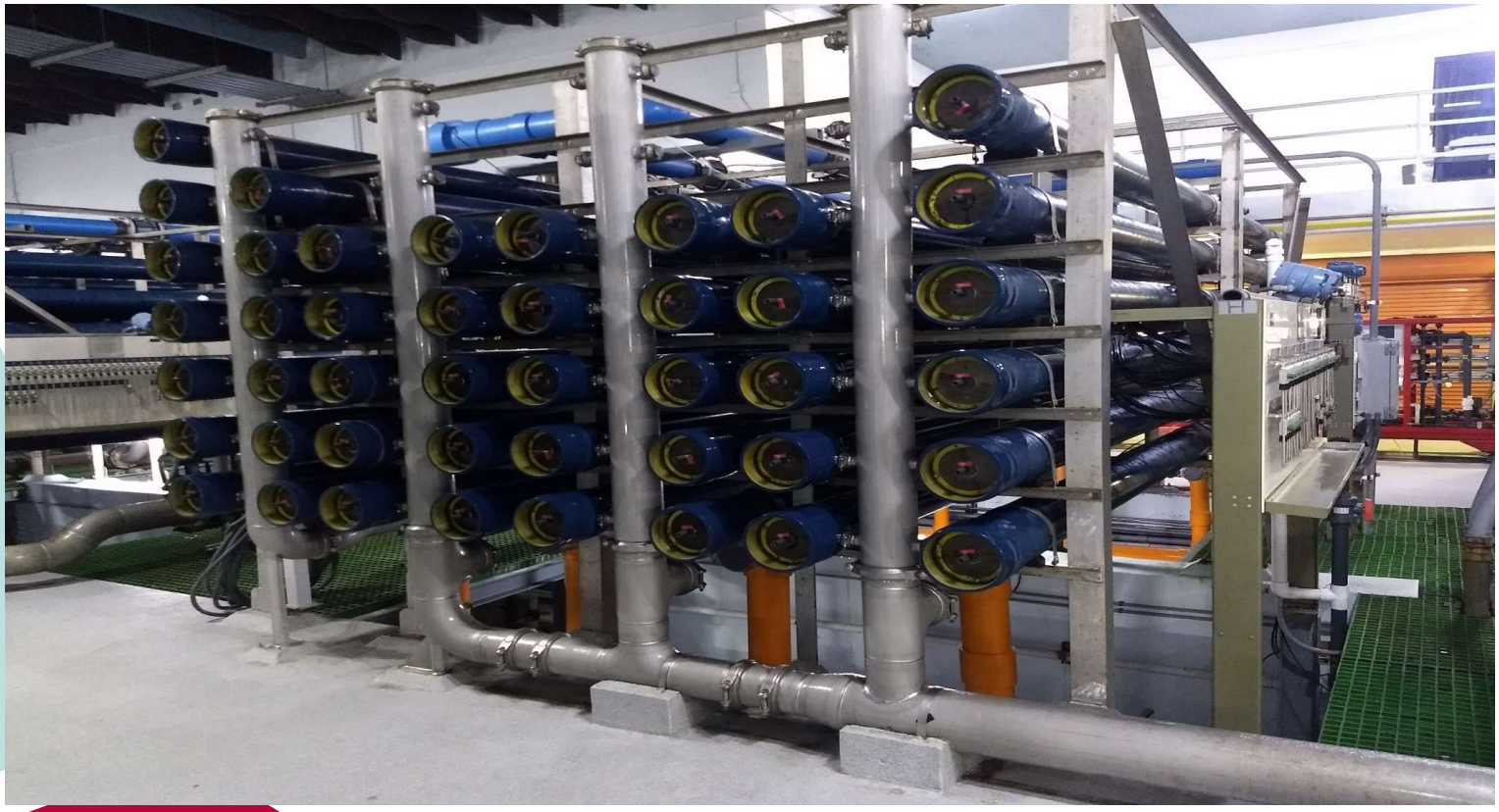
Reverse Osmosis Treatment

- Master Plan Development
- Three Phased Approach
  - Phase 1: 4,700 to 7,300ppm TDS
  - Phase 2: 7,300 to 8,500ppm TDS
  - Phase 3: 8,500 to 11,500ppm TDS

Reverse Osmosis Treatment

Bank I includes Trains A, B, C, and D

Reverse Osmosis Treatment



Bank II includes Trains E, F, G, and H

Reverse Osmosis Treatment

Train I

Phase 1

- Bank I Membrane Replacement
- Bank 1 Array Change
  - Match Bank 2
- ERD Replacement
- Interstage Piping Replacement
  - Serve Through Phase 3

Master Plan Phase	Raw Water Quality TDS (PPM)	Min. Feed Pressure (psi)	Max. Feed Pressure (psi)	Min. Boost Pressure (psi)	Max. Boost Pressure (psi)
1	4,700 - 7,300	162.2	238.6	55.5	127

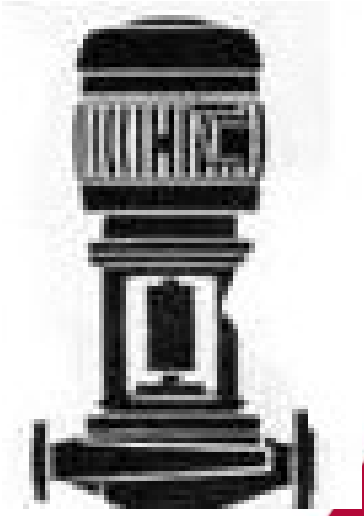
Phase 2

Membrane Replacement

Master Plan Phase	Raw Water Quality TDS (PPM)	Min. Feed Pressure (psi)	Max. Feed Pressure (psi)	Min. Boost Pressure (psi)	Max. Boost Pressure (psi)
2	7,300 - 8,500	234.6	282	117.7	140

Phase 3

- Interstage Booster Pump
- Elevate Raw Water Pressure
- Pressure Vessel Replacements
- Stage 2 Permeate Second Pass



Master Plan Phase	Raw Water Quality TDS (PPM)	Min. Feed Pressure (psi)	Max. Feed Pressure (psi)	Min. Boost Pressure (psi)	Max. Boost Pressure (psi)
3	8,500 - 11,500	231.1	362.1	103	144.5