SWIFT Managed Aquifer Recharge: From Influent to the Aquifer and Everything In Between

Dan Holloway, P.G.|HRSD

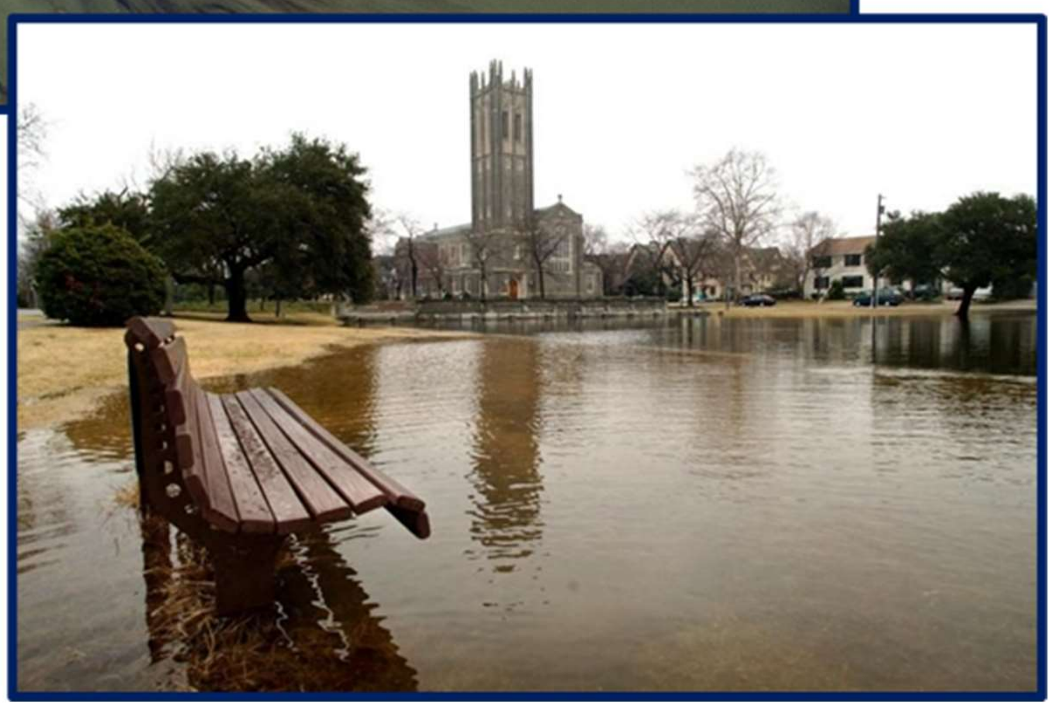
Groundwater Protection Council
ASR-MAR Workgroup,
January 16, 2024

About Us

- Population served: 1.9 million
- 14th Largest Wastewater Utility
- Political Subdivision created in 1940
- Serves 20 Cities and Counties
- Combined wastewater treatment capacity: 225 million gallons/day
- Operate 8 major and 6 smaller treatment plants and more than 100 pump stations
- Separate Sanitary System with > 500 miles of pipe

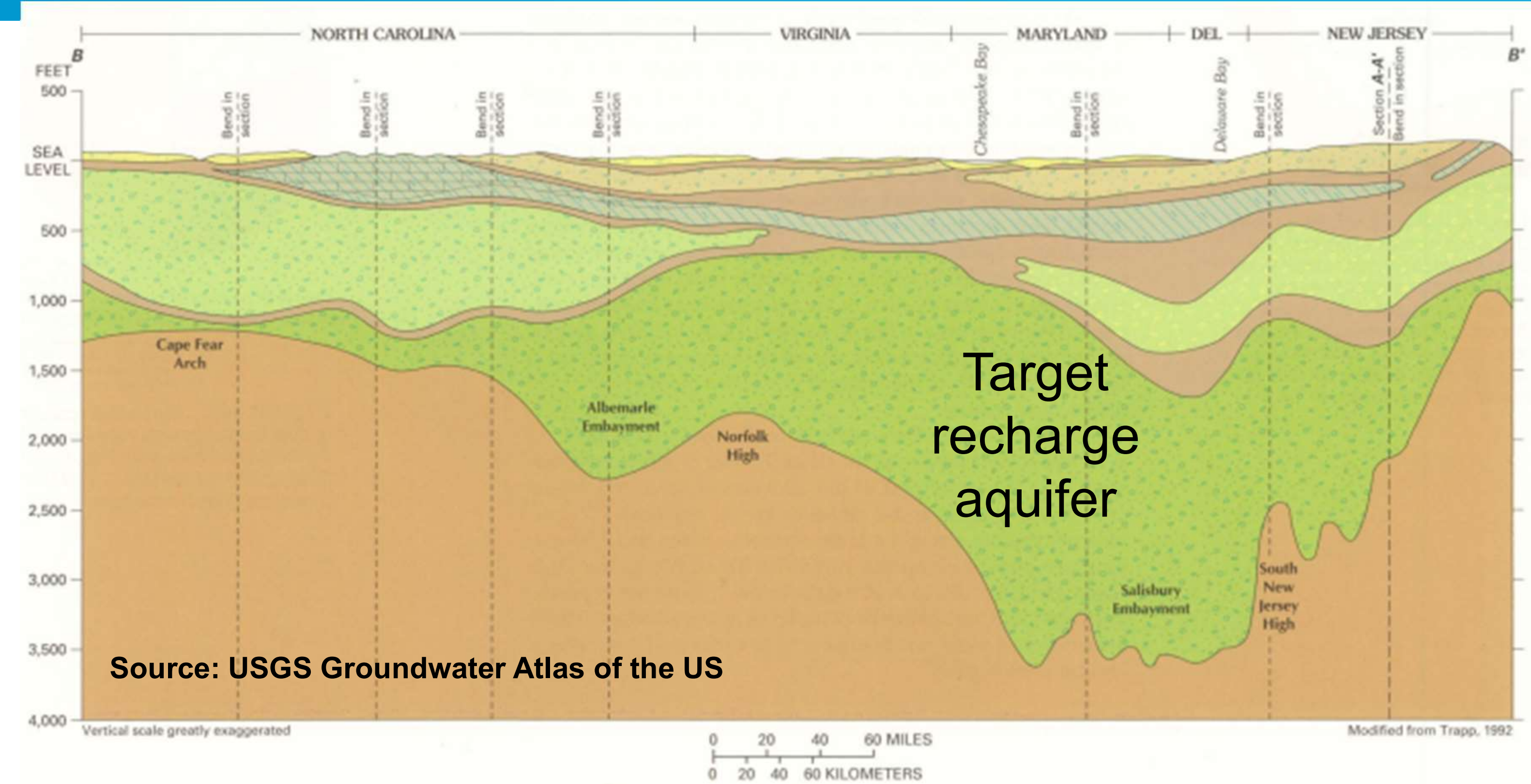
Service area is approx. 5,000 square miles

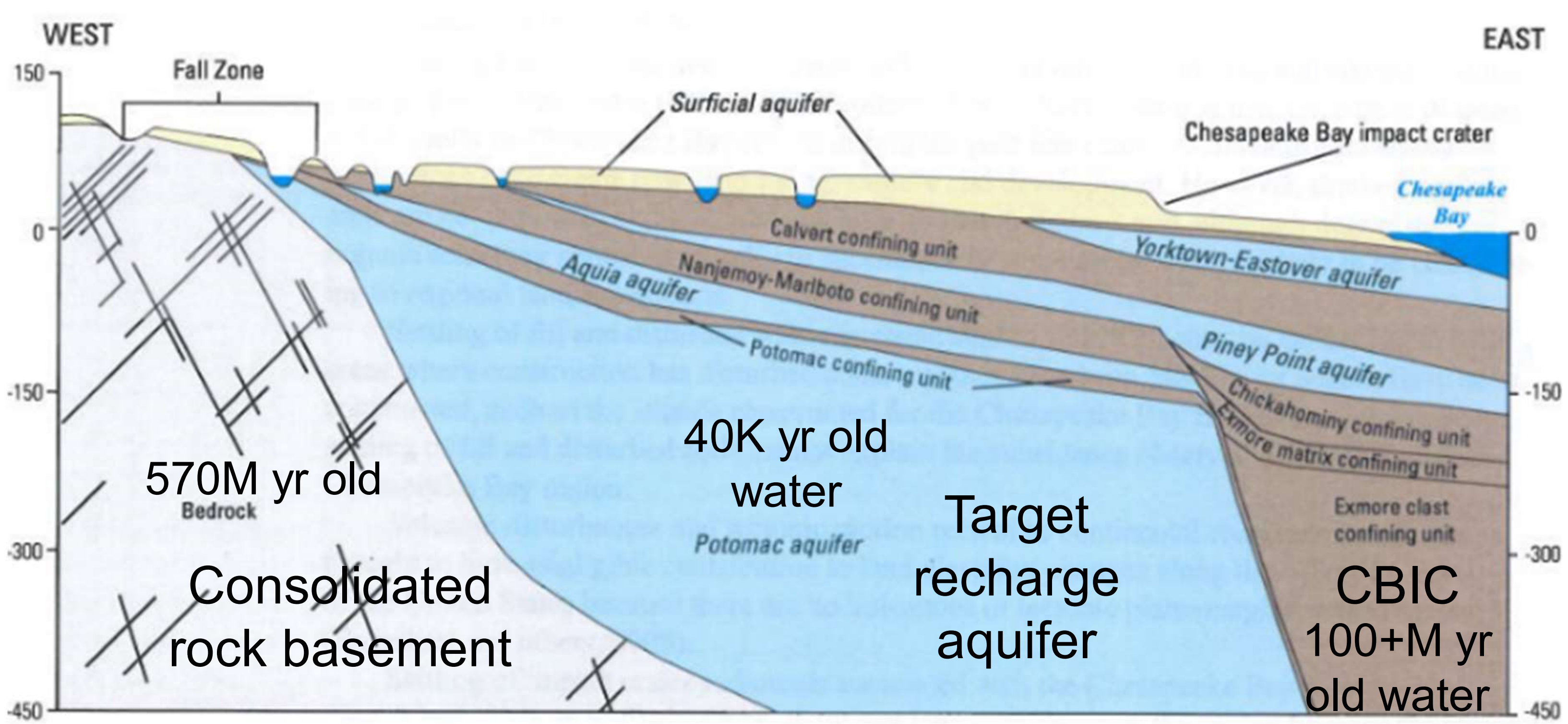
Water Challenges for Coastal Virginia



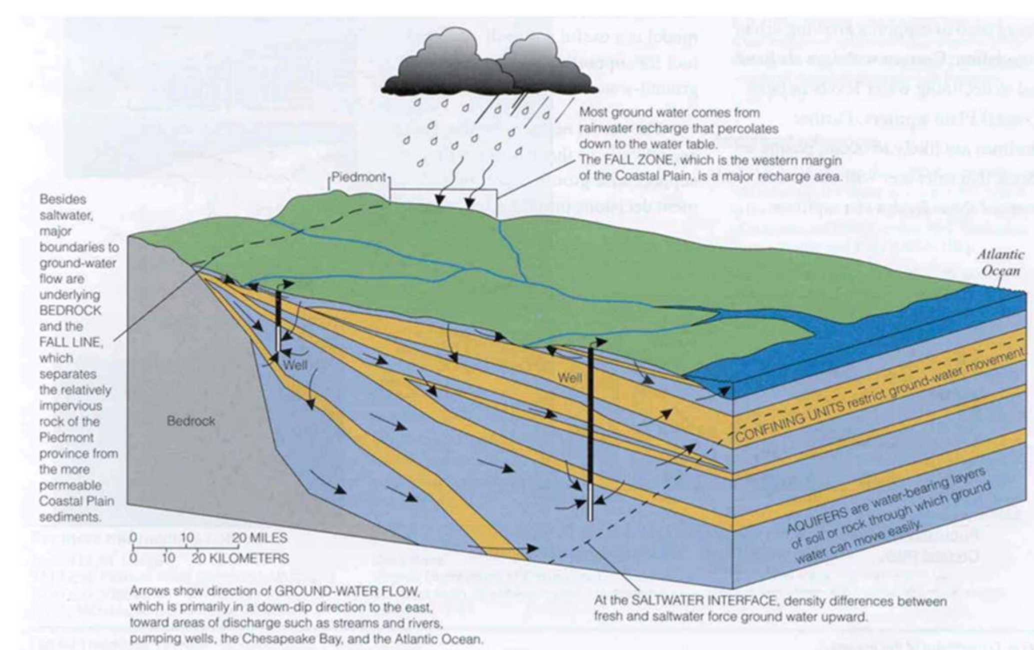
- Restoration of the Chesapeake Bay
  - Harmful Algal Blooms
  - Localized bacteria impairments (beaches, oyster grounds)
  - Urban stormwater retrofits (cost and complexity)
- Compliance with Federal enforcement action
  - Wet weather SSOs
  - Regional approach
- Adaptation to sea level rise
  - Recurrent flooding
  - More severe flooding
- Depletion of groundwater resources
  - Potential dewatering of confined aquifers
  - Potential for saltwater contamination
  - Causes land subsidence

Mid-Atlantic Coastal Plain Aquifer System

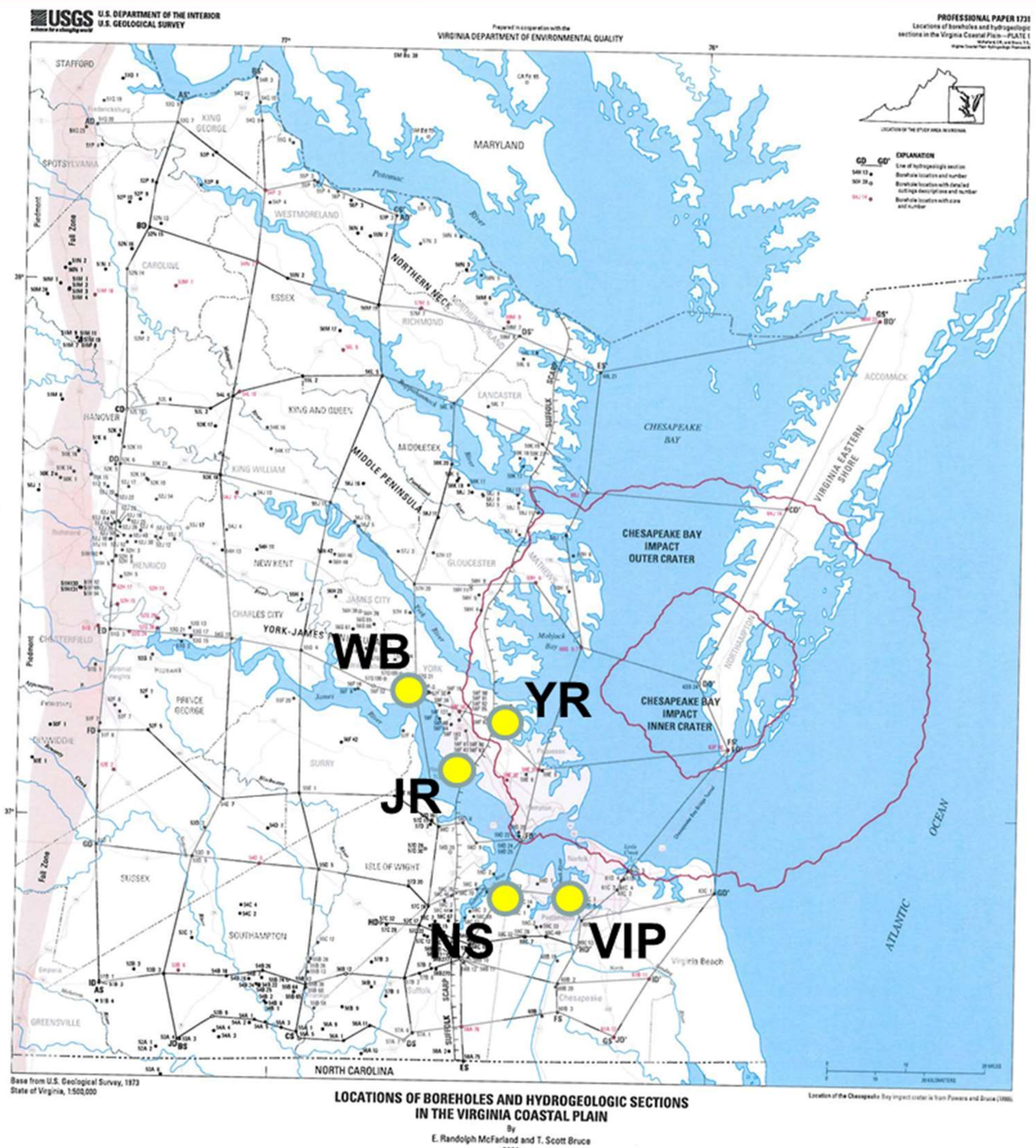




Source: USGS Professional Paper 1731, McFarland and Bruce 2006



Visitors from outer space can make an impact



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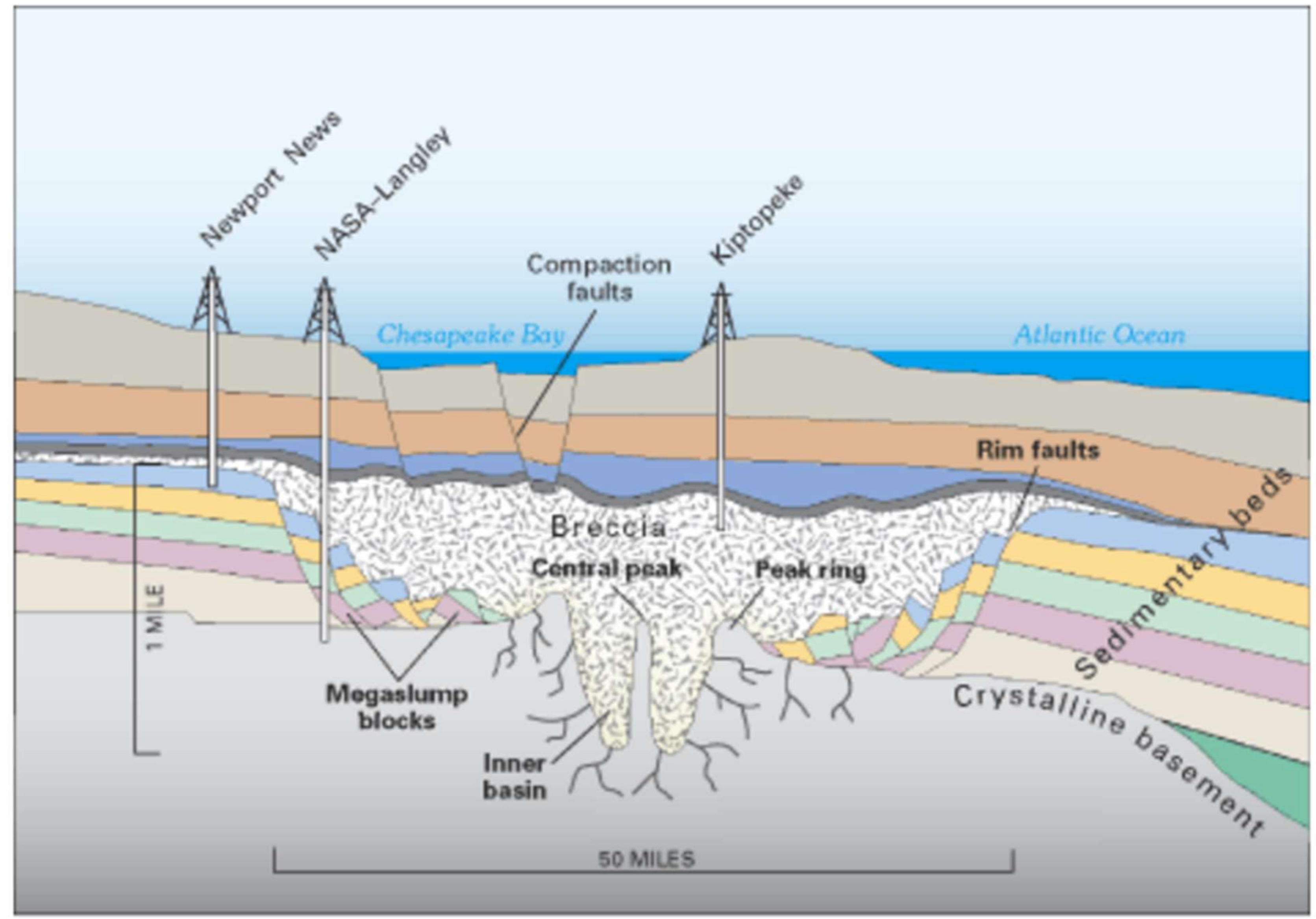
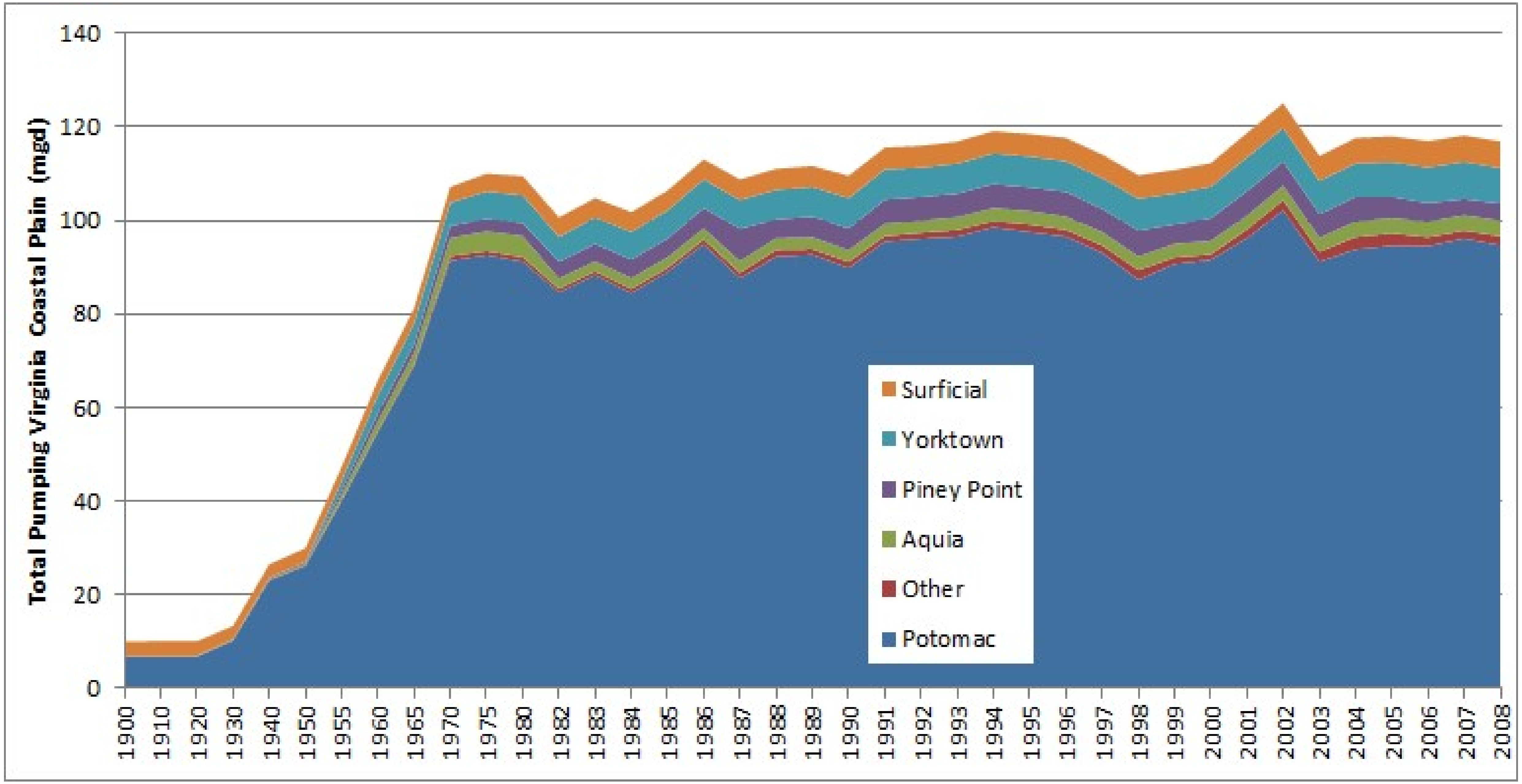
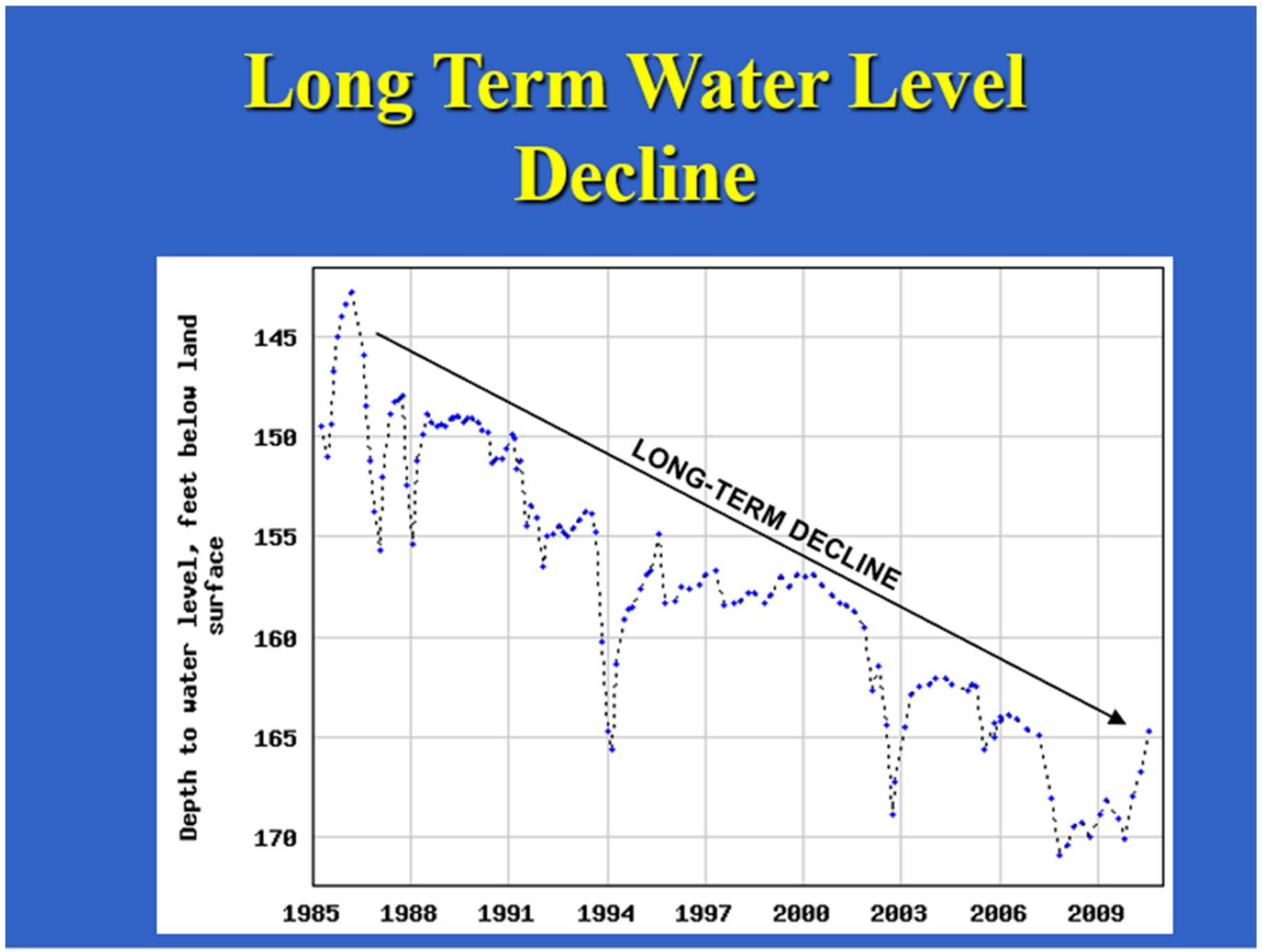


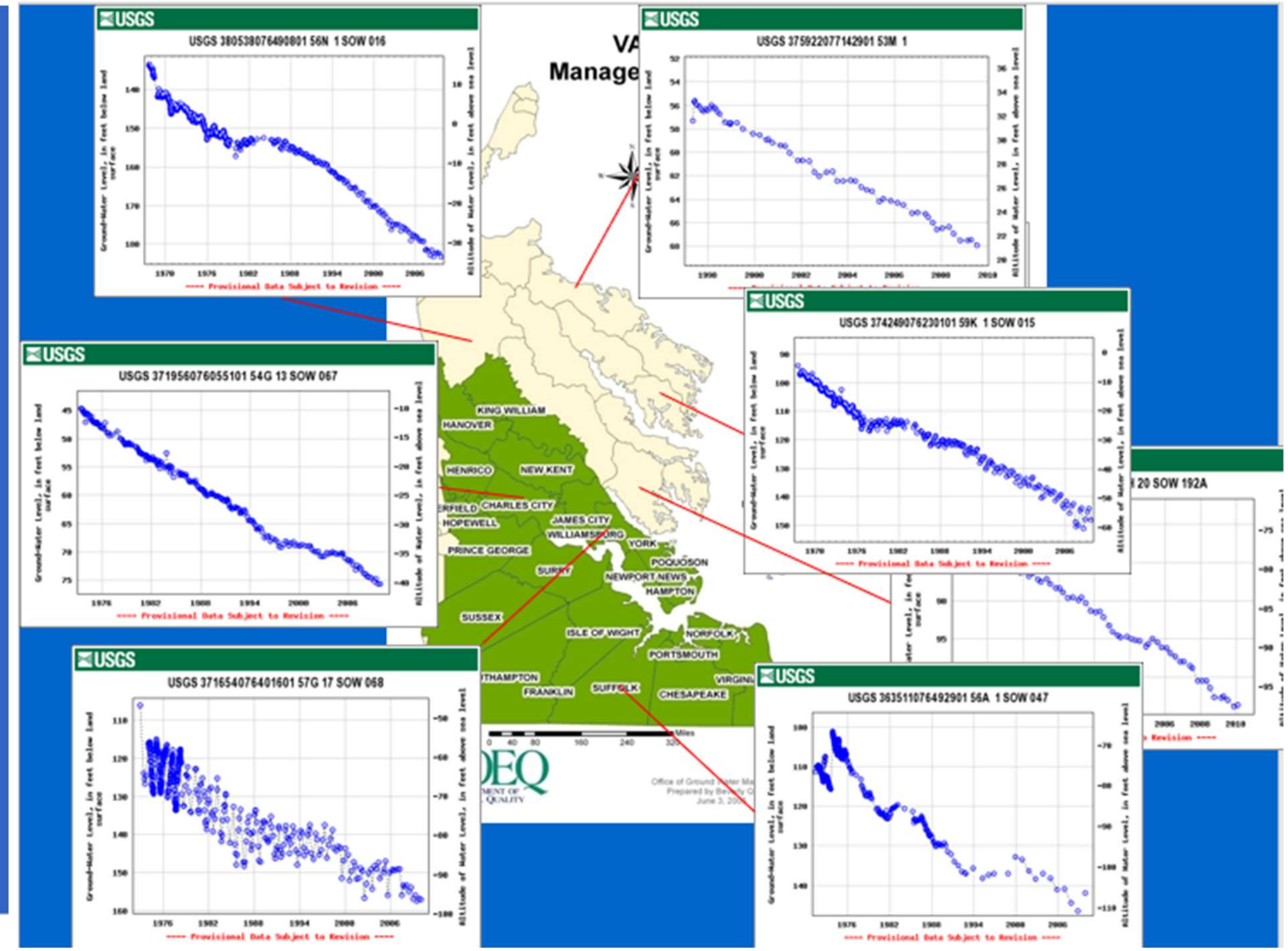
Withdrawals rose sharply then generally stabilized



Virginia Department of Environmental Quality

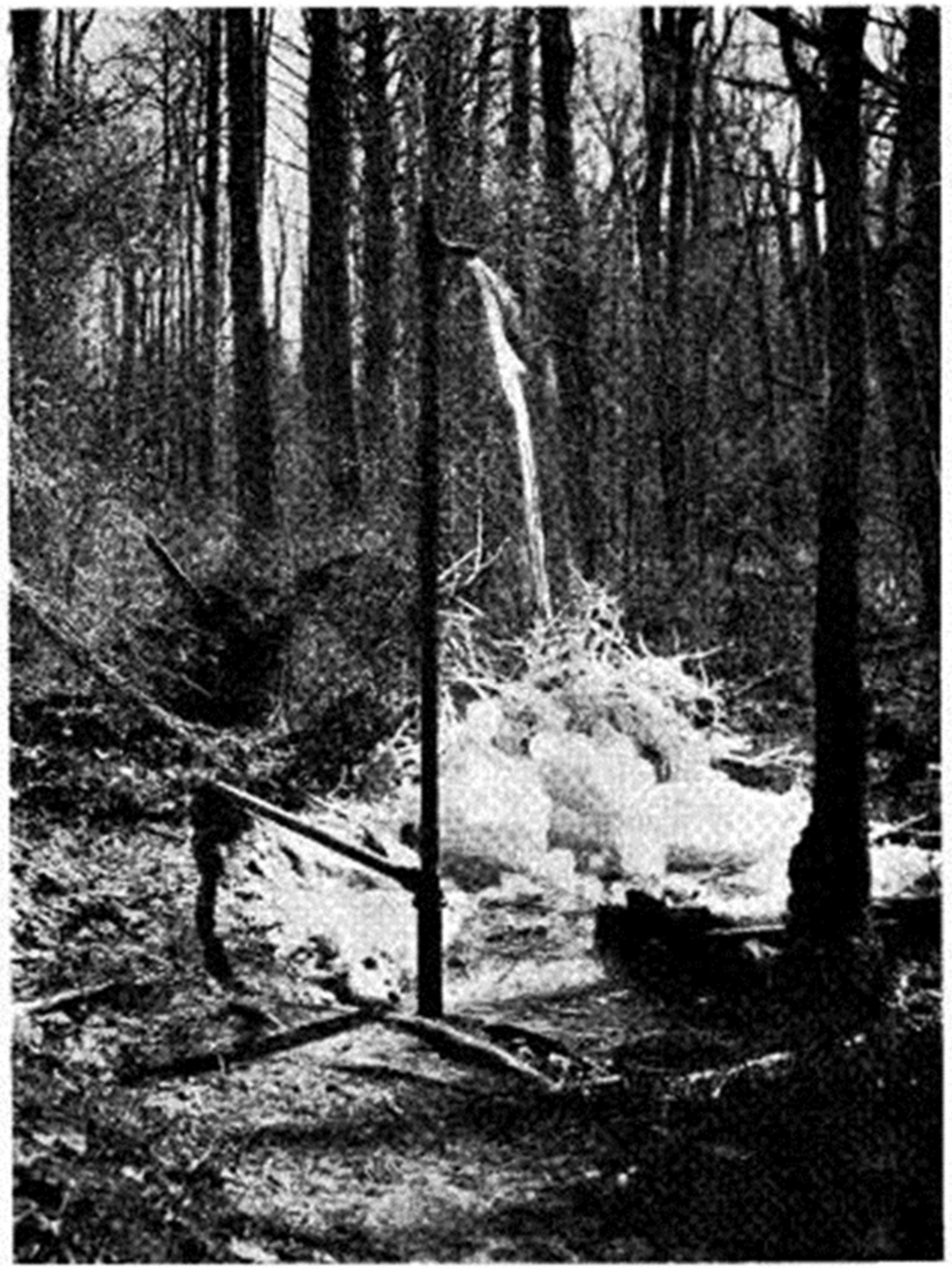
However, the aquifer takes a long time to stabilize



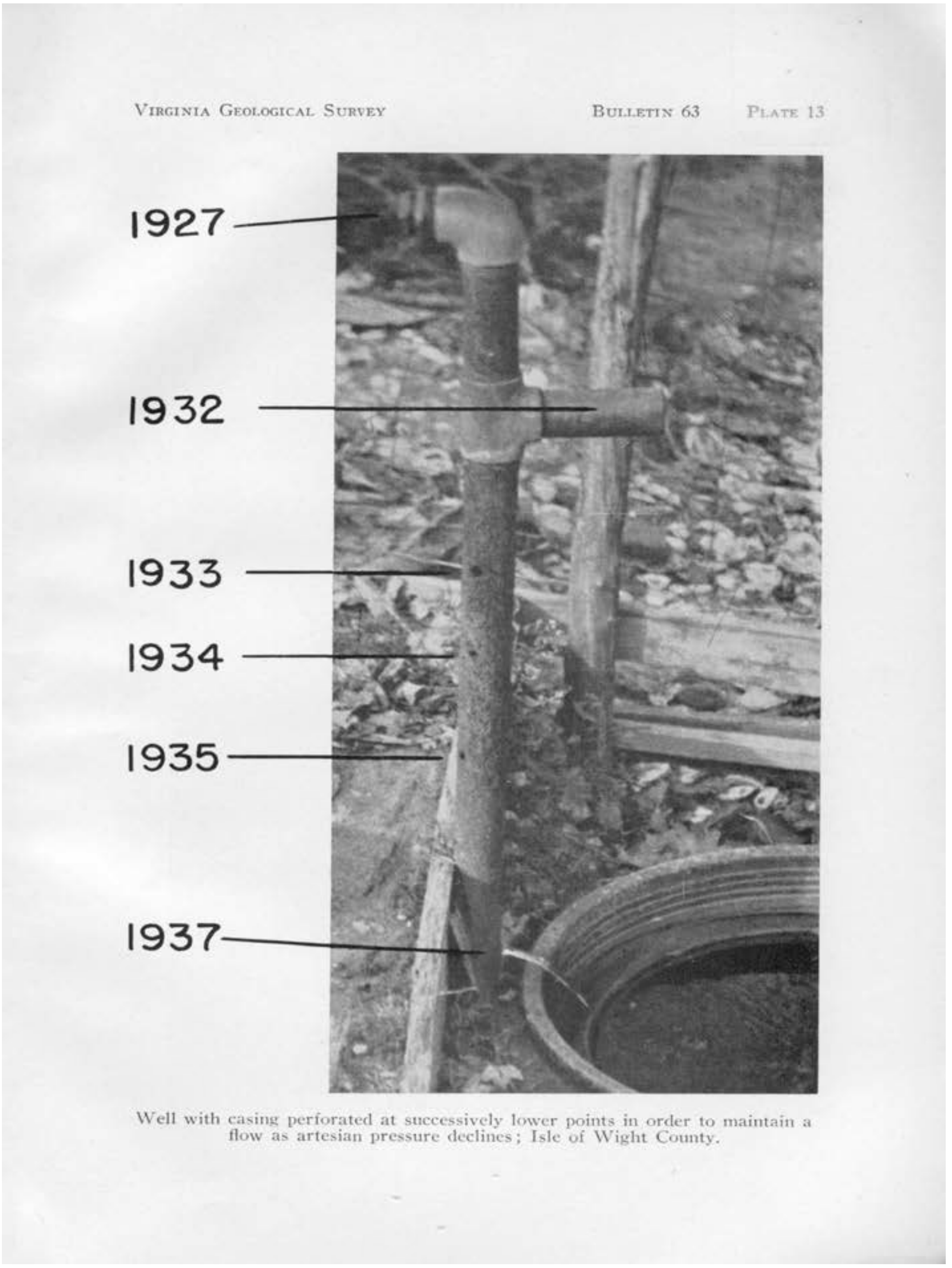


Virginia Dept of Environmental Quality

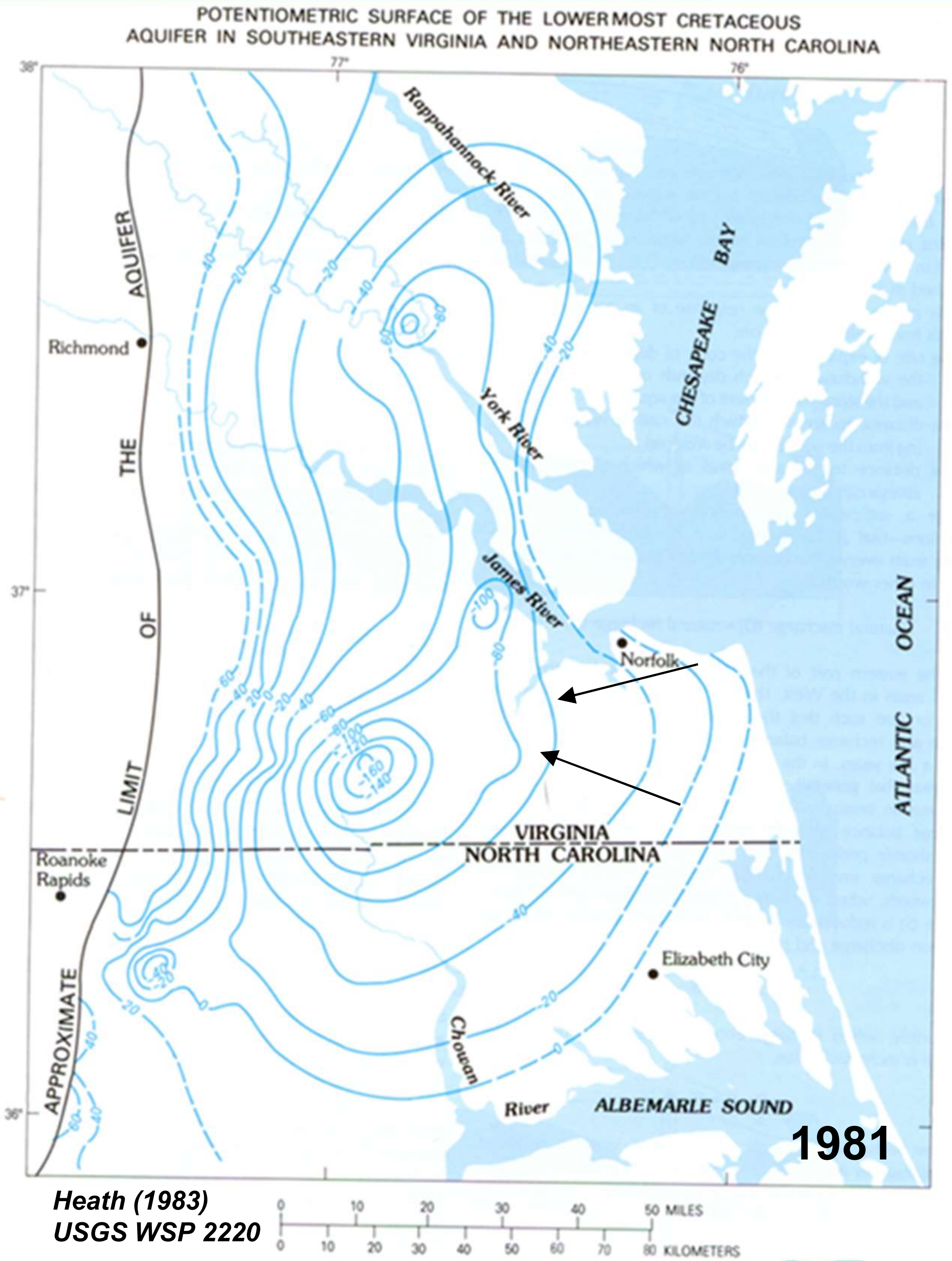
From artesian to depression



A, Overflow from artesian well in Isle of Wight County is wasted.



Well with casing perforated at successively lower points in order to maintain a flow as artesian pressure declines; Isle of Wight County.

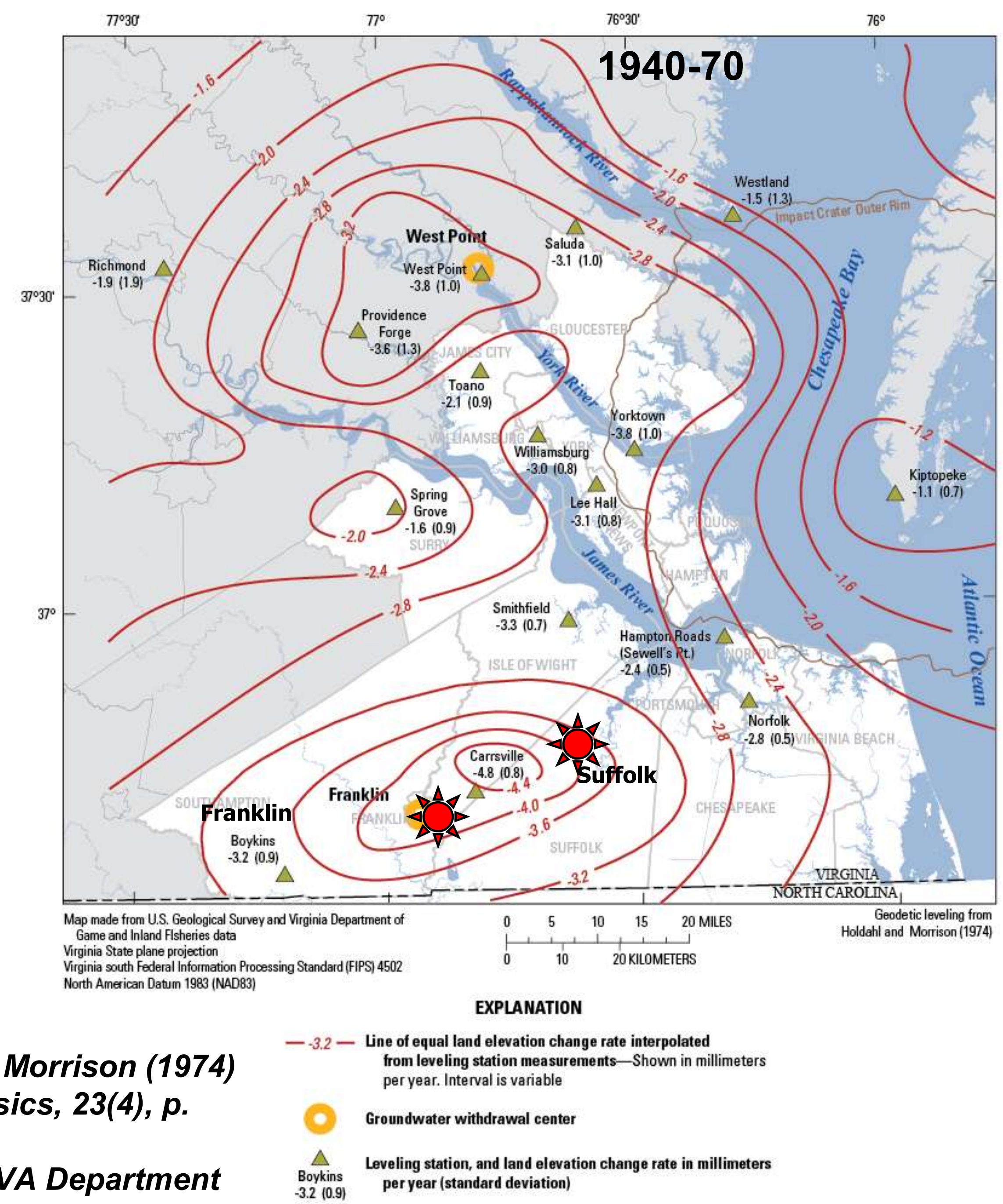


Heath (1983)
USGS WSP 2220

HAMPTON ROADS IS THE #2 LARGEST POPULATION CENTER AT RISK

Sea level rise is a relative proposition

- Up to 50% of relative SLR may be due to land subsidence
- Up to 50% of land subsidence may be due to aquifer compaction
- Measured rates of aquifer system compaction (1979-96)
  - Franklin 1.6 mm/yr
  - Suffolk 3.7 mm/yr



Holdahl and Morrison (1974) Tectonophysics, 23(4), p. 373–390
Taken from VA Department of Environmental Quality

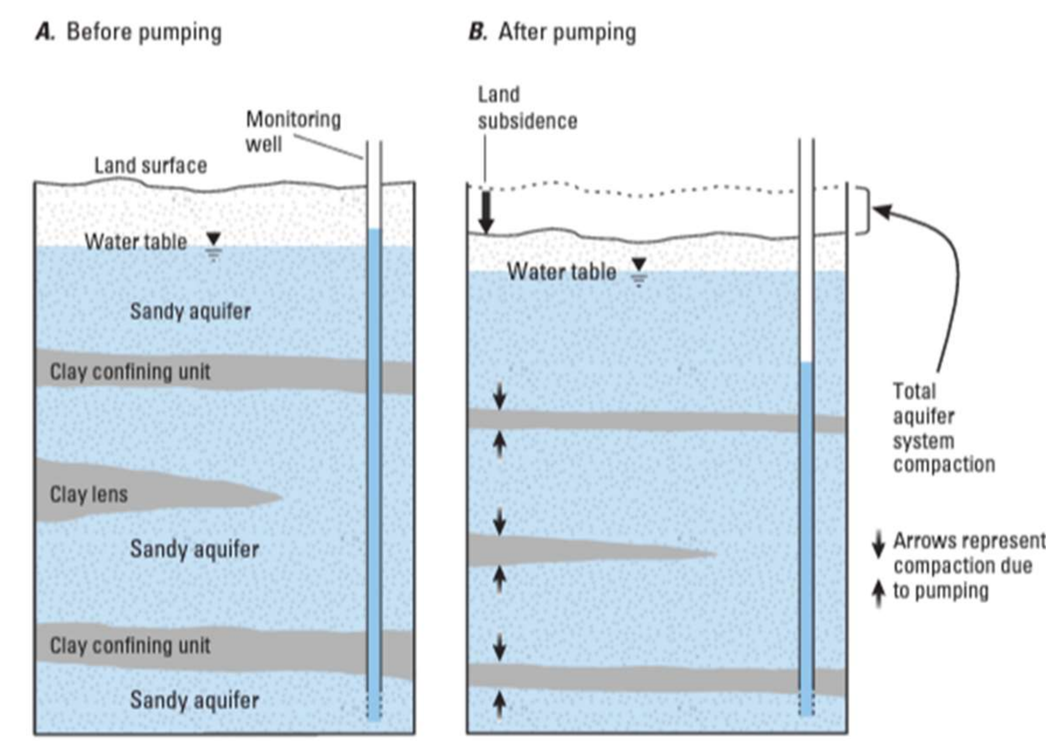
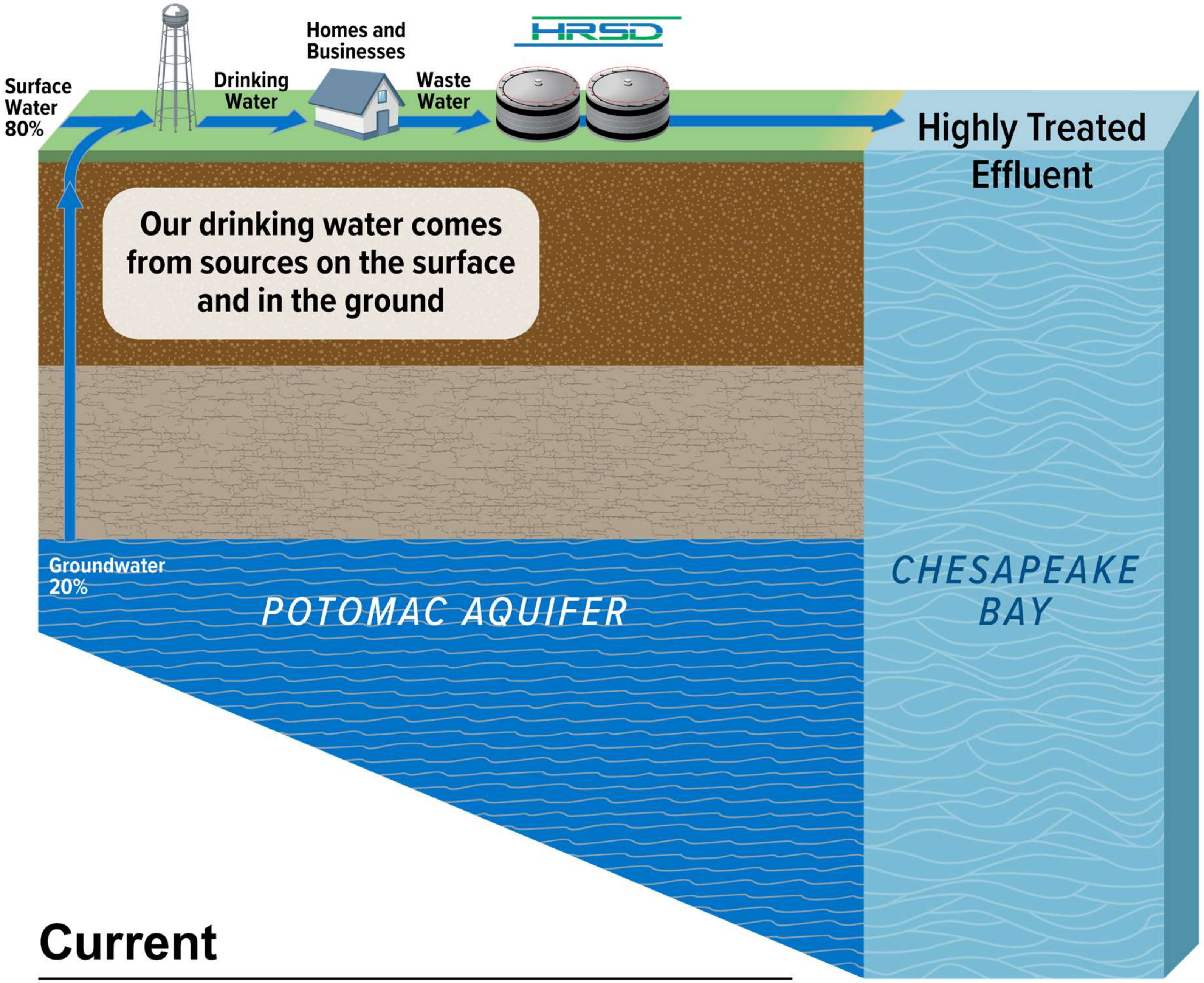


Figure 10. Aquifer-system compaction caused by groundwater withdrawals *A*, before and *B*, after pumping. Modified from Galloway and others (1999).

USGS, Circular 1392, Eggleston and Pope

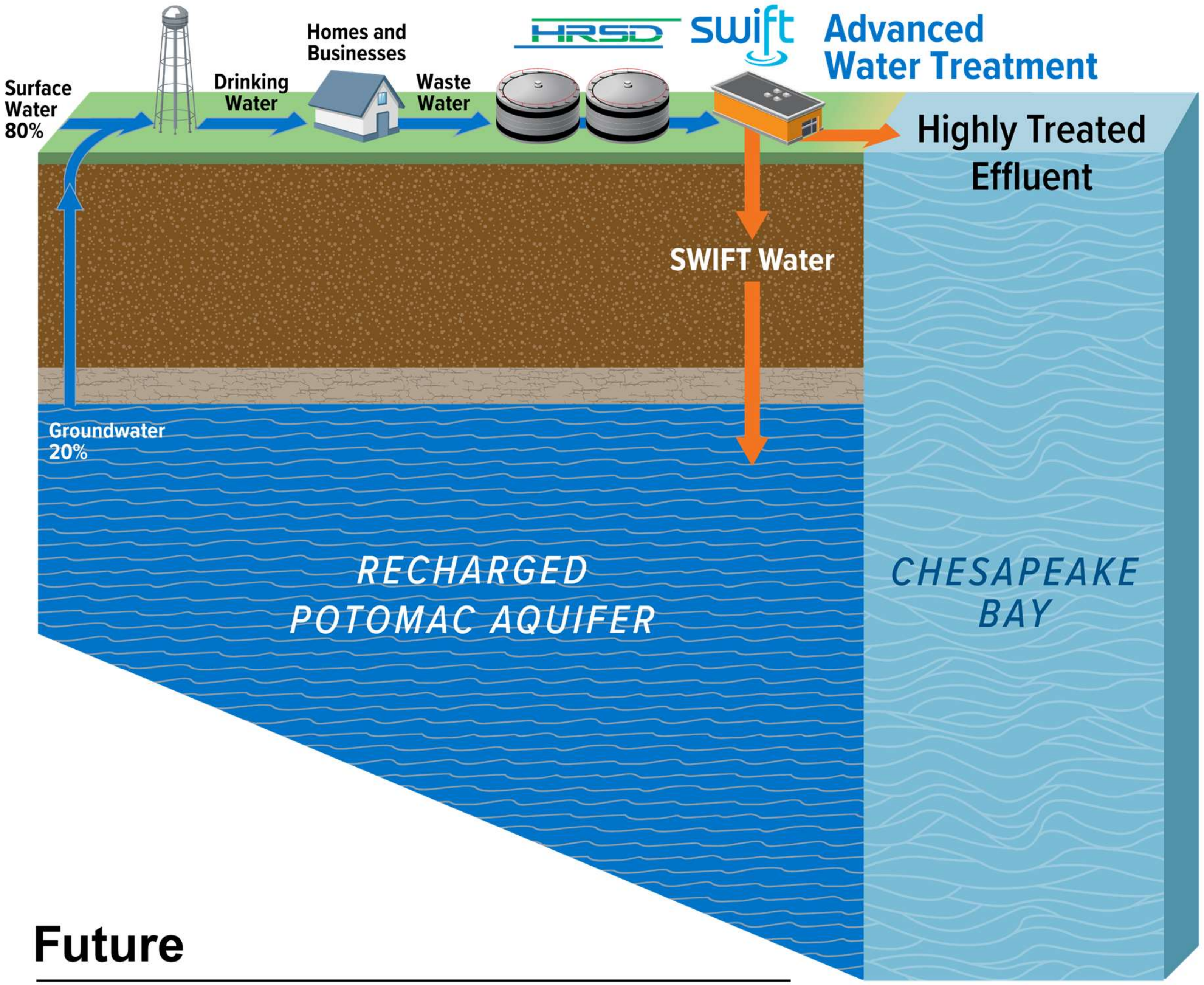
Business as usual



Current

- Withdraw ancient groundwater
- One pass use and discharge to surface water.
- Open loop system
- Not sustainable

What is SWIFT?



Future

BENEFITS OF SWIFT

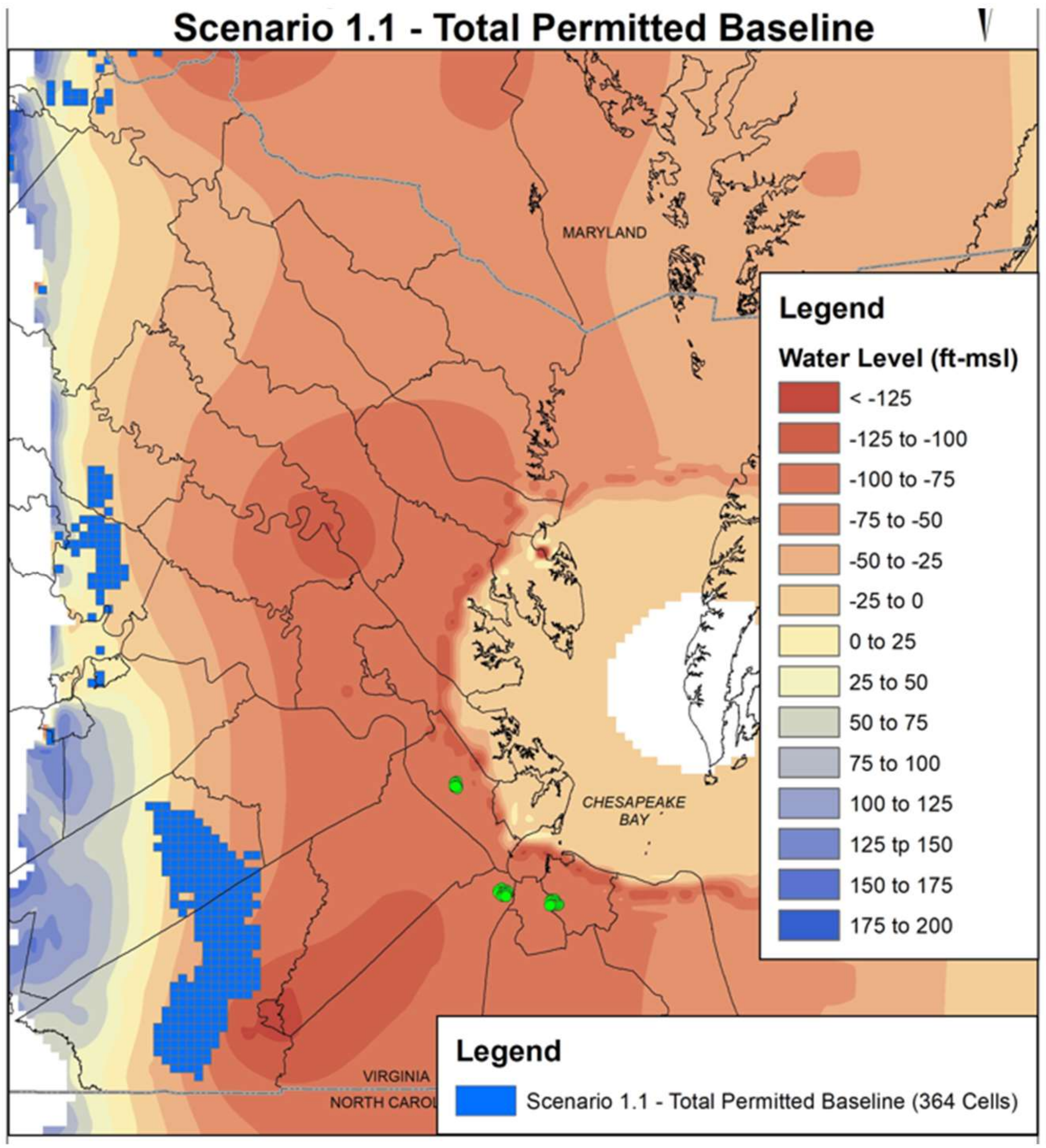
- Protecting the Chesapeake Bay
- Reducing the rate of land subsidence
- Creating a sustainable source of groundwater
- Helping prevent groundwater contamination from salt water

How is HRSD able to implement SWIFT?

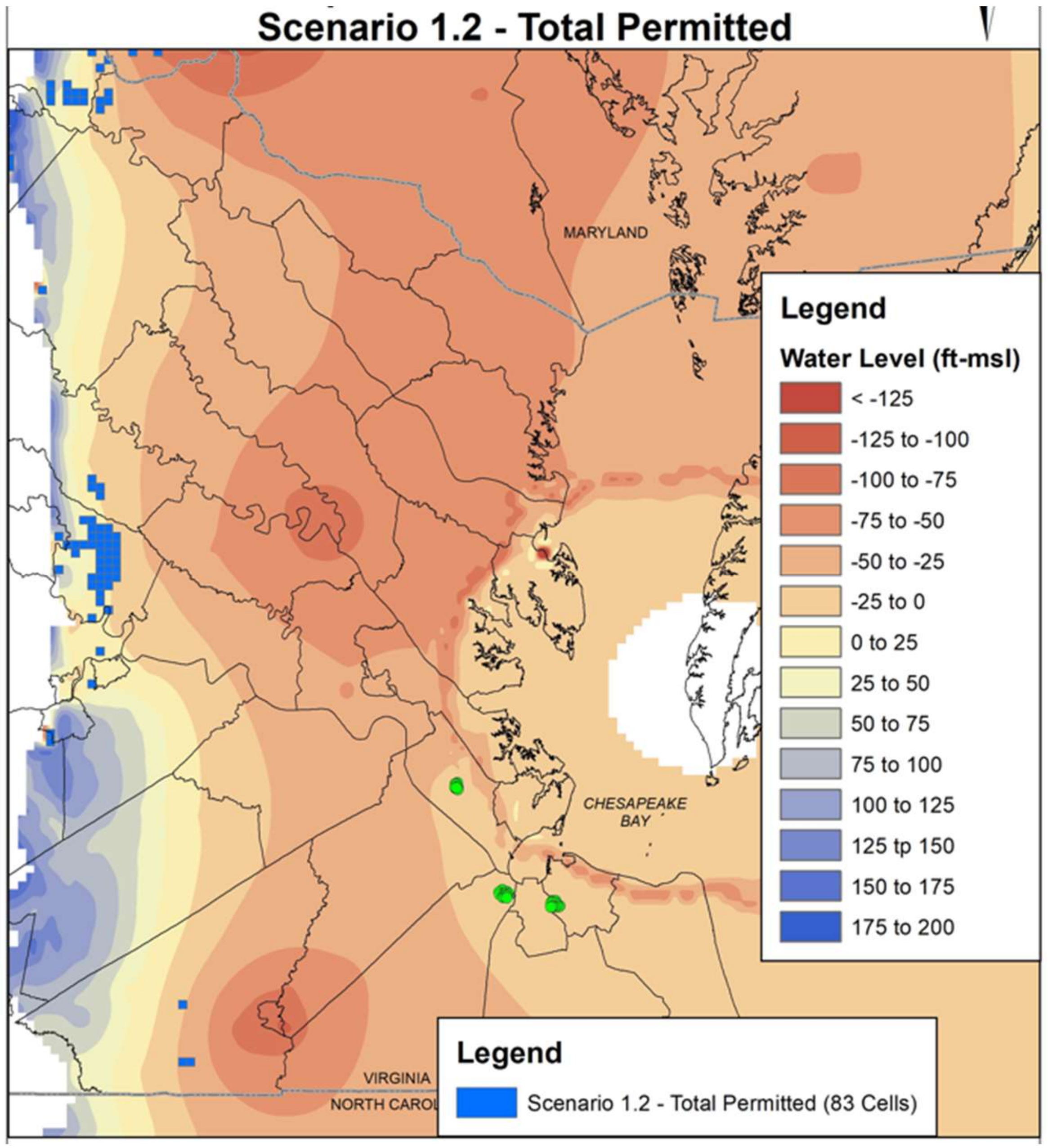
- **Hydrogeologically favorable** - large prolific confined aquifer that can take the water, water doesn’t go far from recharge site, but positive pressure effect does
- **Geographically favorable** – no downstream users (Chesapeake Bay doesn’t need HRSD’s discharge)
- **Regulatorily favorable** – EPA’s CWA integrated planning system, prioritize CWA projects and adjust spending and schedule accordingly
- **HRSD itself** – fits into our Enabling Act, Mission and Vision

Modeling of SWIFT suggests room for permitting

NO SWIFT



W/ SWIFT

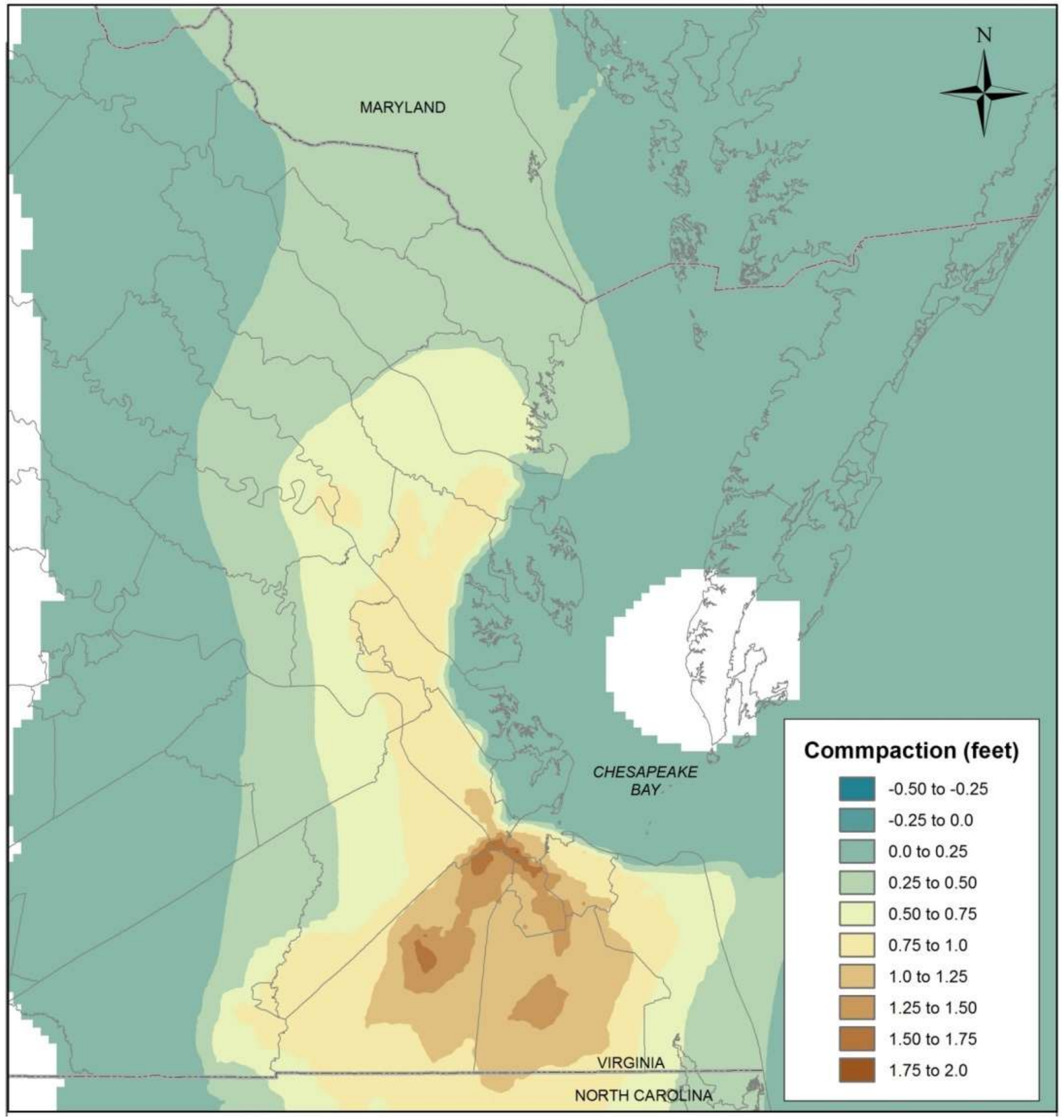


Total Permitted Withdrawals
JR SWIFT
NP SWIFT

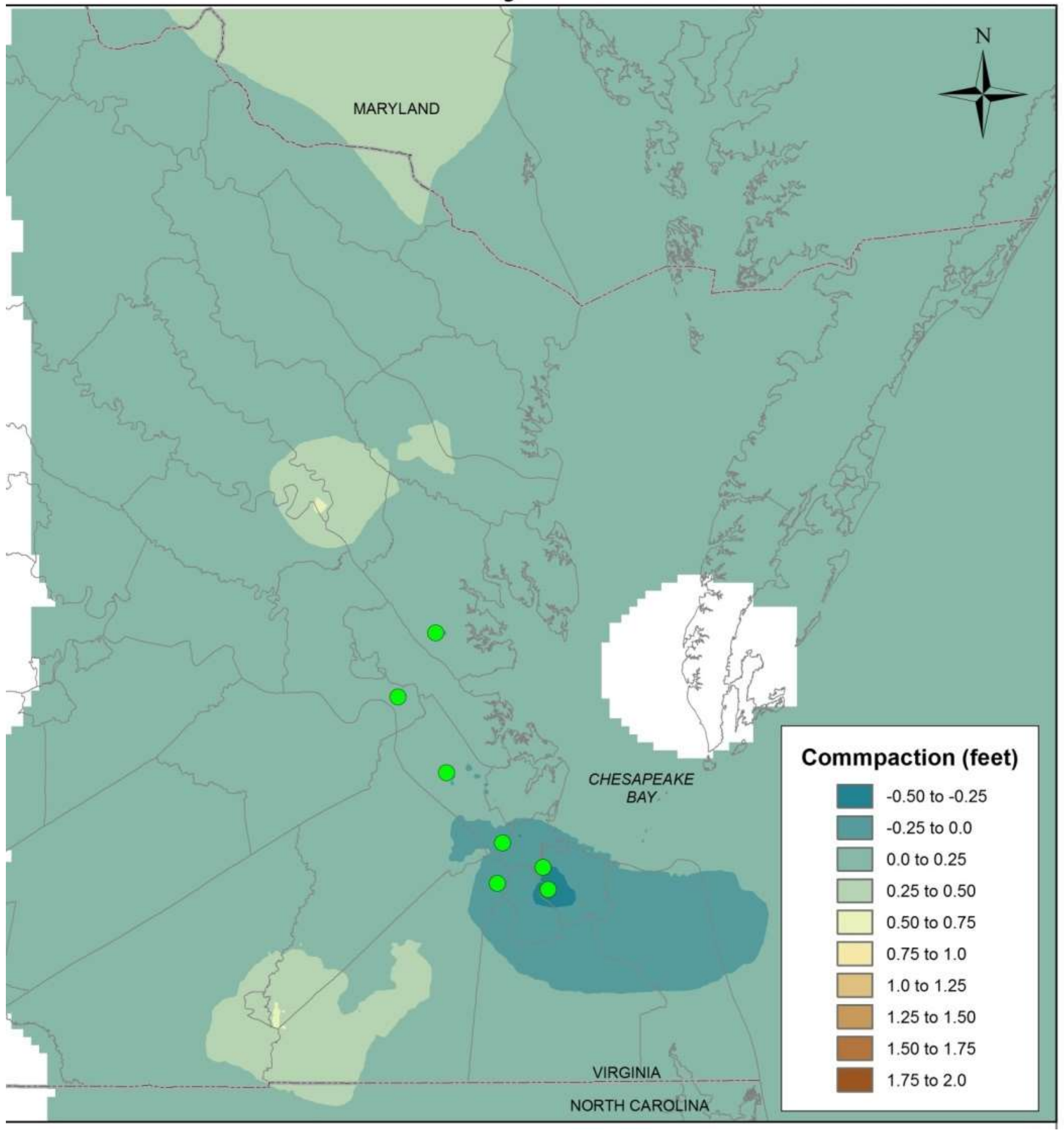
Critical cell failures
Baseline – 364
Scenario 1.2 – 83

"All models are wrong, but some are useful" George E. P. Box

Simulated Total Aquifer System Compaction from 1890 to 2064 - Total Permitted



Simulated Total Aquifer System Compaction from 1890 to 2064 - Total Permitted with All Injection Wells



Elastic Rebound of land subsidence is real

Extensometer

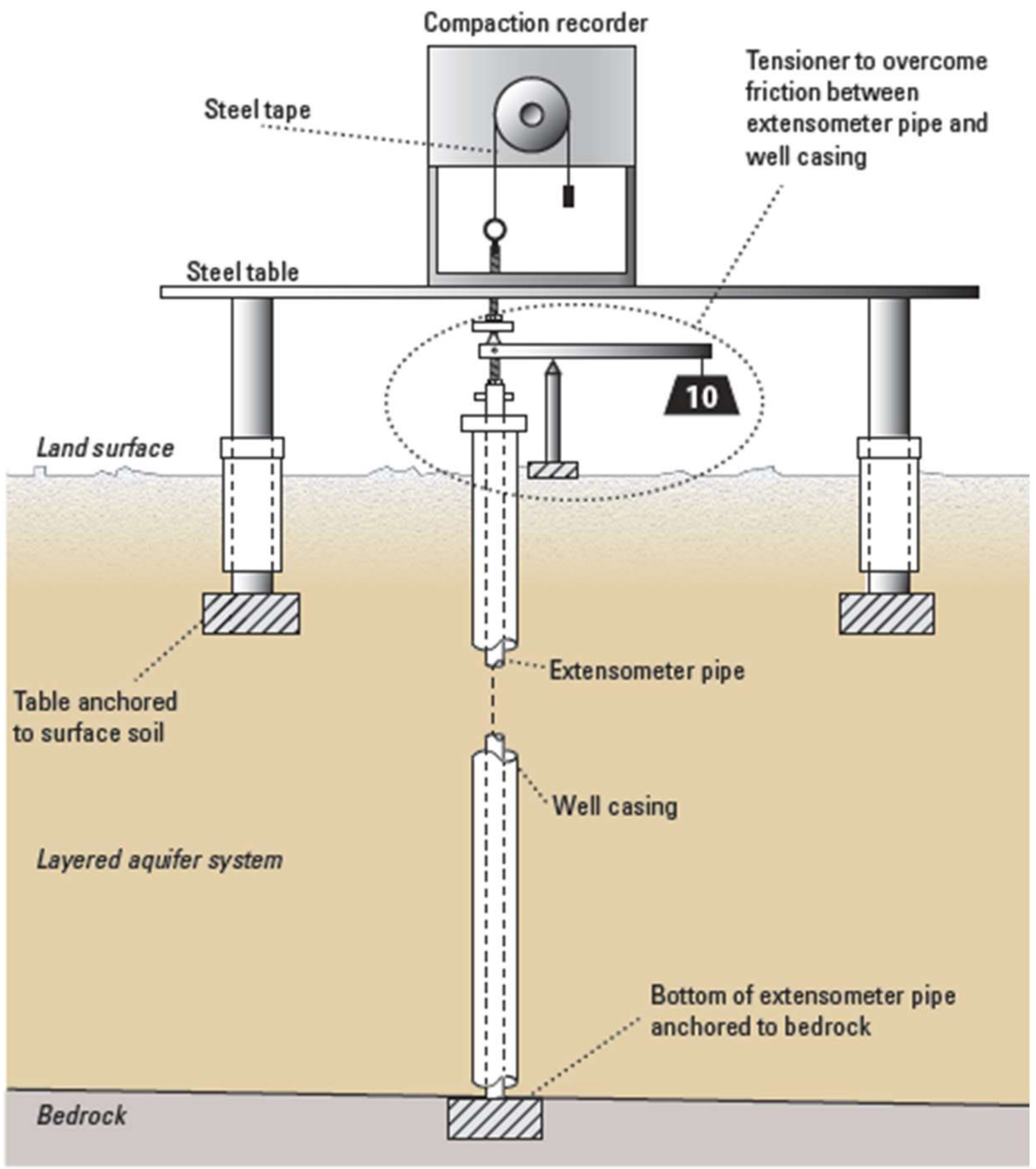
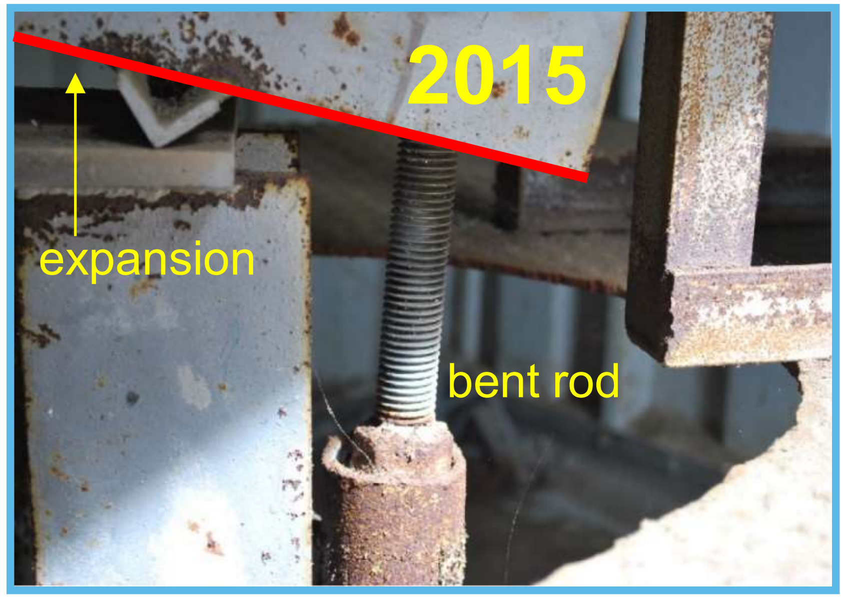


Figure 8. The borehole extensometer in Franklin, Virginia. Modified from Pope (2002).

USGS, Circular 1392, Eggleston and Pope

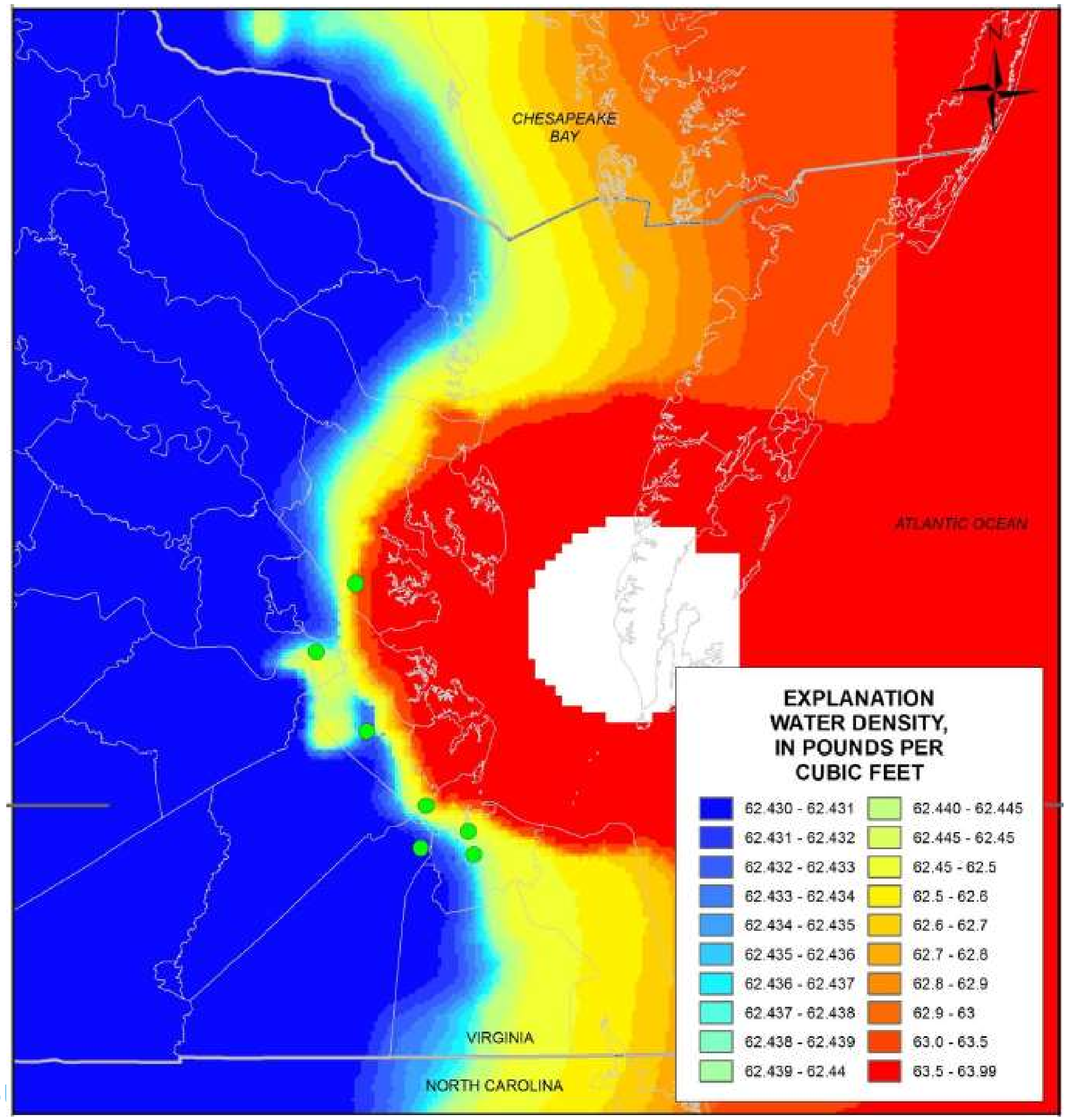


Two types of deformation
- Irreversible inelastic
- Recoverable elastic

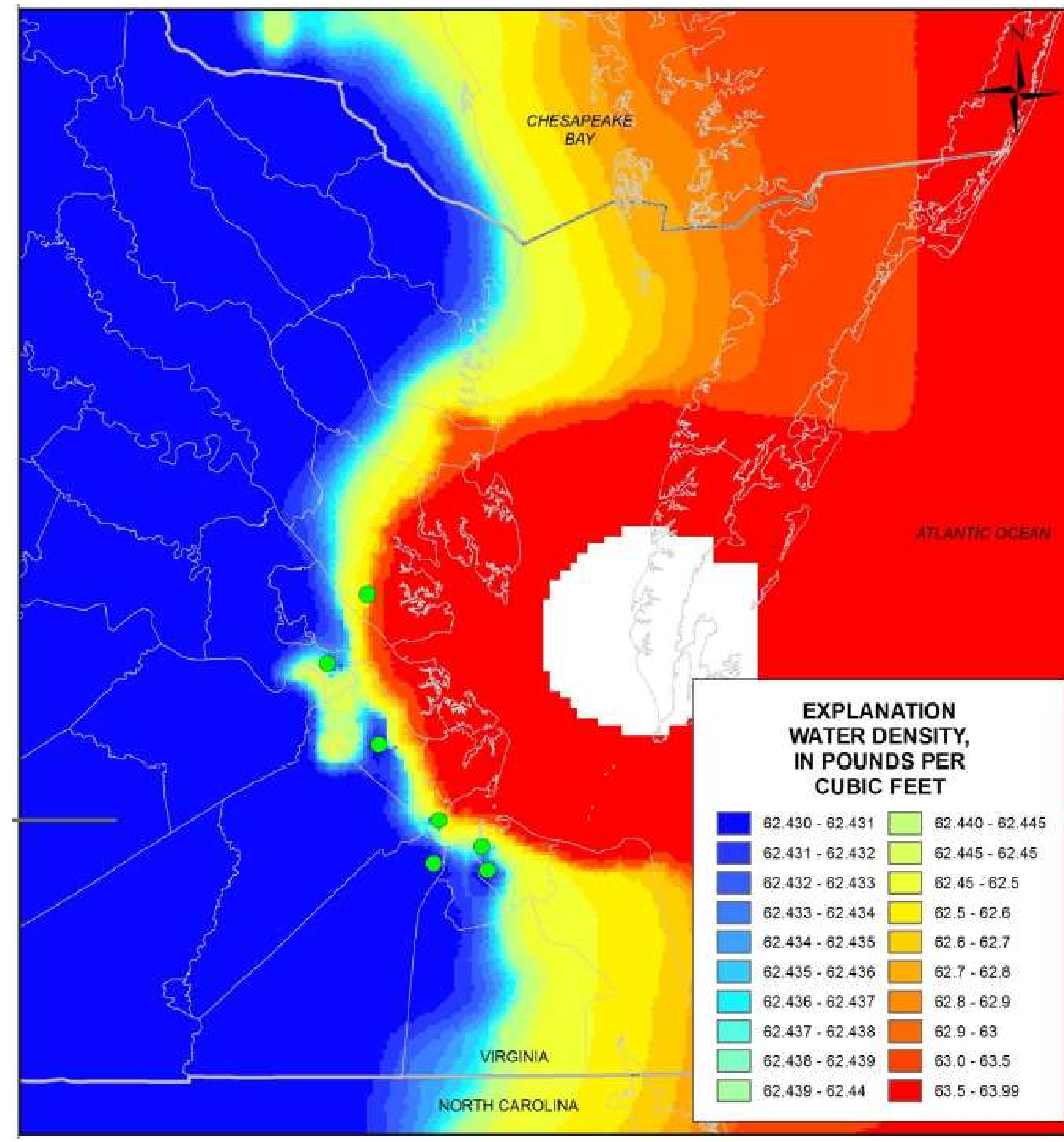
Ground surface rebounded 32 mm from withdrawal shutdown in Franklin from 2009-2010.

Where does the water go?

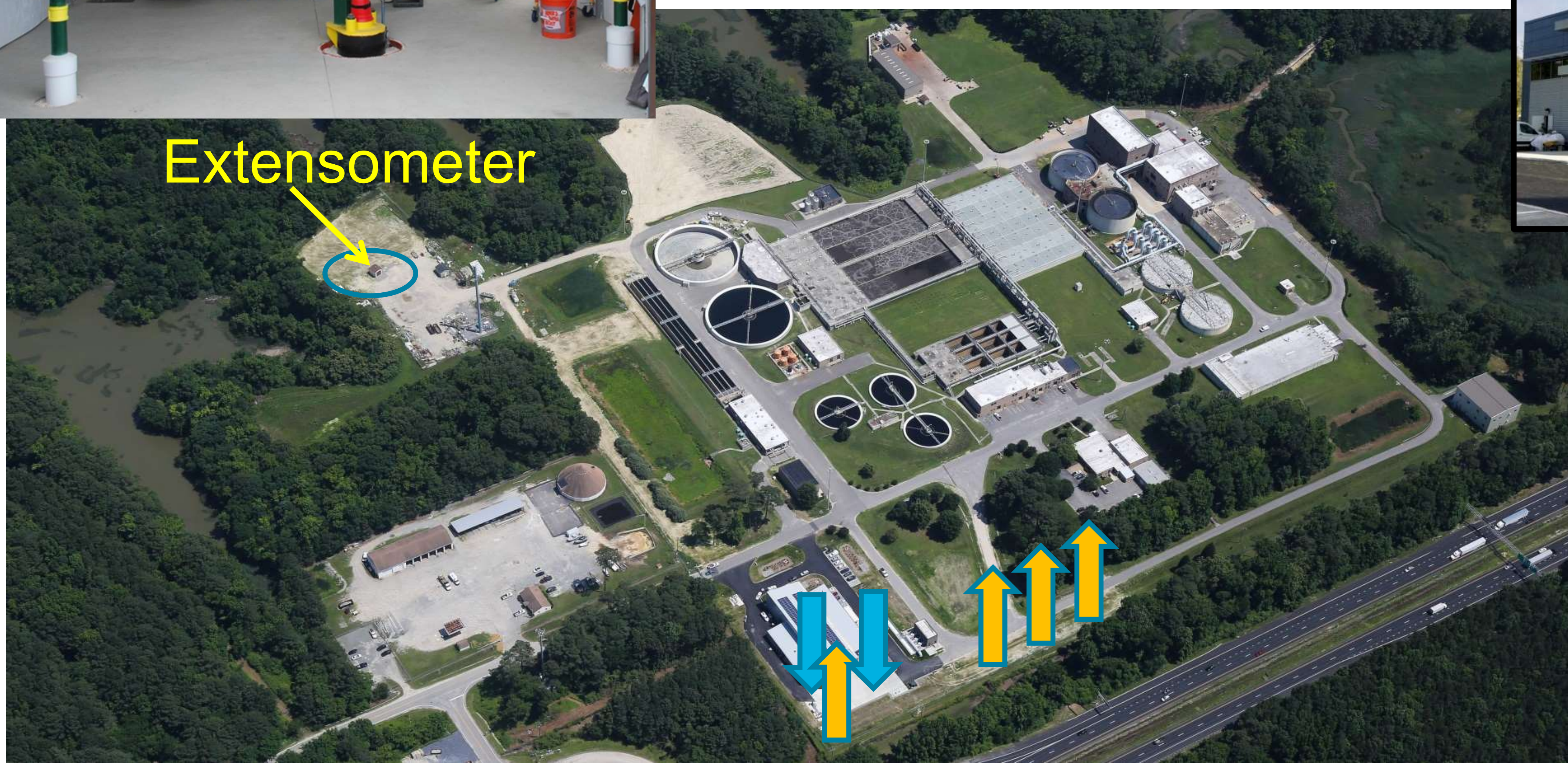
Baseline (w/o SWIFT Recharge)



SWIFT Recharge



SWIFT Research Center: demonstration of many things



1.0 MGD Demonstration Facility

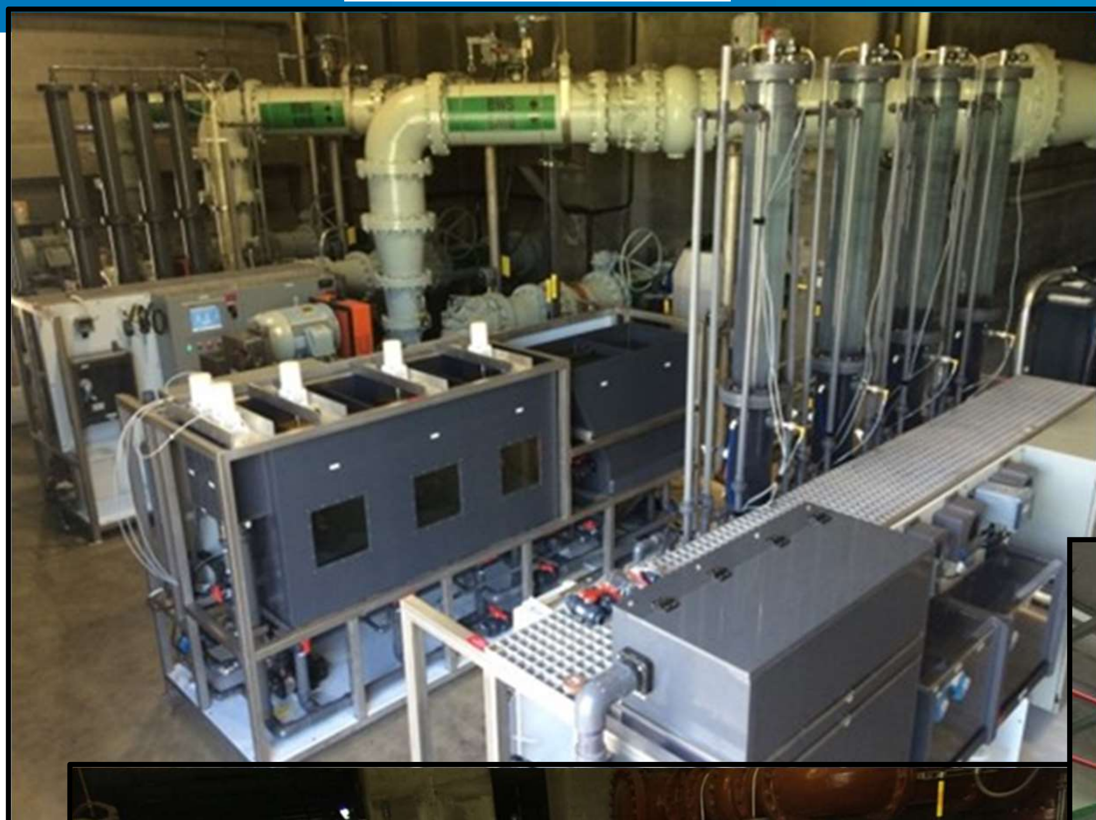
AWT + recharge well + monitoring wells + public outreach and education center + research facilities

800,000,000+ Gallons recharged into the Potomac Aquifer

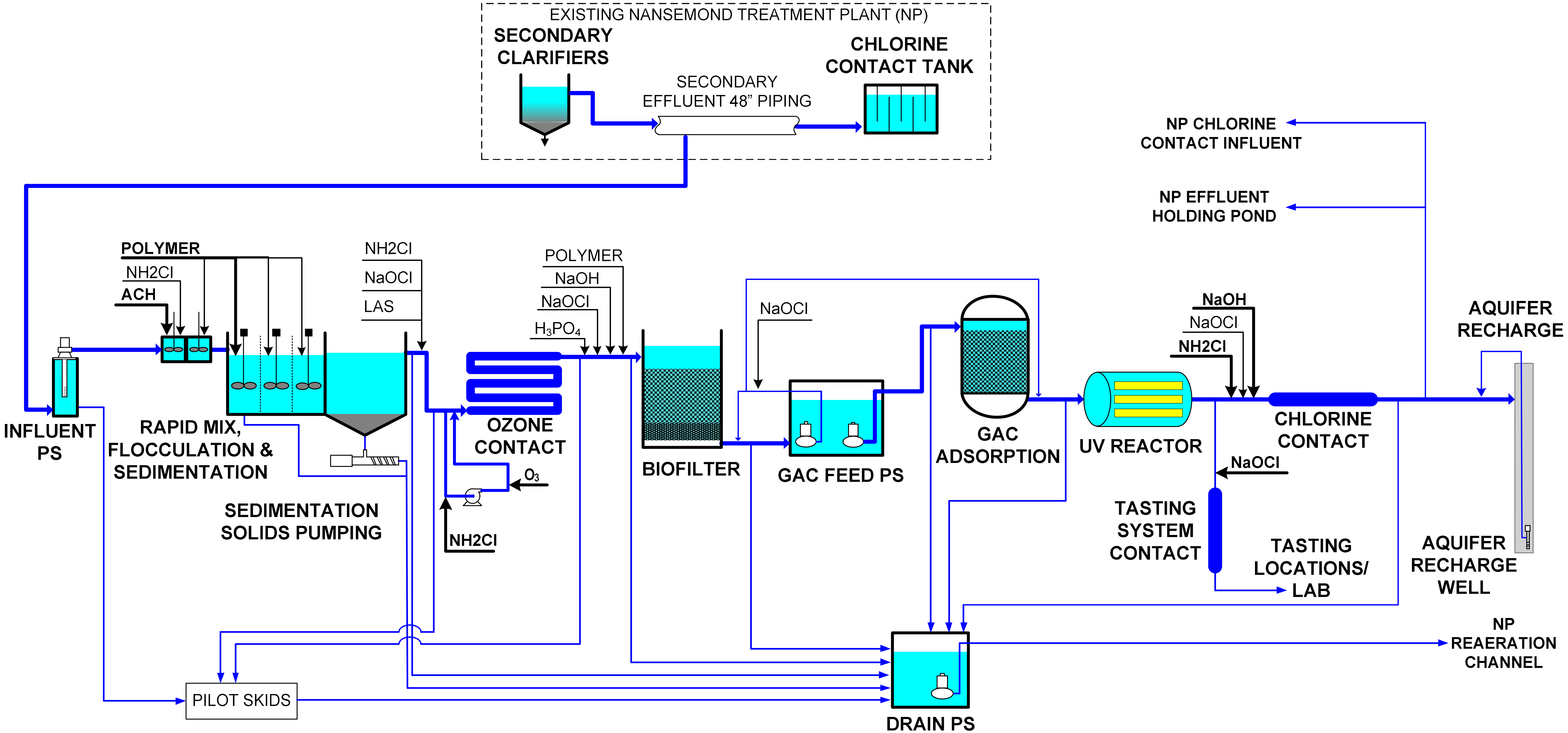
swift

HRSD swift
HRSD

swift

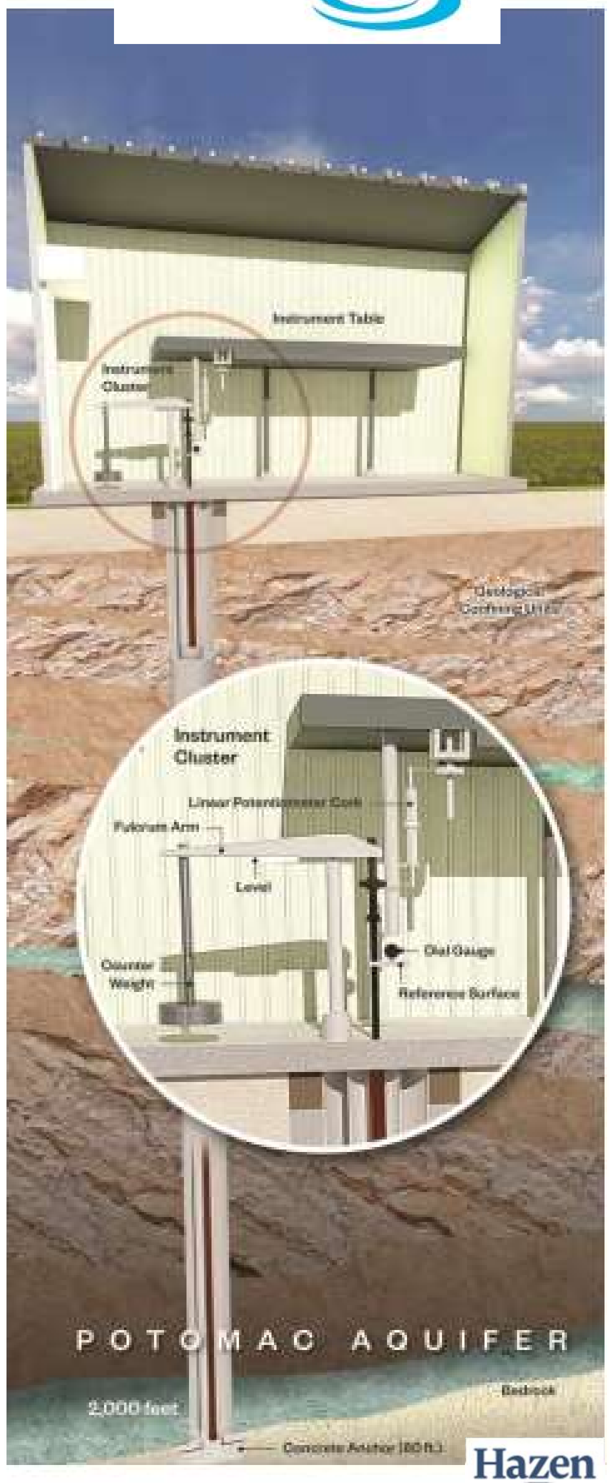


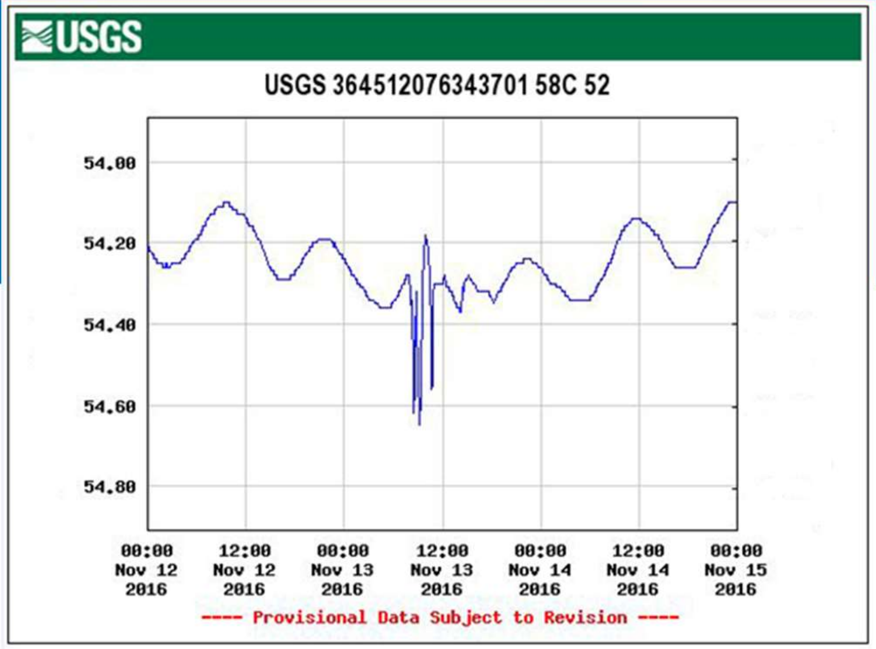
Process Flow Diagram for SWIFT Research Center



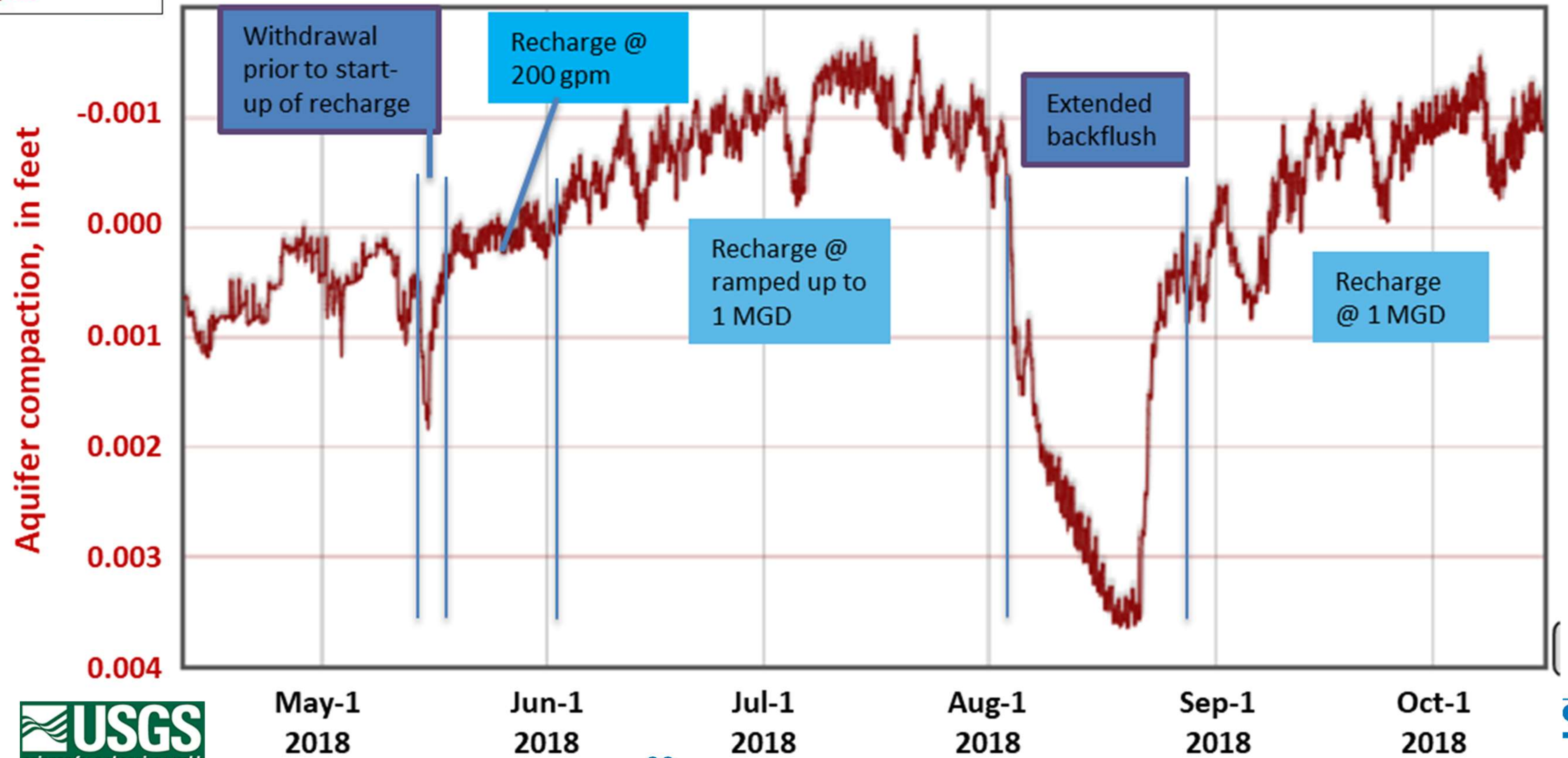
SWIFT RESEARCH CENTER PROCESS FLOW DIAGRAM

How will SWIFT effect vertical land motion?





First three months of operation



Geochemical challenges to putting water into the aquifer

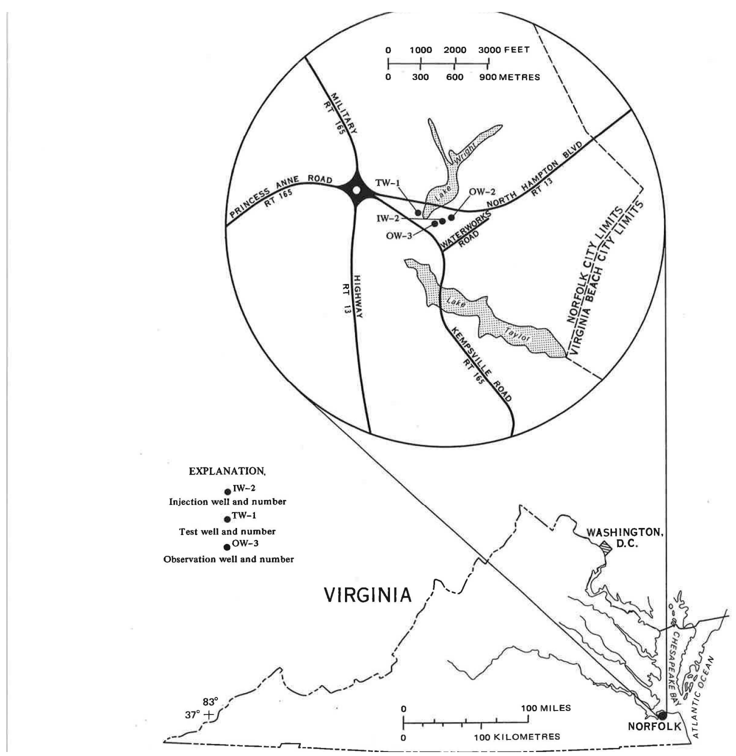
Operational concerns

- Clay destabilization
- Well plugging

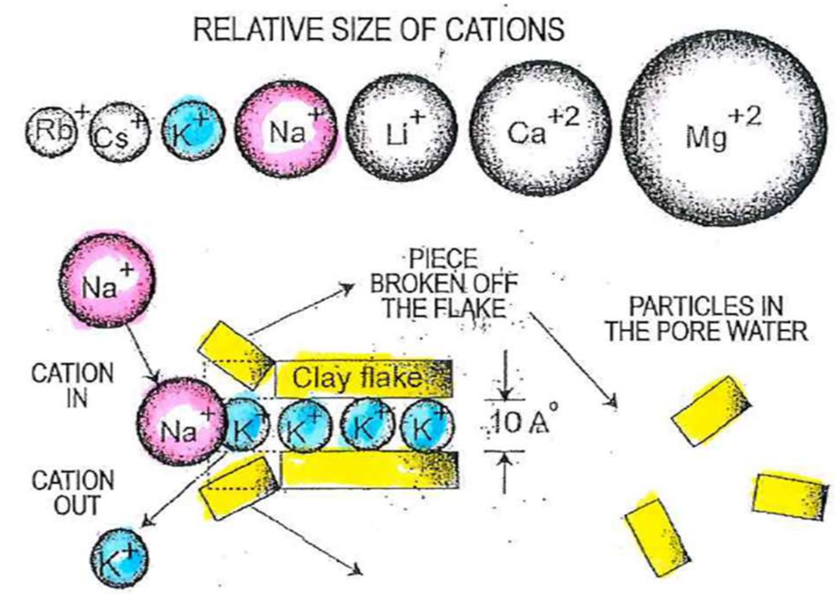
Environmental/Regulatory concerns

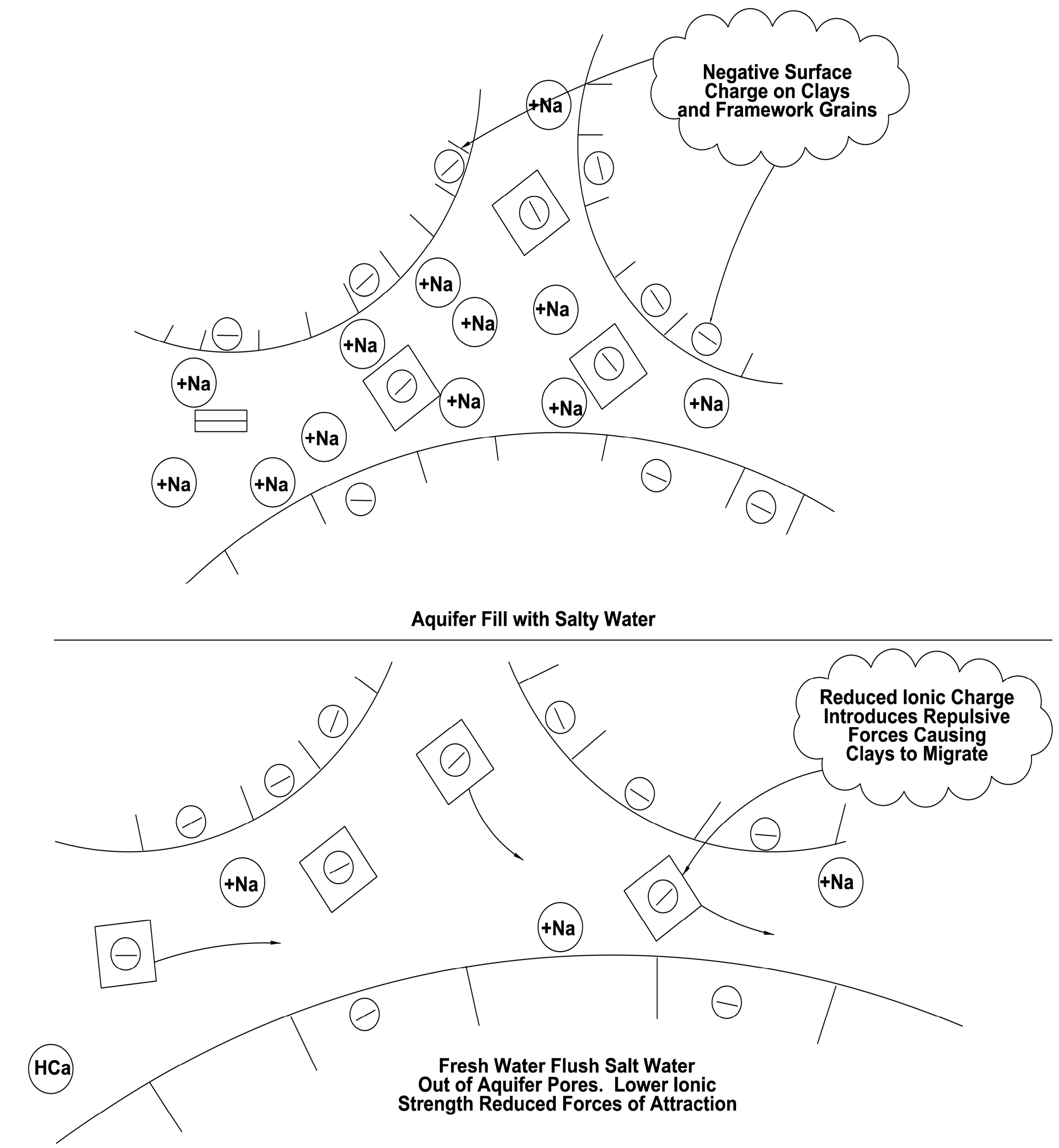
- Liberating metals
- Metals migration in the aquifer

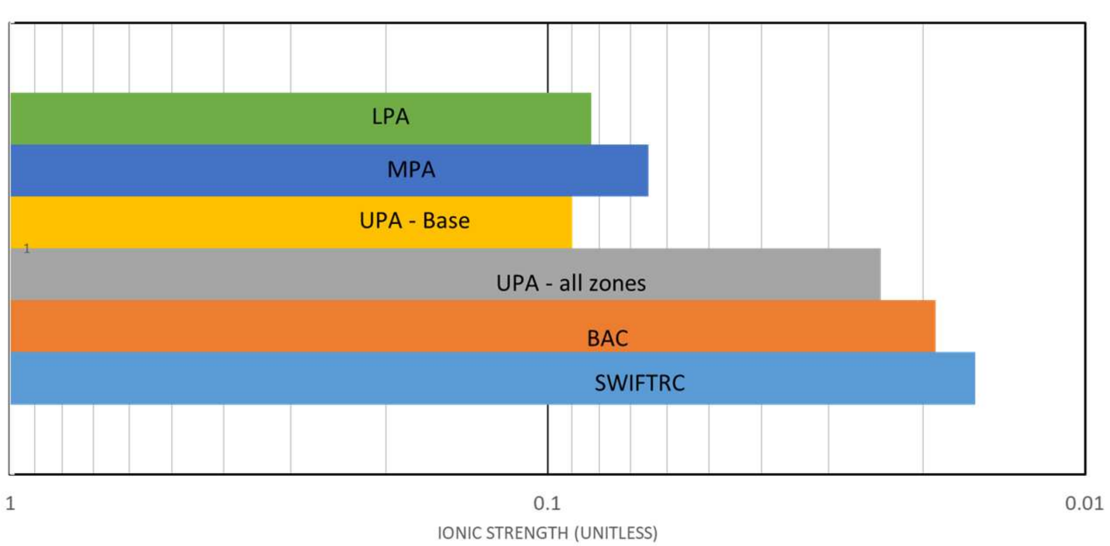
Challenges with MAR at HRSD SWIFT sites



USGS, PP 939, Brown and Silvey, 1977

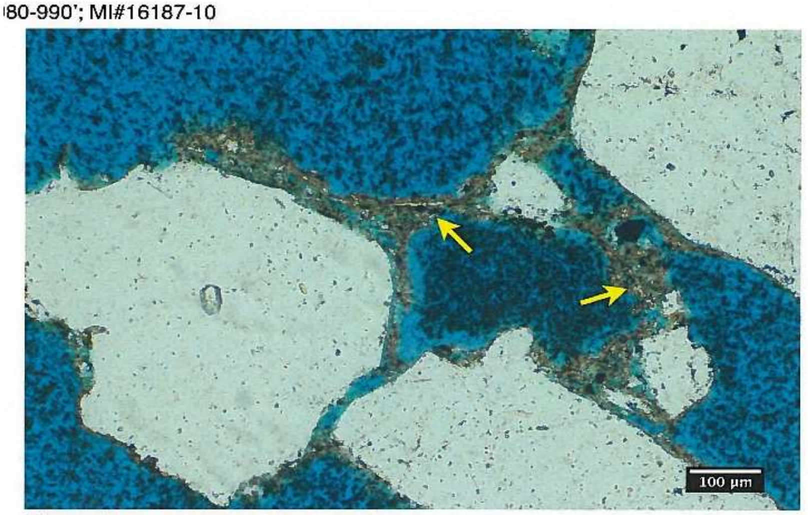






MINERALOGY-INC

80-990'; MI#16187-10

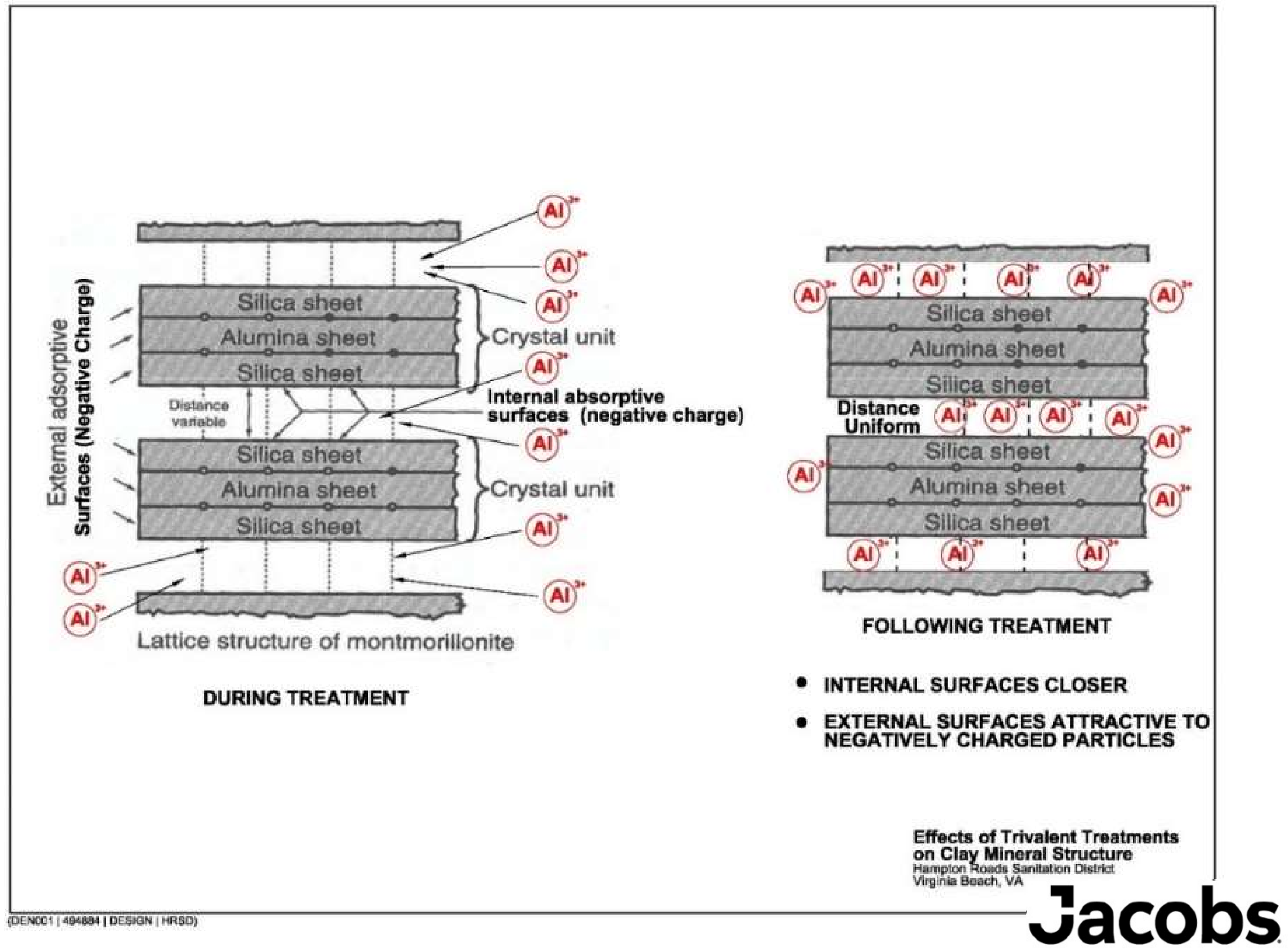


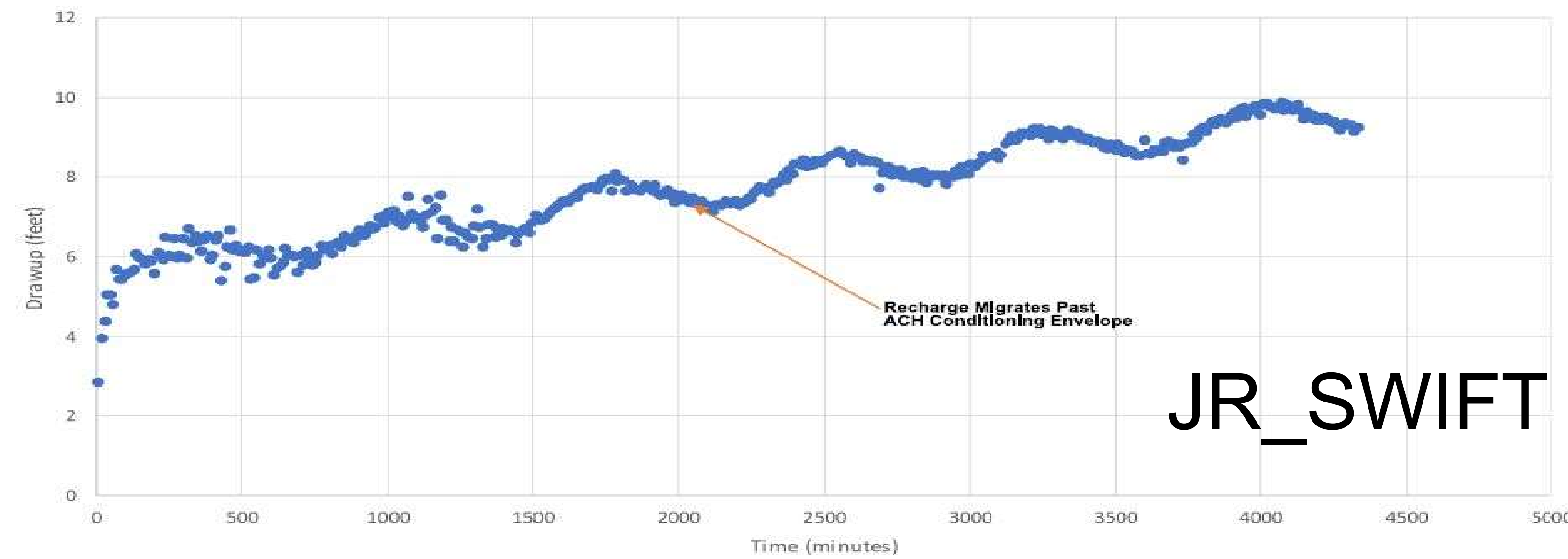
The grain-coating detrital clay (red) is dominated by montmorillonite. The grain-coating matrix locally bridges the intergranular pore throats (yellow).

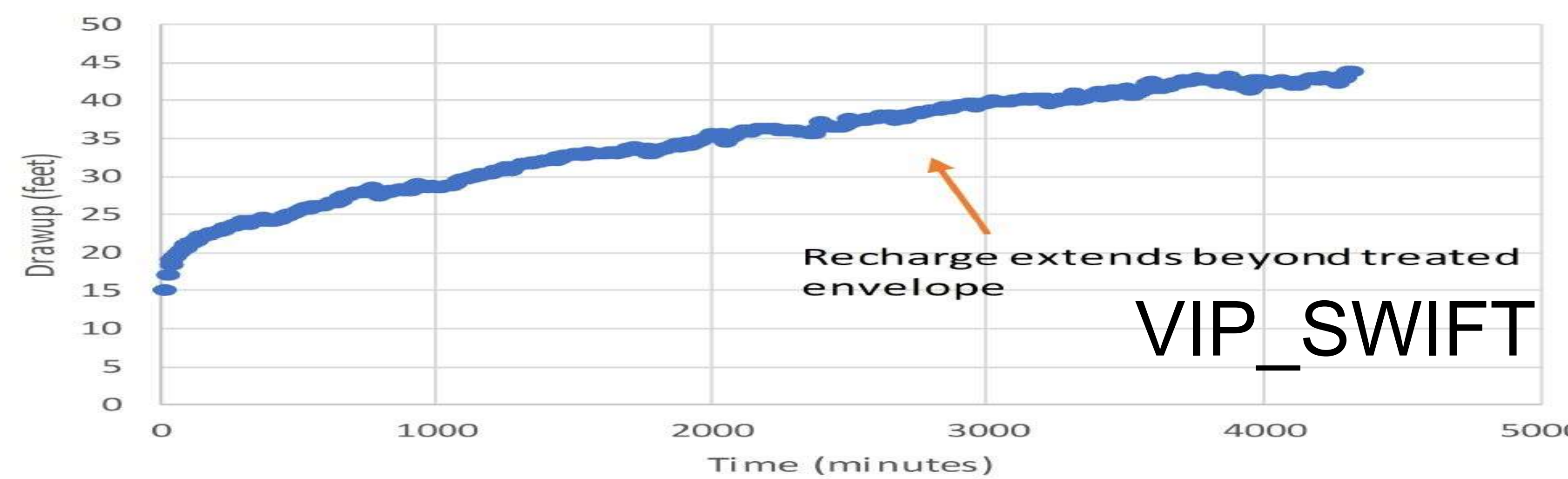
Jacobs

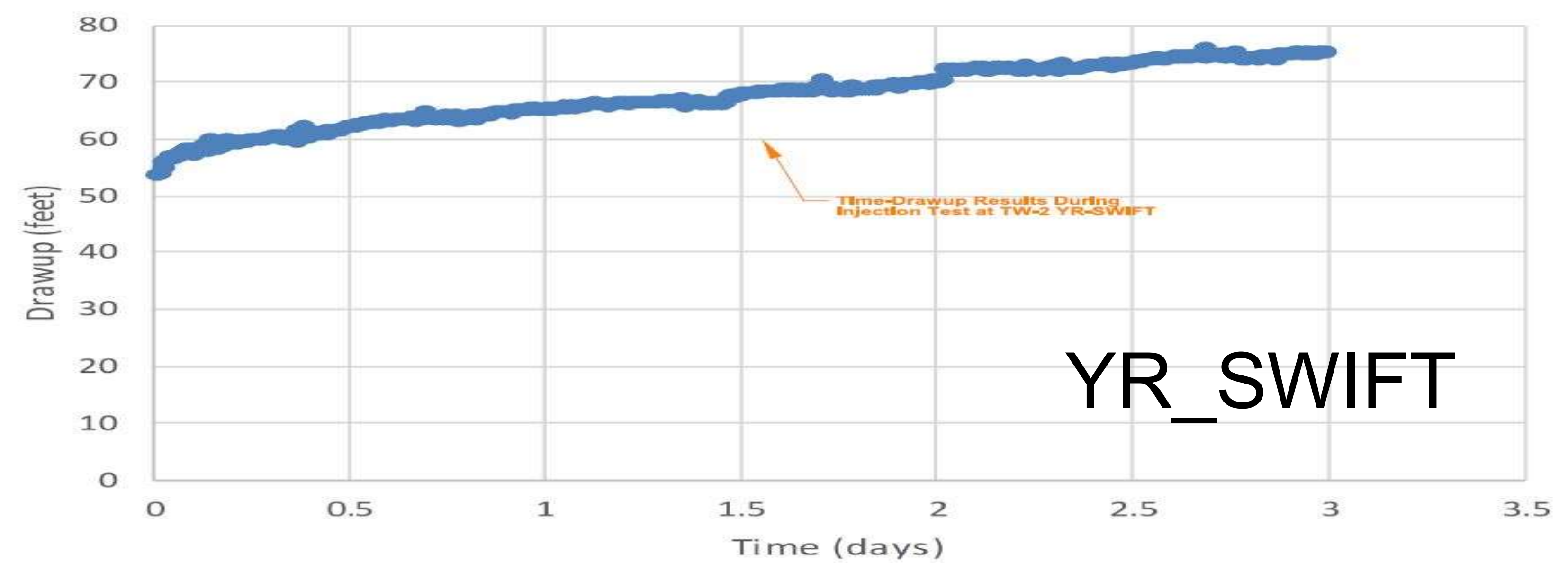
HRSD swift

ACH conditioning and testing was successful





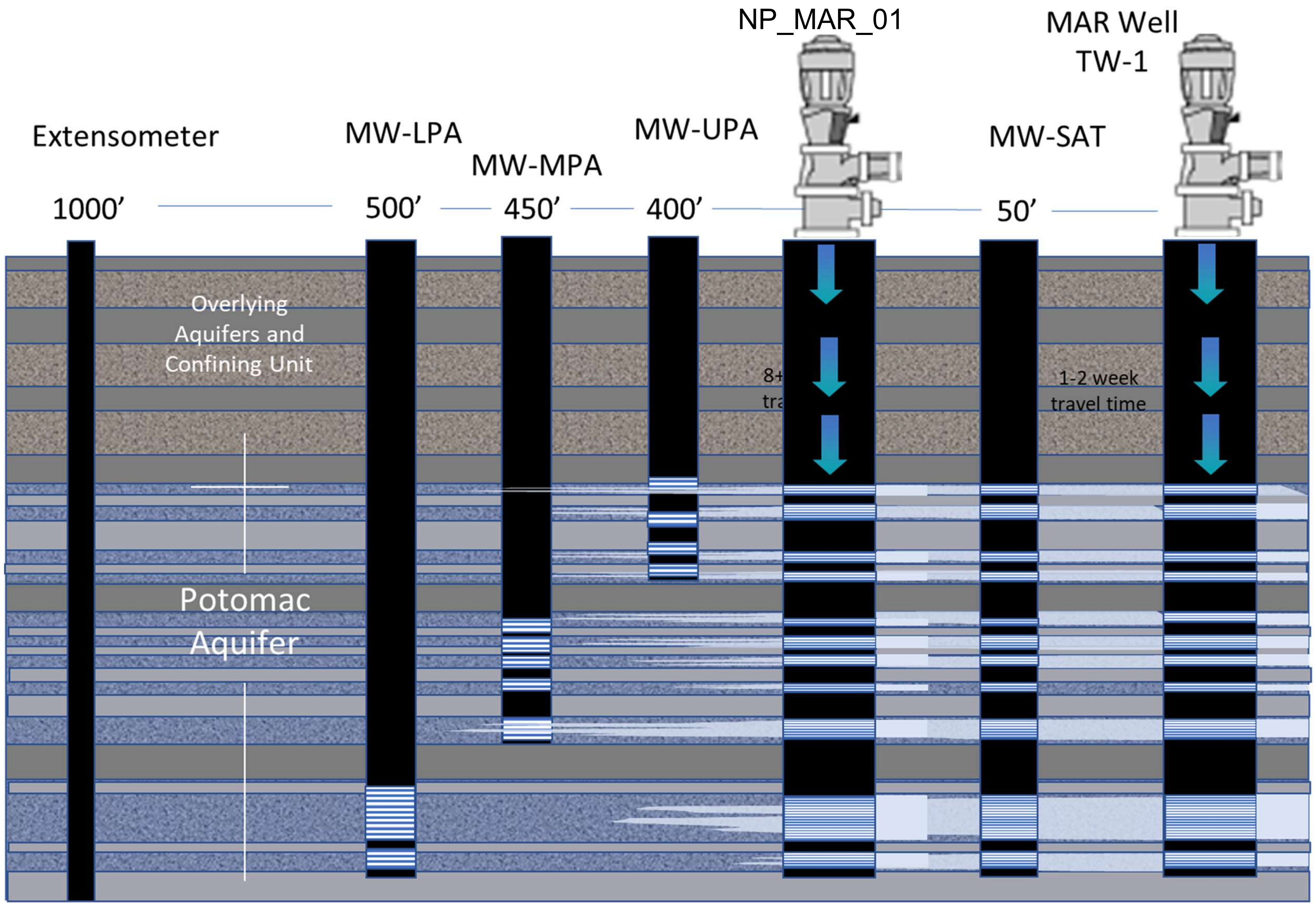




Differences in water quality can cause metals mobilization

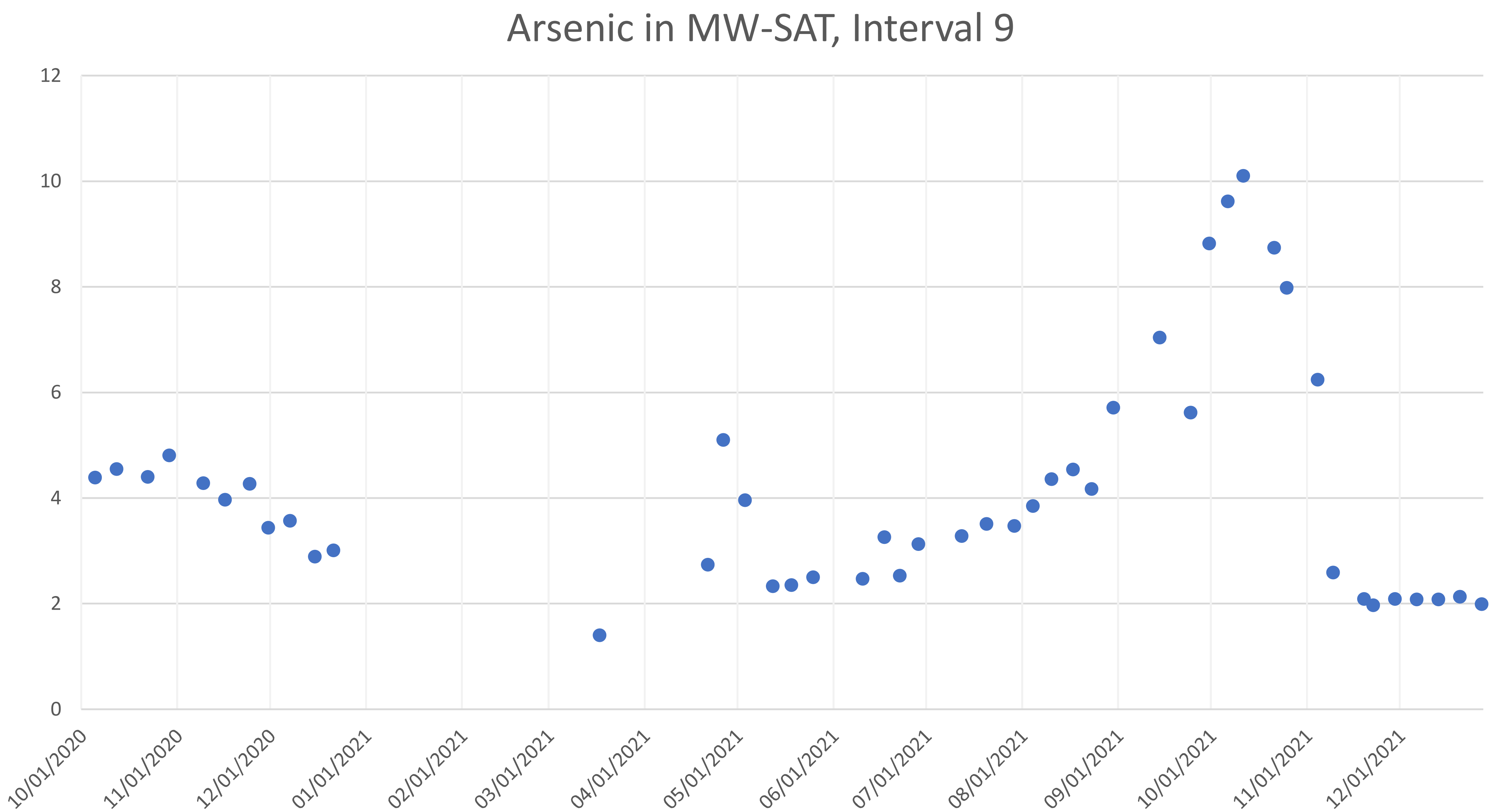
- Didn't observe As – **must assume it is present**
- Increase SWIFT Water pH above the solubility limit of iron,
- Buffers the dissolution of iron-bearing minerals, and
- Precipitating **Hydrous Ferric Oxide (HFO)** on the surface of the minerals, which performs the following:
  - **Inhibits the reactivity of reduced metal-bearing minerals (passivate)**
  - **Adsorbs arsenic migrating in the aquifer**
  - **Adsorbs potential competitive oxyanions**
- The approach works well in aquifers rich in iron-bearing minerals and redox-transitional zones, like the Potomac aquifer in the SWIFT site areas

MW_SAT, a discretized look

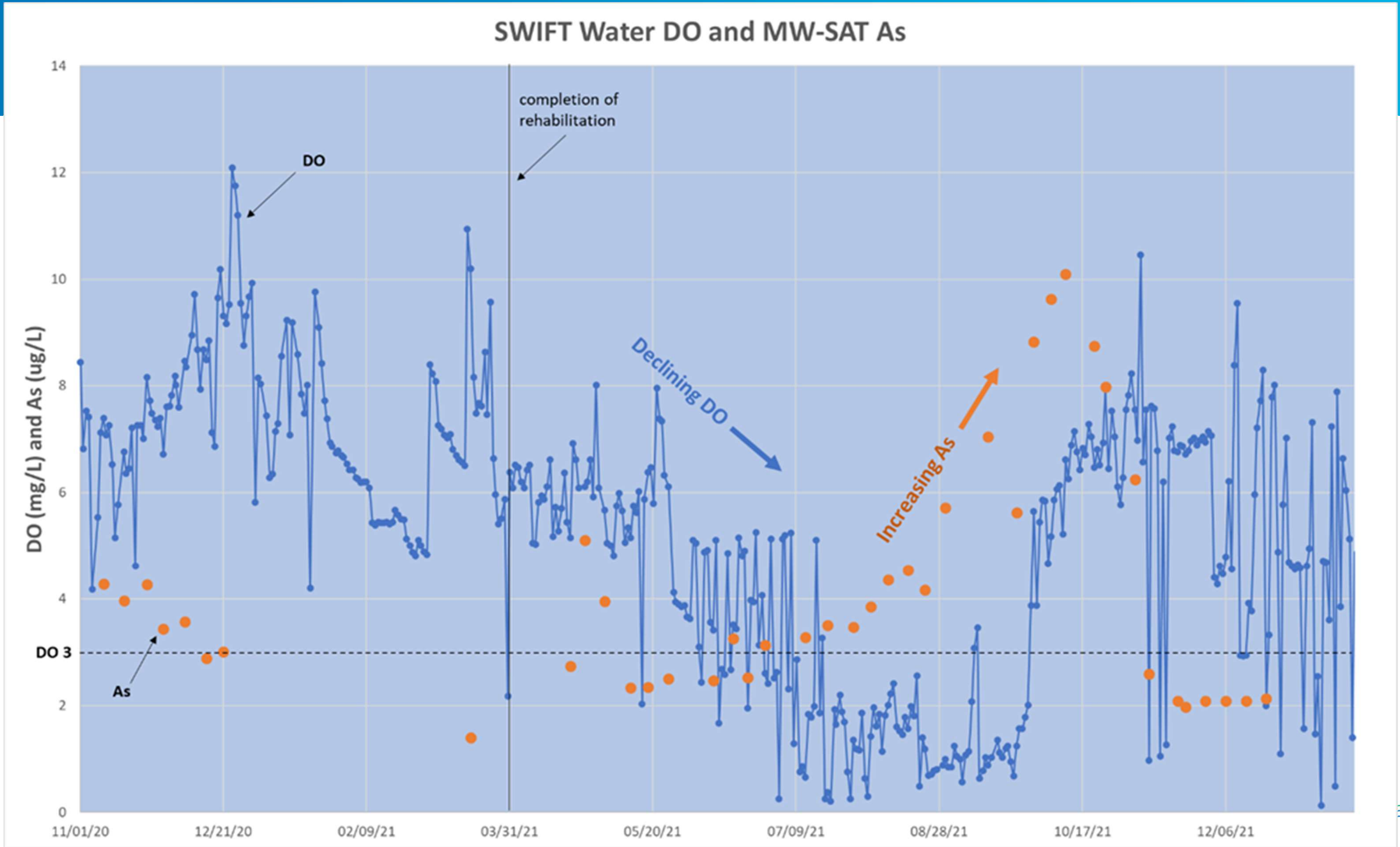


- Sister well, matches TW-1
- Research, not compliance
- 11 screen zones
- FLUTe sampling system
- Sample each screen separately

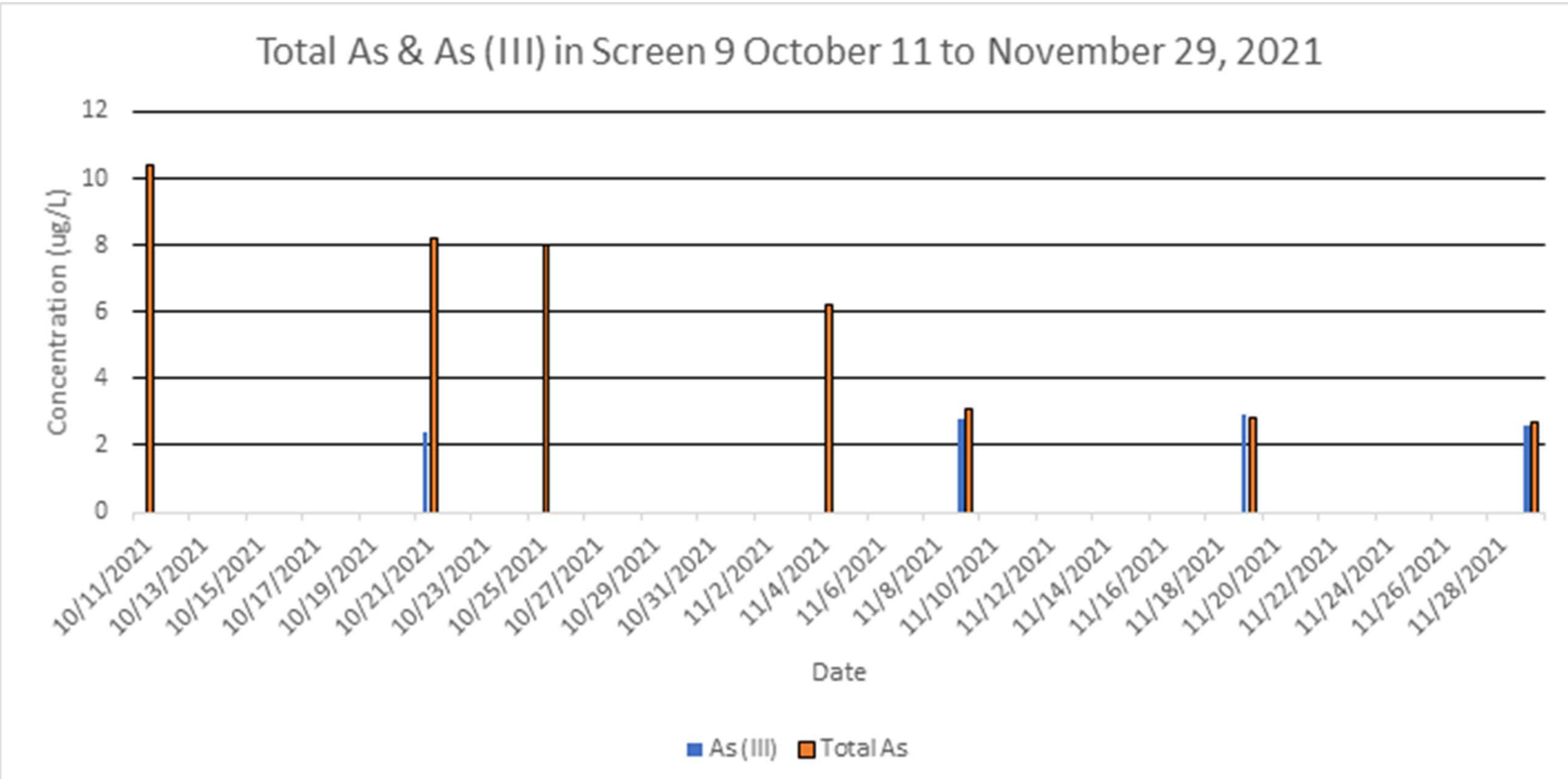
SWIFT Research Center, MW-SAT: screen 9



- Pyrite Oxidation, (melting pyrite) – occurs at leading edge of bubble
- Competitive desorption (phosphate kicks off the arsenic) – occurs later in recharge operations
- **Reductive dissolution** of arsenic-bearing iron oxides (melting HFO),

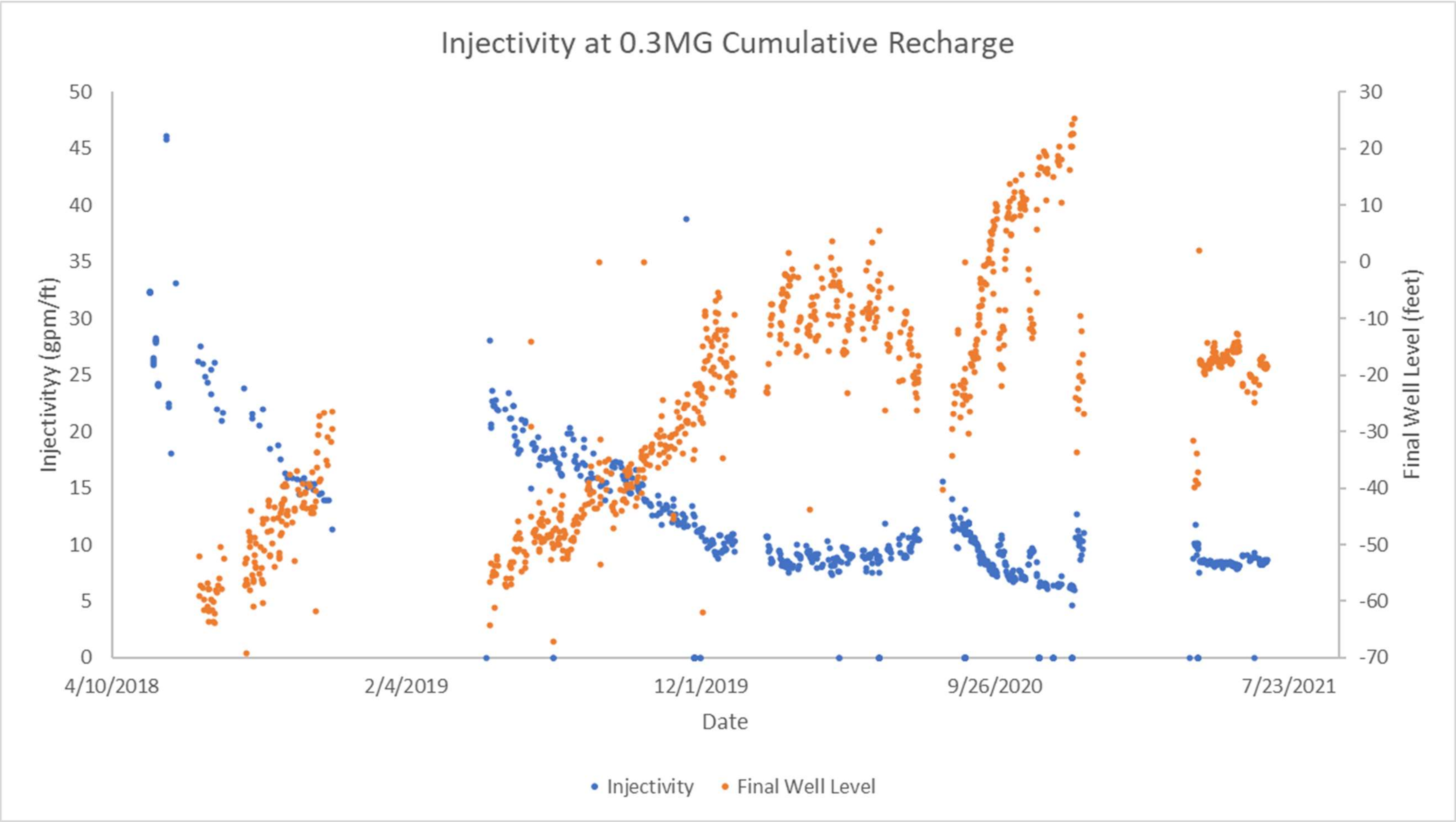

SWIFT Water DO and MW-SAT As
DO (mg/L) and As (ug/L)
0
2
4
6
8
10
12
14
11/01/20
12/21/20
02/09/21
03/31/21
05/20/21
07/09/21
08/28/21
10/17/21
12/06/21
completion of rehabilitation
DO
As
DO 3
Declining DO
Increasing As

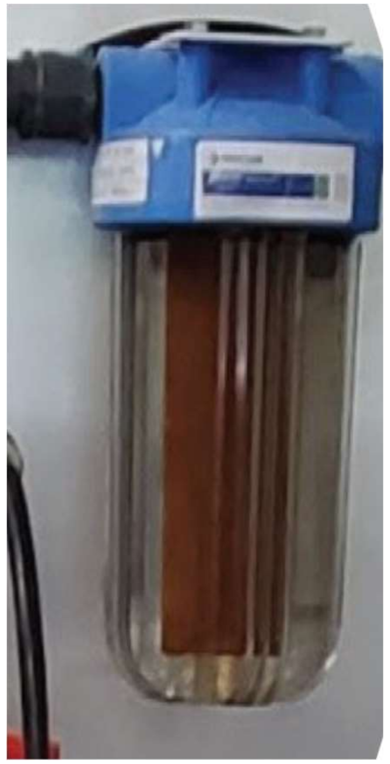
Arsenic speciation

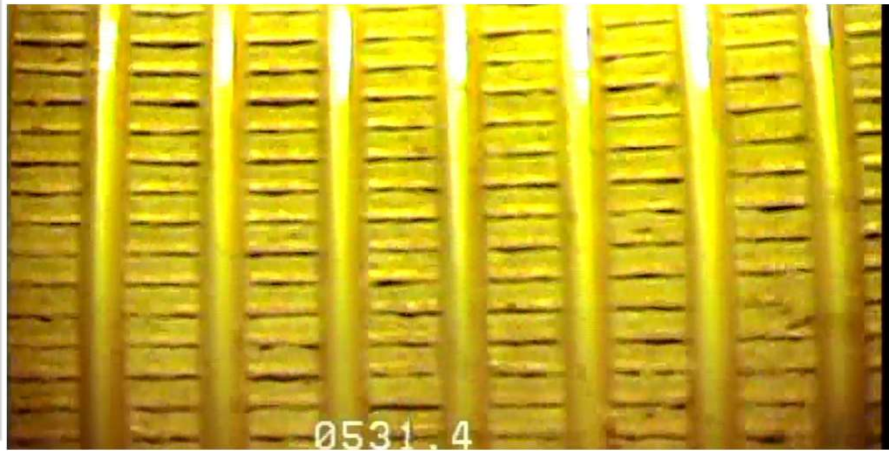


- Arsenic III is very stable across the speciated samples, just above 2 Ug/L
- When As values are low, As (III) dominates
- When As concentration is elevated, As (III) stable, As (V) increases
- Points to reductive dissolution
- Declining DO in the SWIFT Water produce reducing conditions and dissolve HFO – increase in As V

Injectivity tracking at TW-1

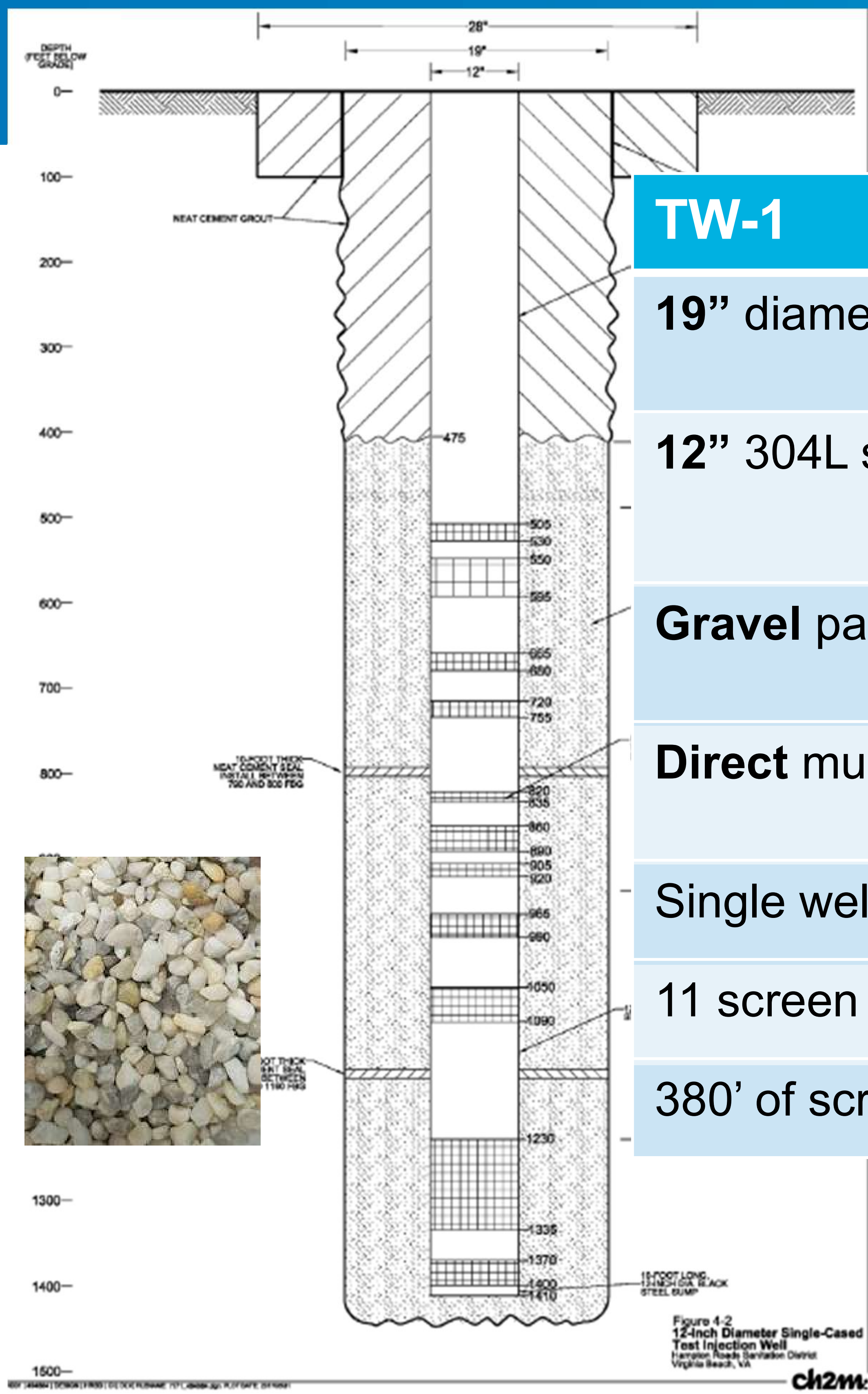


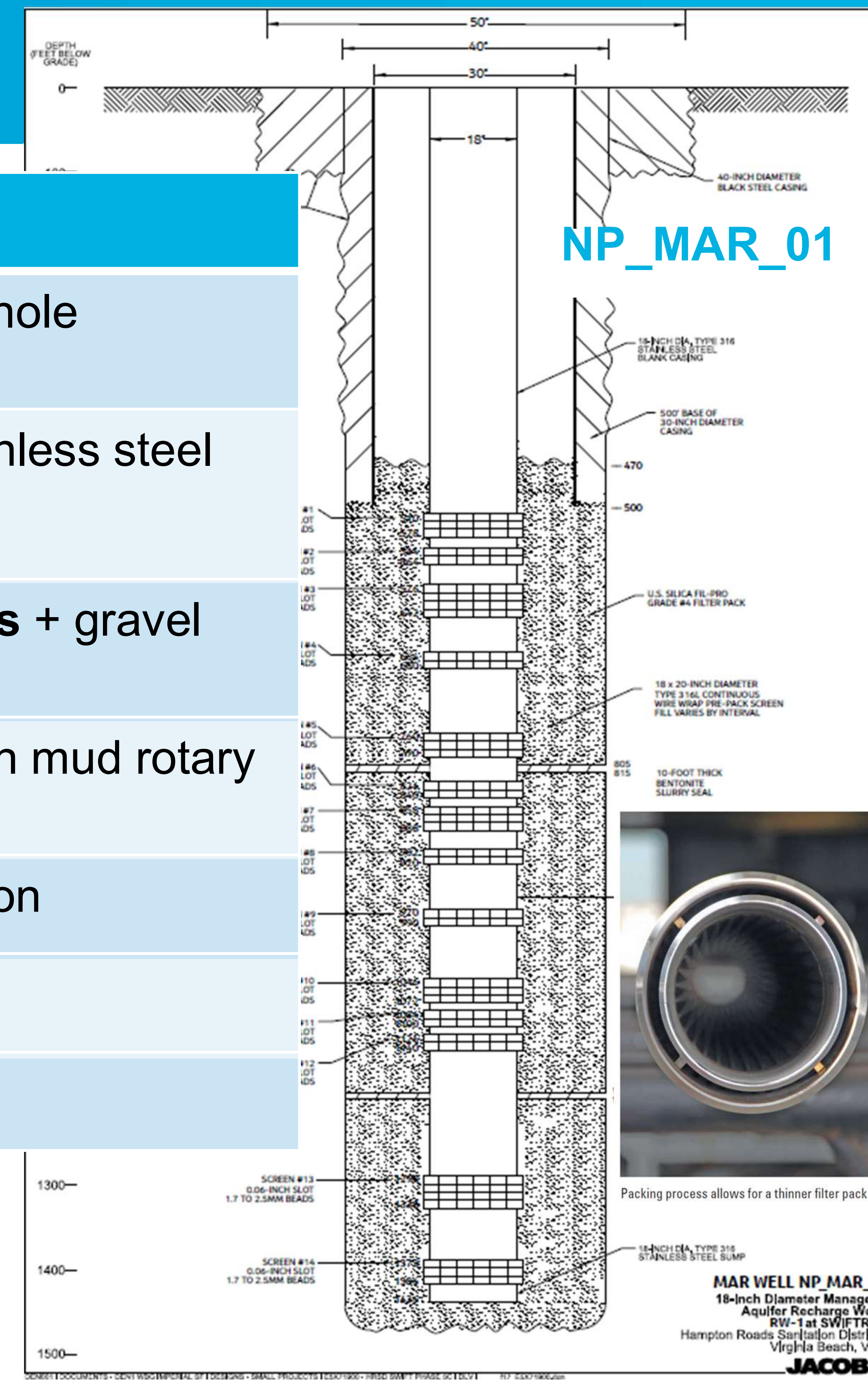




TW-1 vs NP_MAR_01

TW-1	NP_MAR_01
19” diameter borehole	**30”** diameter borehole
12” 304L stainless steel screen	**18”x20”** 316L stainless steel pre-packed screen
Gravel pack only	Si **spherical beads** + gravel pack
Direct mud rotary drilling	**Reverse** circulation mud rotary drilling
Single well casing/screen	Overlap construction
11 screen zones	14 screen zones
380’ of screen	342’ of screen





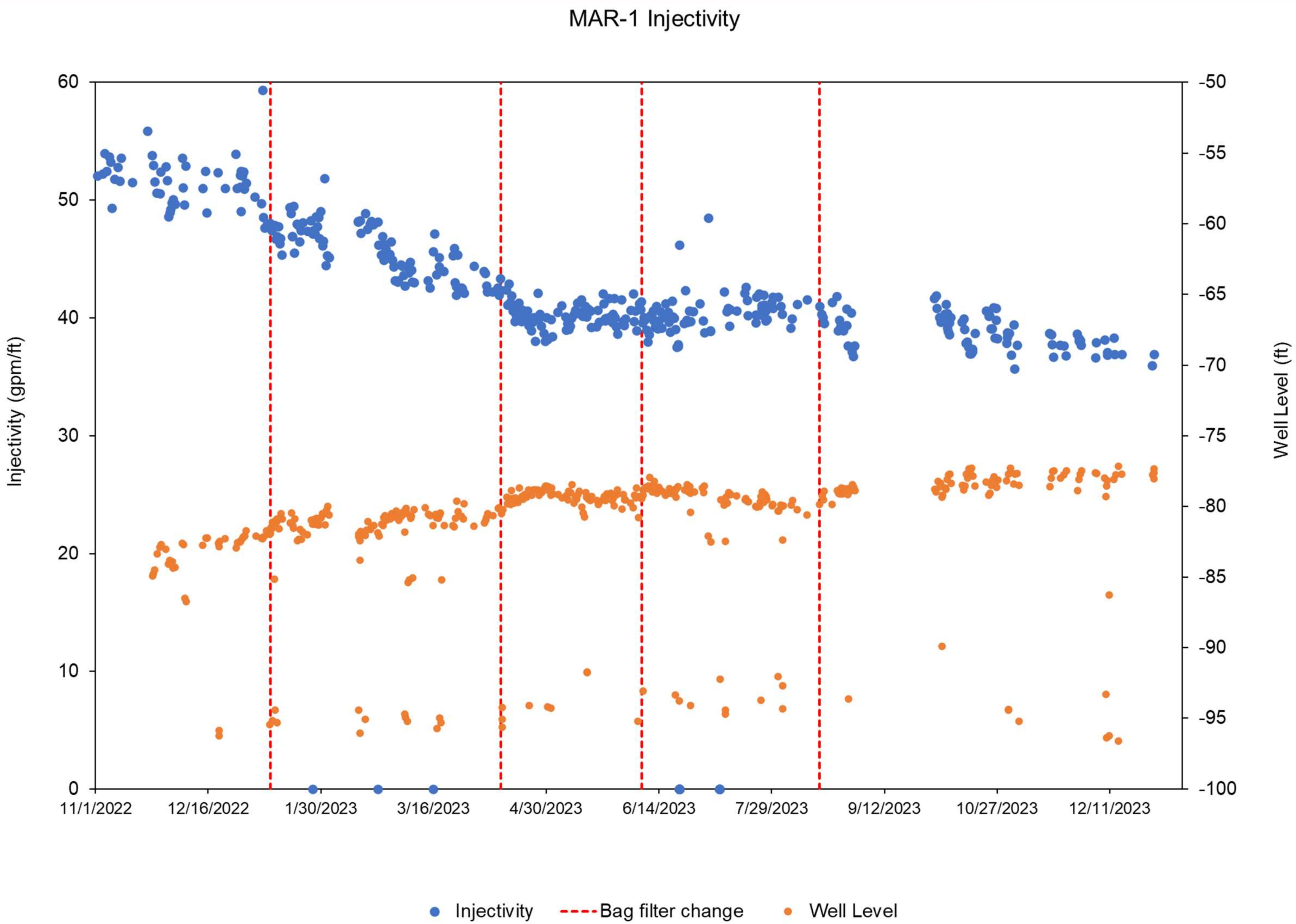
Packing process allows for a thinner filter pack

NP_MAR_01 Performance

- Pumped topped out at 2,813 gpm (4 MGD!)
- Specific Capacity @ 2,700 gpm = **69 gpm/ft**
- TW-1 SC @ 1,100 gpm = 37 gpm/ft
- NP_MAR_01 @ 1,220 gpm = 83 gpm/ft

- Transmissivity (ft^2/day)
  - Ranged 31,200 – 57,500
  - Average 41,500

NP_MAR_01 much better!

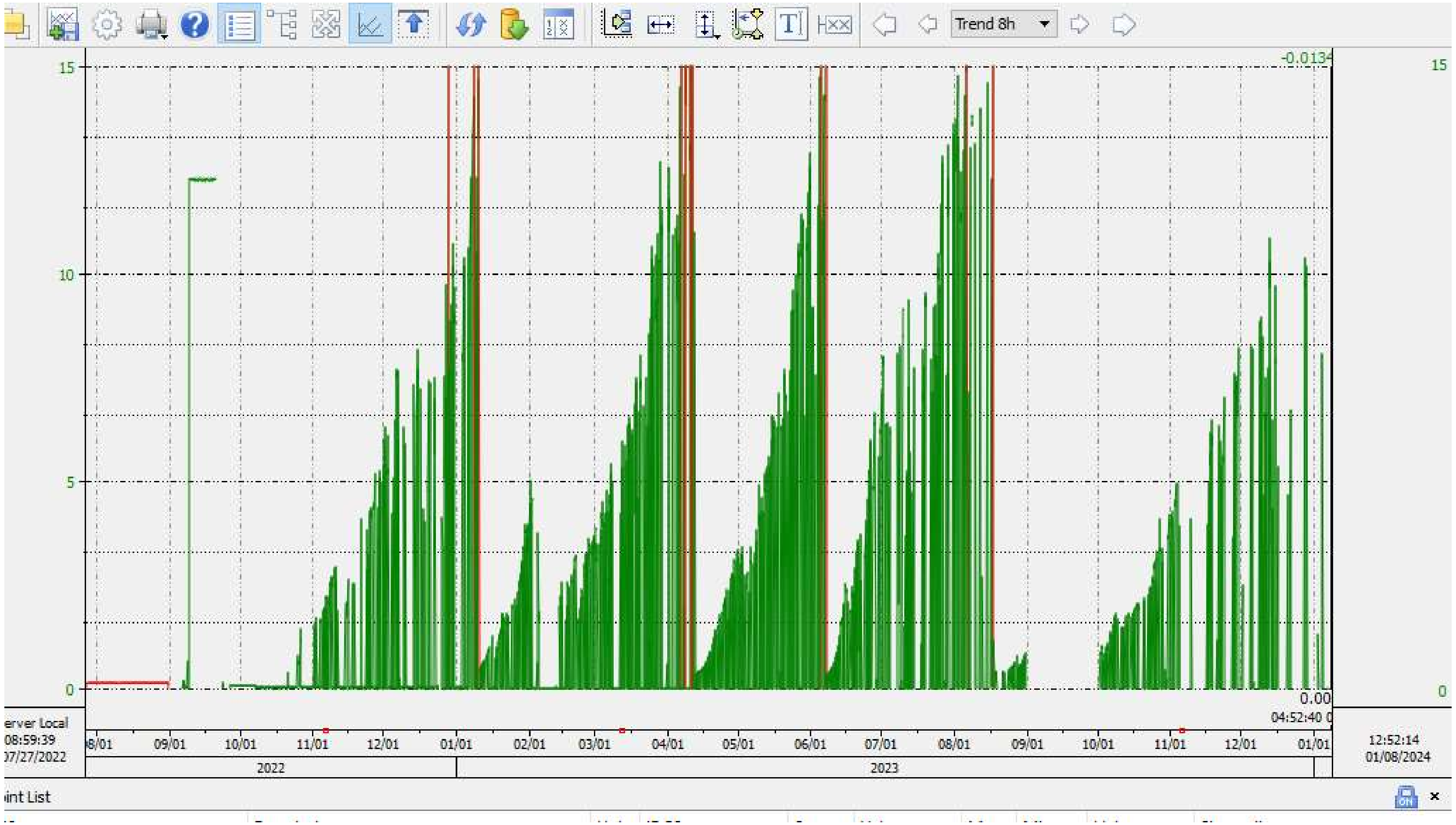


Wellhead filtration to learn

- Filter bags replaced approximately every 2 months

- Reminder: Currently using absolute filters (0.5 micron – Efficiency 99.99%)

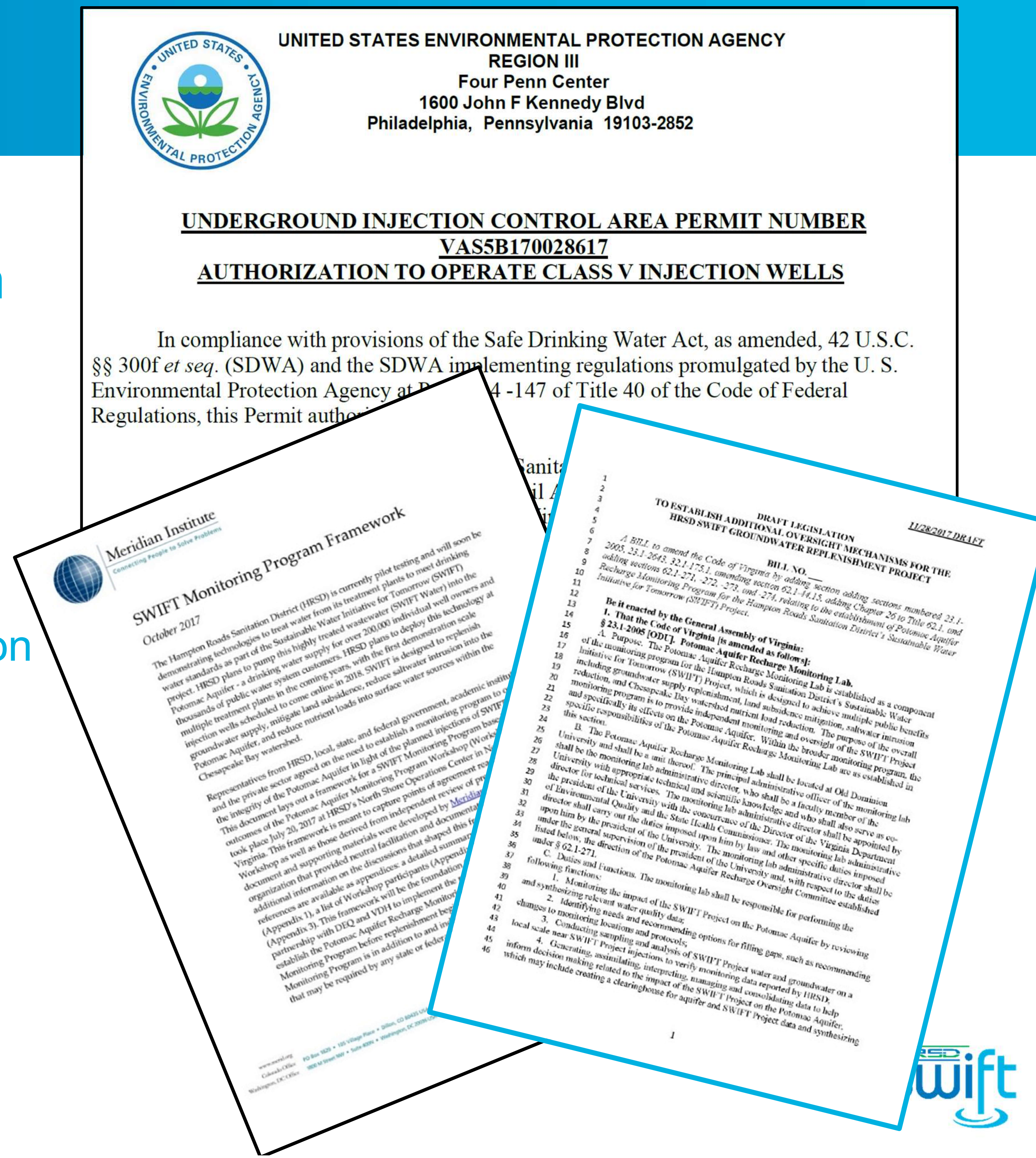
- Normally using nominal (1 micron –Efficiency 70%)



Regulatory Structure

- SWIFT falls under EPA's Region 3 Underground Injection Control Program
  - Class V Well
  - SRC EPA Permit by Rule
  - JR SWIFT Area Permit

- Independent Monitoring and Oversight
  - Developed oversight framework in collaboration with regulators and key stakeholders
  - Oversight committee includes representation from regulatory community and local stakeholders
  - Incorporates Potomac Aquifer Monitoring Research Laboratory
    - Jointly managed by Virginia Tech and Old Dominion University
  - Quarterly meetings since August 2019



Takes a village to put water into the ground

HRSD

Chief of Design & Construction
HRSD

AECOM
Hazen

Program Management
AECOM & Hazen

EarthData INCORPORATED

Managed Aquifer Recharge
Earth Data Inc.

Individual Project Teams

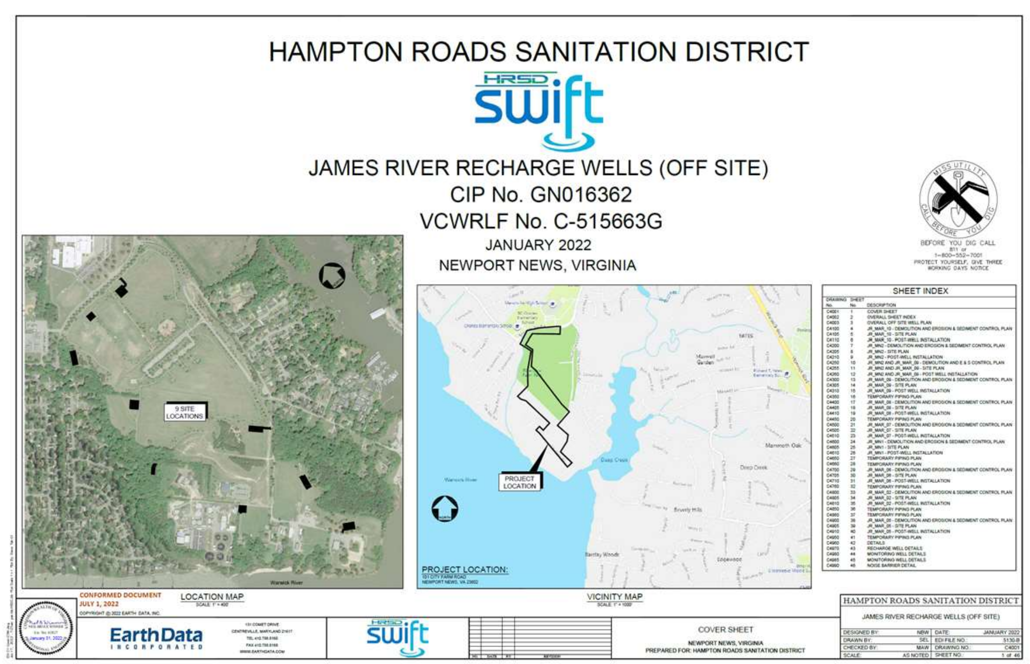
Phase 1

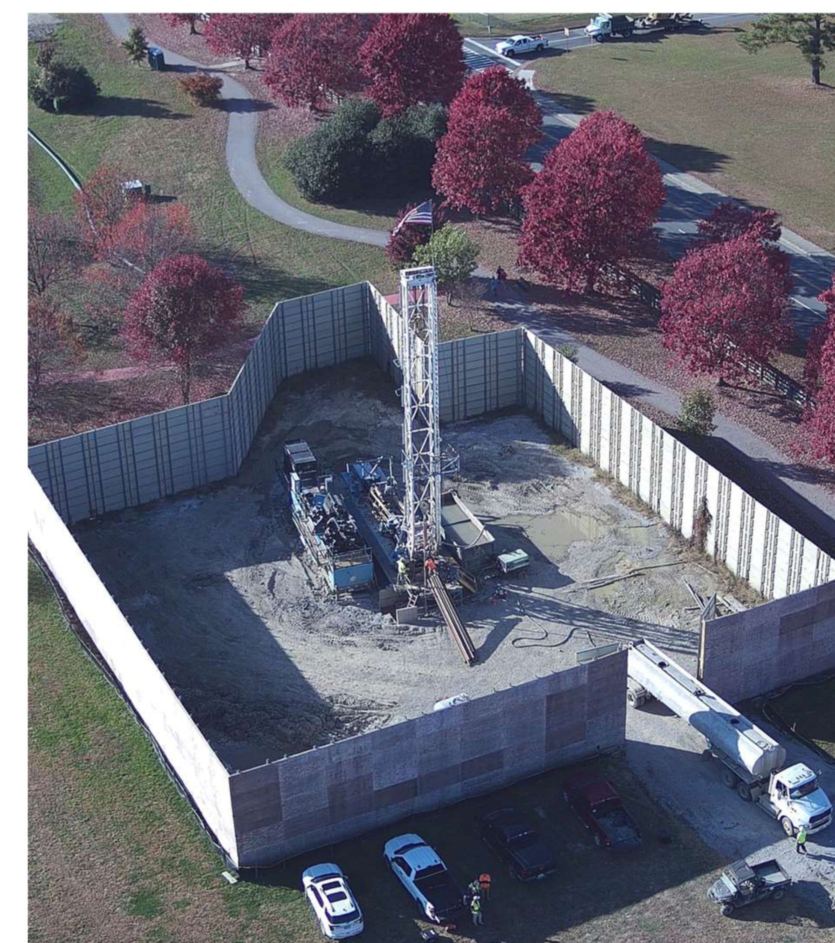
- James River SWIFT (16 MGD): US-A DB Team, AC Schultes of Maryland, 2026
- Nansemond SWIFT (33 MGD): Active Procurement, 2029
- VIP SWIFT: Tertiary treatment to reduce nutrients, no recharge Phase 1

James River SWIFT Wells, not just a pipe in the ground

Recharge Well Profile

- Total depth: ~1250 feet below ground
- 30-inch SS diameter upper casing X 20-inch diameter SS screen
- Screen/blank section starting ~500 feet below ground
- 10+ Multiple screen sections
- Pre-packed screens likely
- 4 MGD withdrawal capacity, 2 MGD recharge capacity
- Reverse circulation drilling pass
- Conditioning aquifer with ACH





James River SWIFT MAR Wells

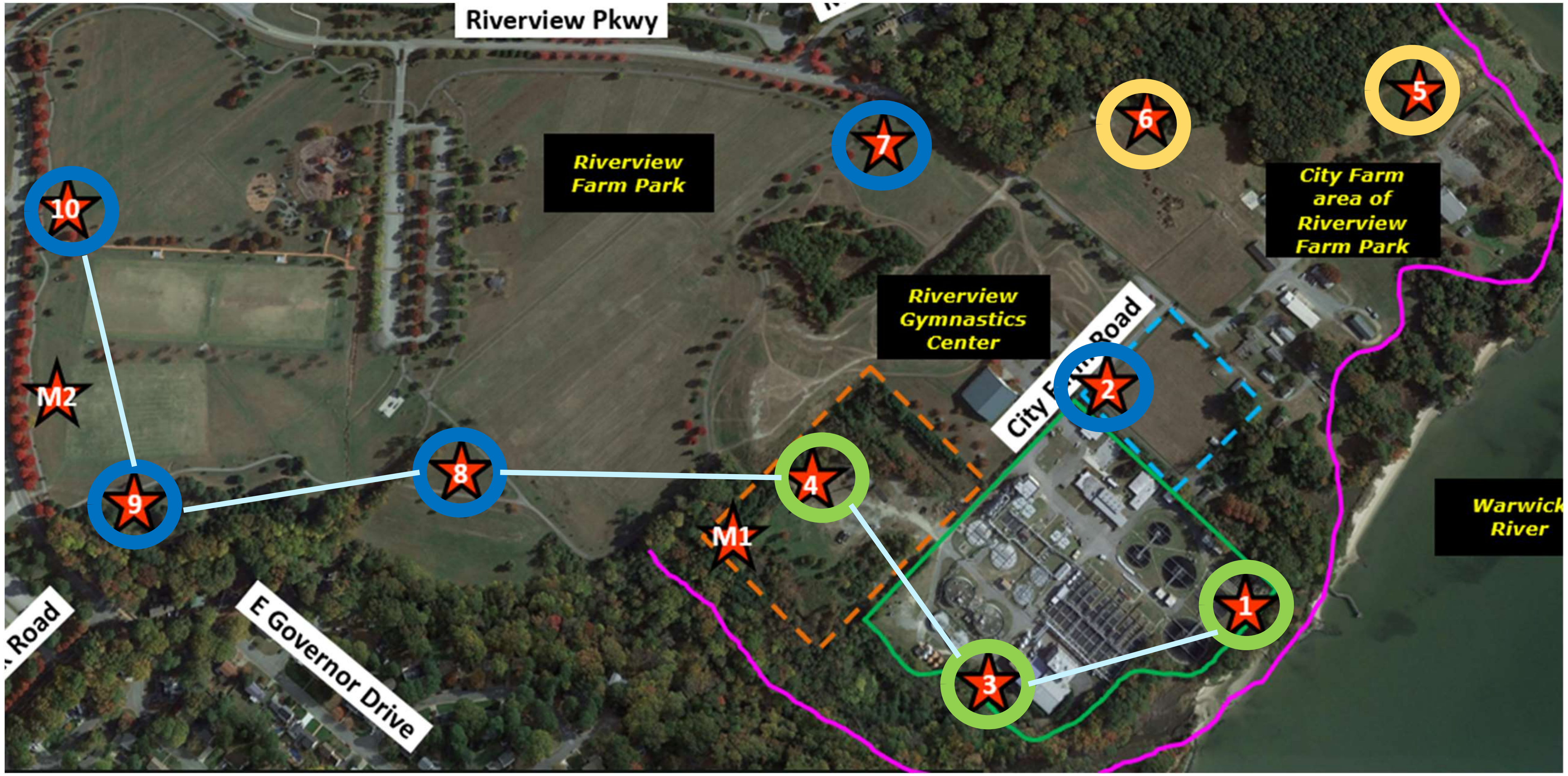
NTP Issued 6/29/2022

Overall Construction Completion – Approx. 50%

Time Elapsed – 50%

SC 6/29/2025

FC 7/30/2025

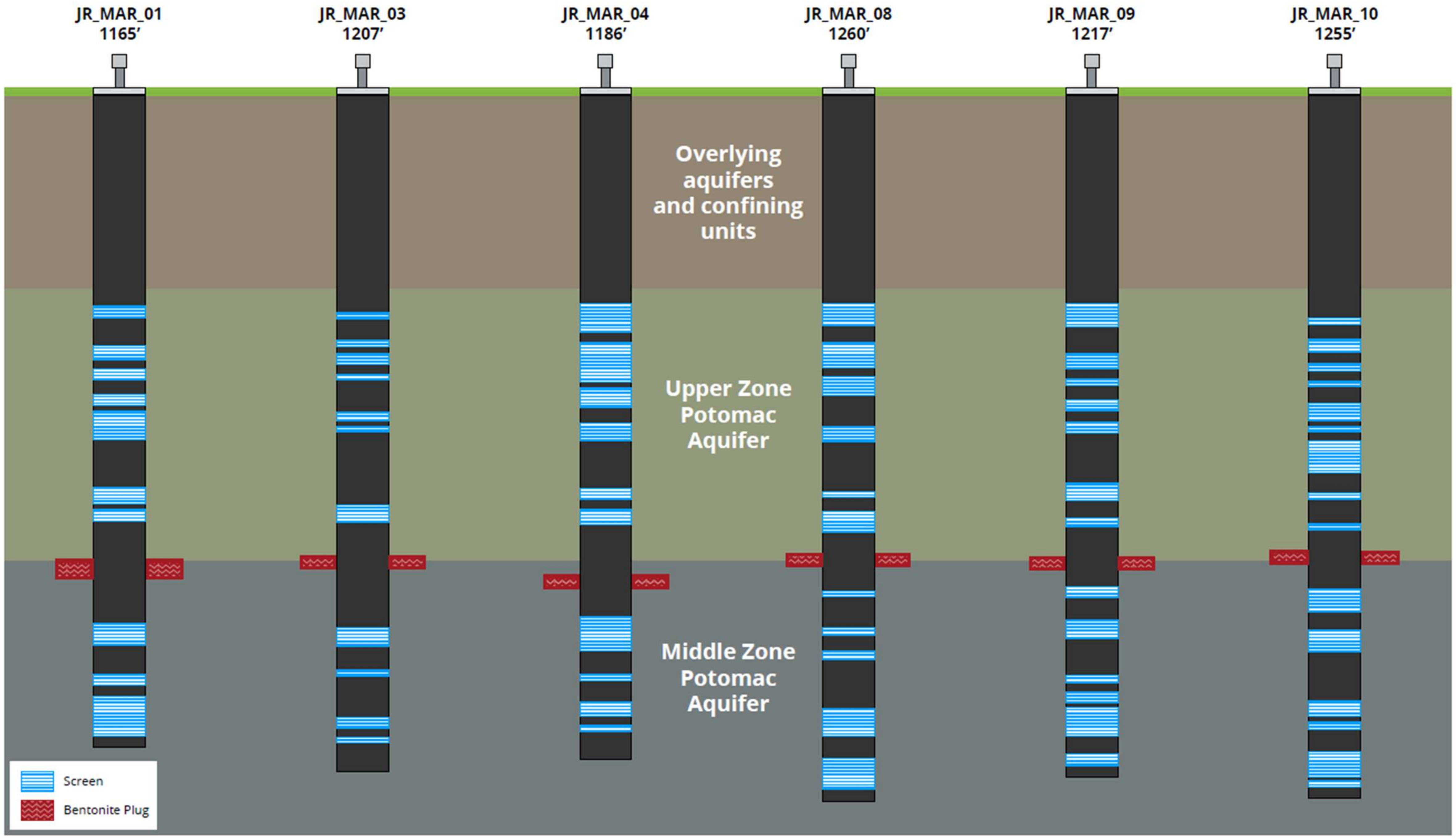


Complete

Active

Site prep

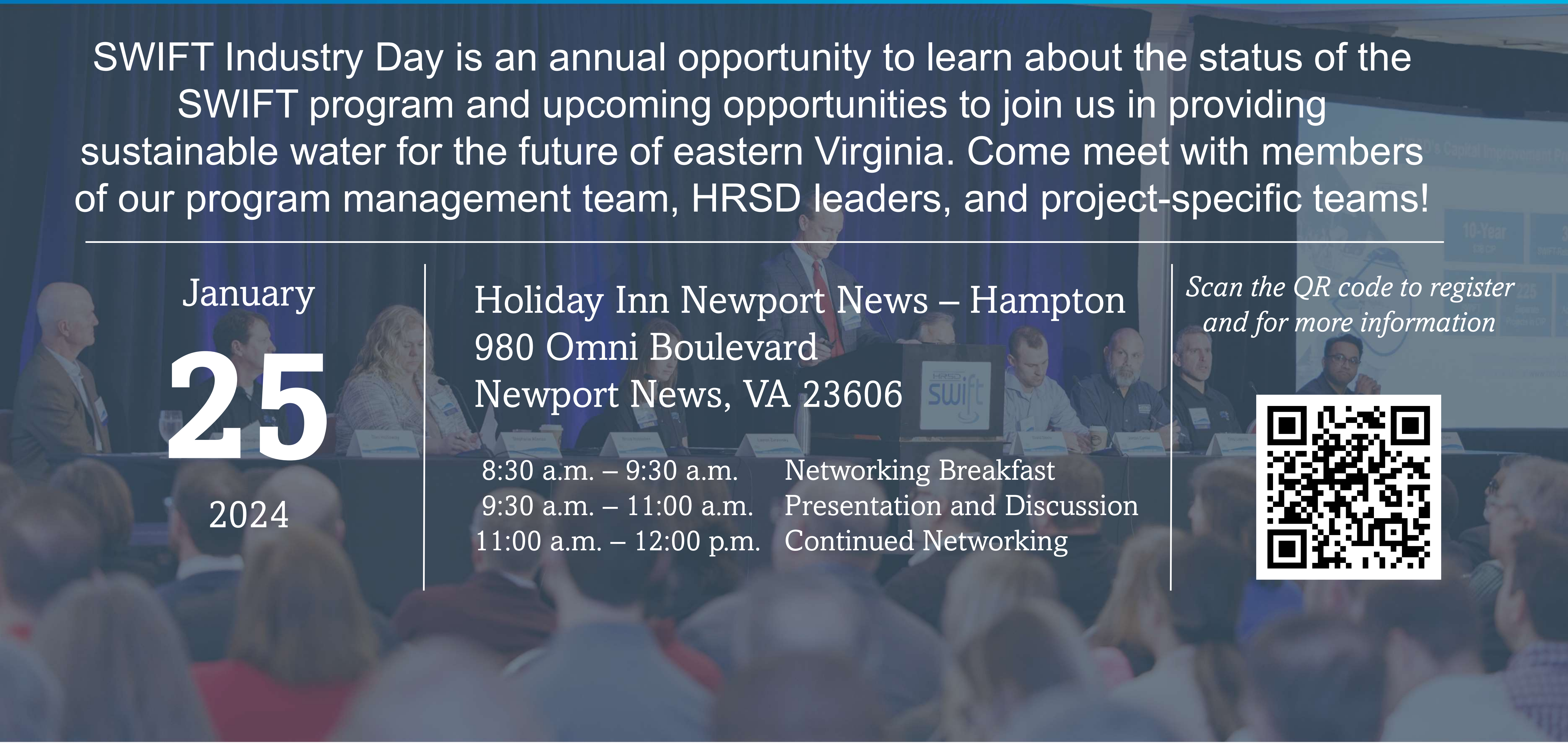
James River SWIFT MAR Wells general comparison



315' 288' 350' 377' 342' 344' Total screen length

MAR Well ID	flow rate (gpm)	specific capacity (gpm/ft)
JR_MAR_01	2112	58
JR_MAR_03	2088	55
JR_MAR_04	2100	76
JR_MAR_10	2083	60
NP_MAR_01	2112	69

Save the Date – HRSD SWIFT Industry Day 2024



SWIFT Industry Day is an annual opportunity to learn about the status of the SWIFT program and upcoming opportunities to join us in providing sustainable water for the future of eastern Virginia. Come meet with members of our program management team, HRSD leaders, and project-specific teams!

January

25

2024

Holiday Inn Newport News – Hampton
980 Omni Boulevard
Newport News, VA 23606

8:30 a.m. – 9:30 a.m.	Networking Breakfast
9:30 a.m. – 11:00 a.m.	Presentation and Discussion
11:00 a.m. – 12:00 p.m.	Continued Networking

Scan the QR code to register and for more information

Thanks! Questions?

SWIFTVA.COM

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