Bench Testing & Field Activities to Identify Distribution Destabilization Risk

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Kennewick, WA

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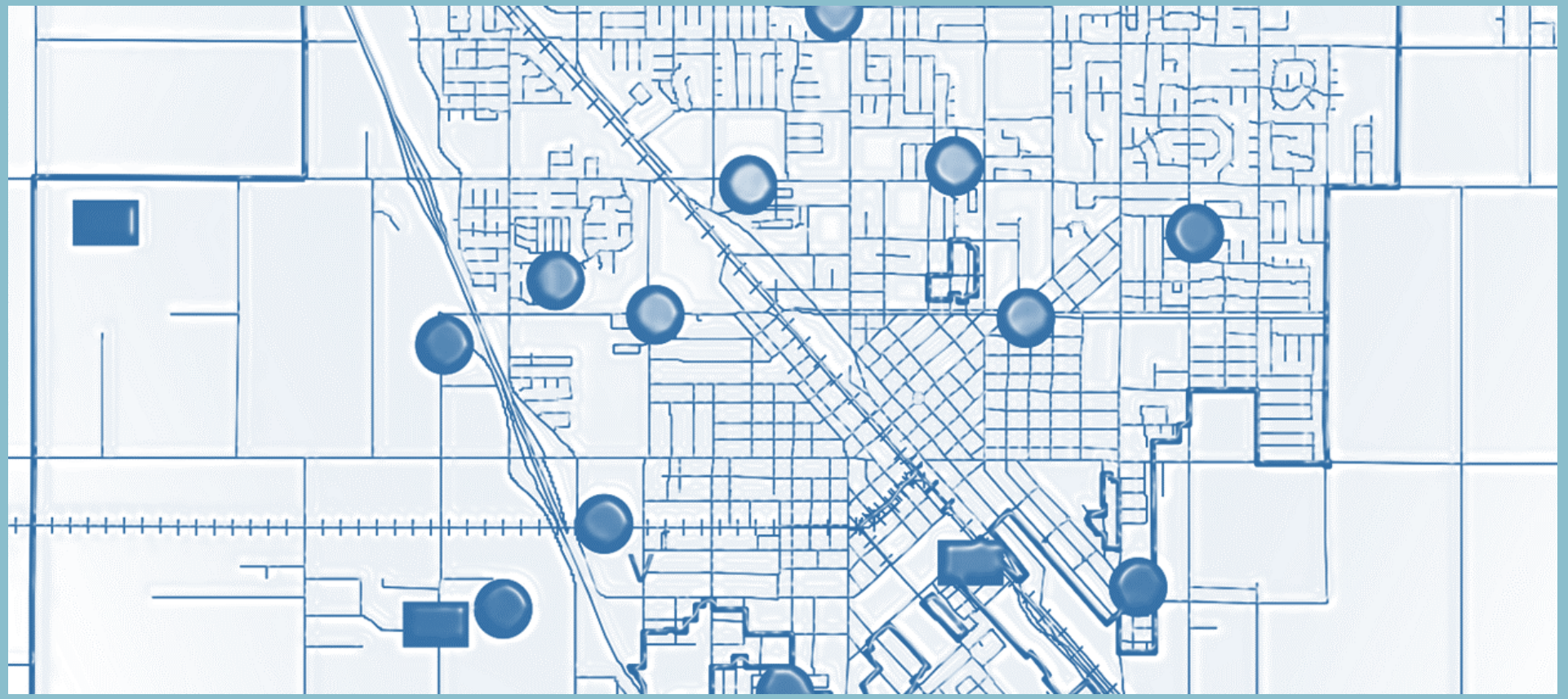
CITY OF TURLOCK INC. 1908 [2]

Discussion Topics

1. Background & Expected System Changes
2. Characterizing the System: Field Investigations
3. Bench-Scale Testing
4. Current Activities and Next Steps

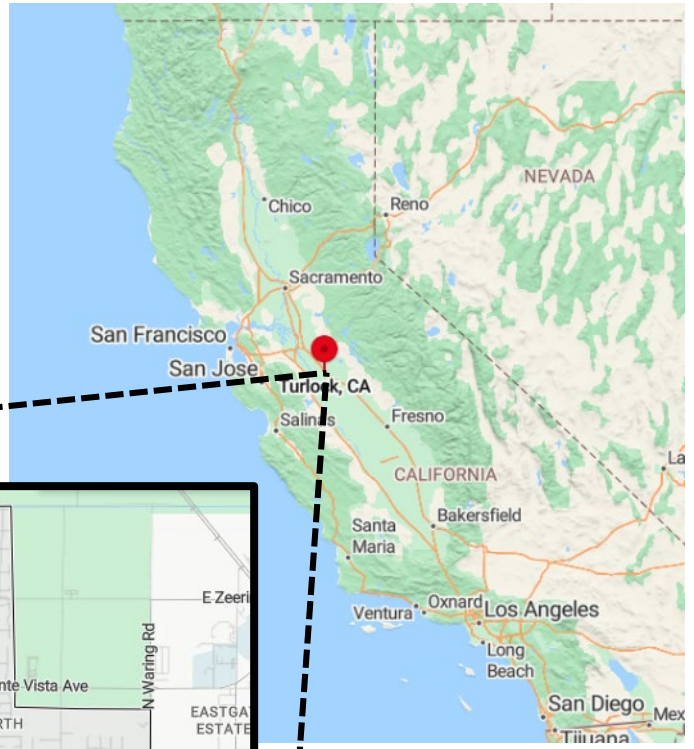


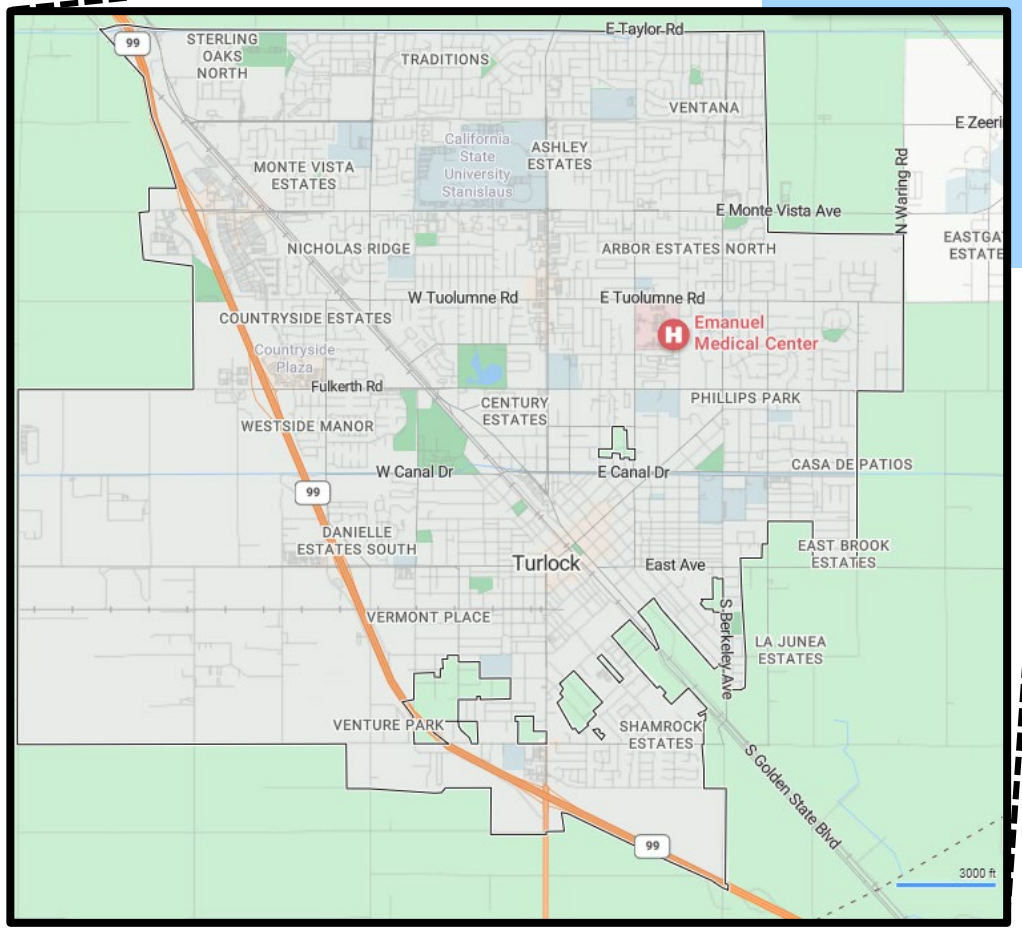
City of Turlock

1 Background & Expected Change

Turlock, California

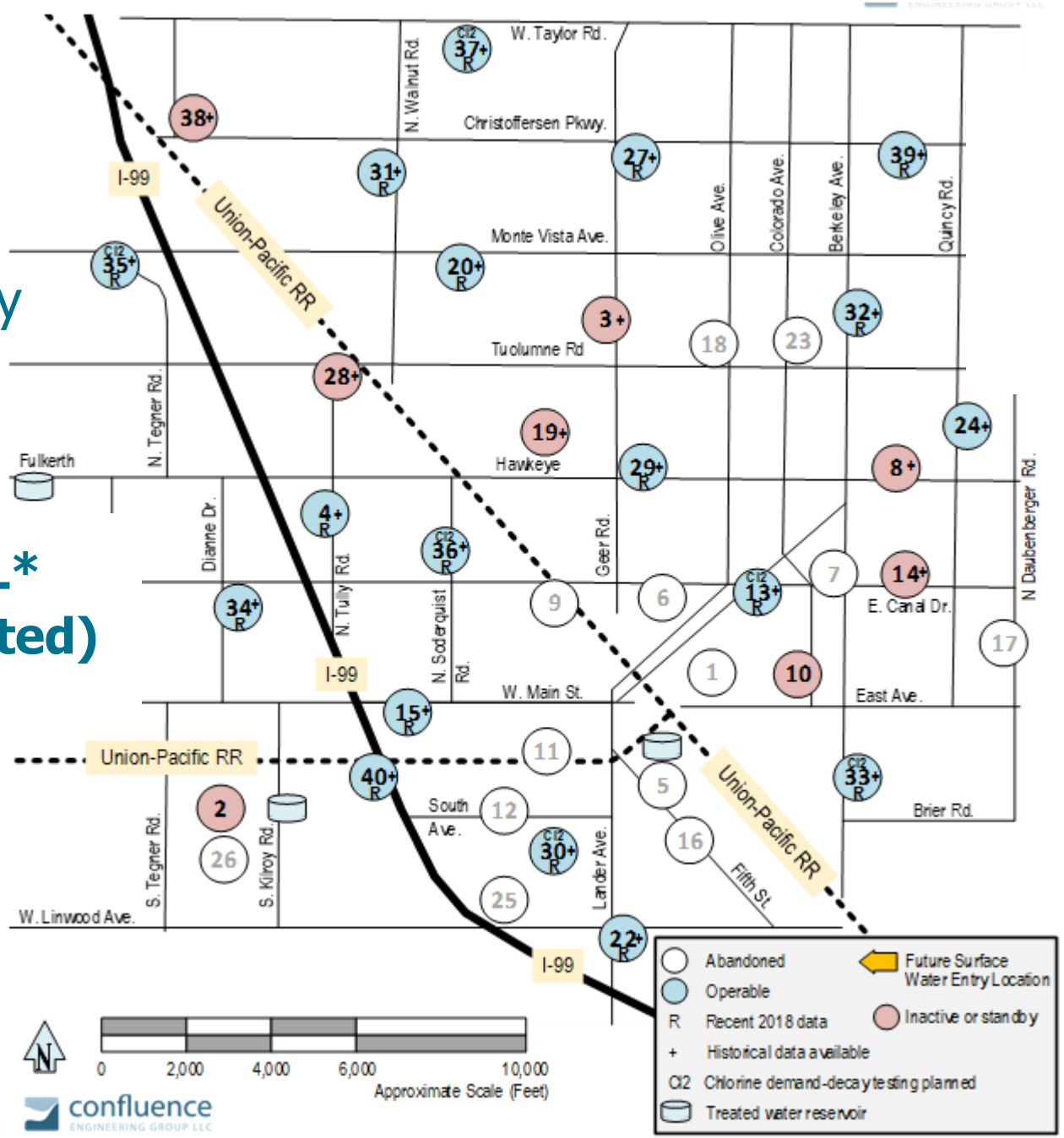
- All unchlorinated groundwater for nearly 100 years; 2020 Population of 72,700





Turlock, California (Cont.)

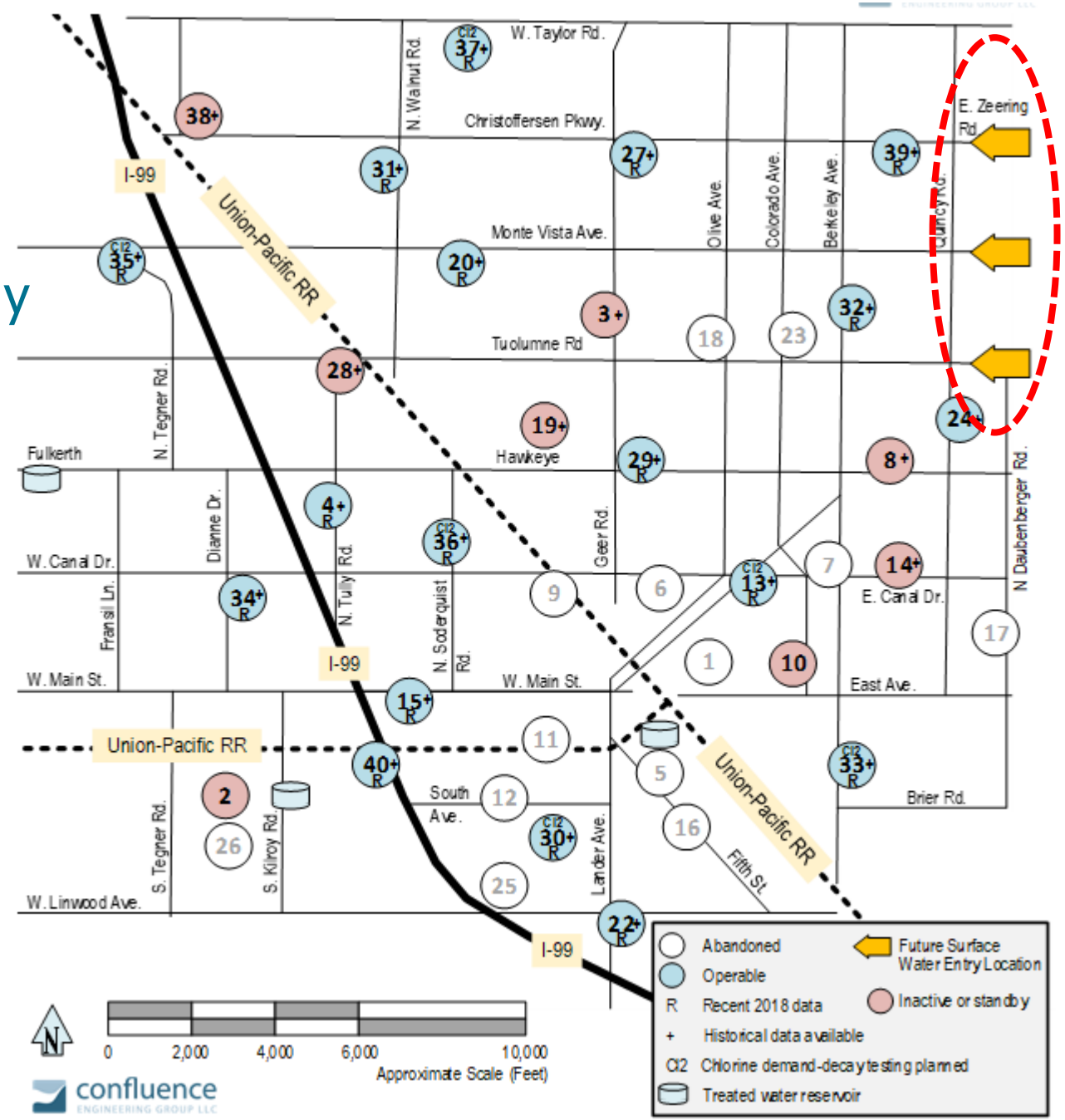
- All unchlorinated groundwater for nearly 100 years; 2020 Population of 72,700
- 18-20 Wells from 500 to 2900 gpm
  - No LCR violations
  - **As: ND to (pre-regulatory) 17 µg/L***
  - **Cr, Al, Pb, Mn, NH_3 all low (~detected)**
  - TOC ≤0.6 mg/L



** Wells with As taken off-line prior to regulation at 10 µg/L*

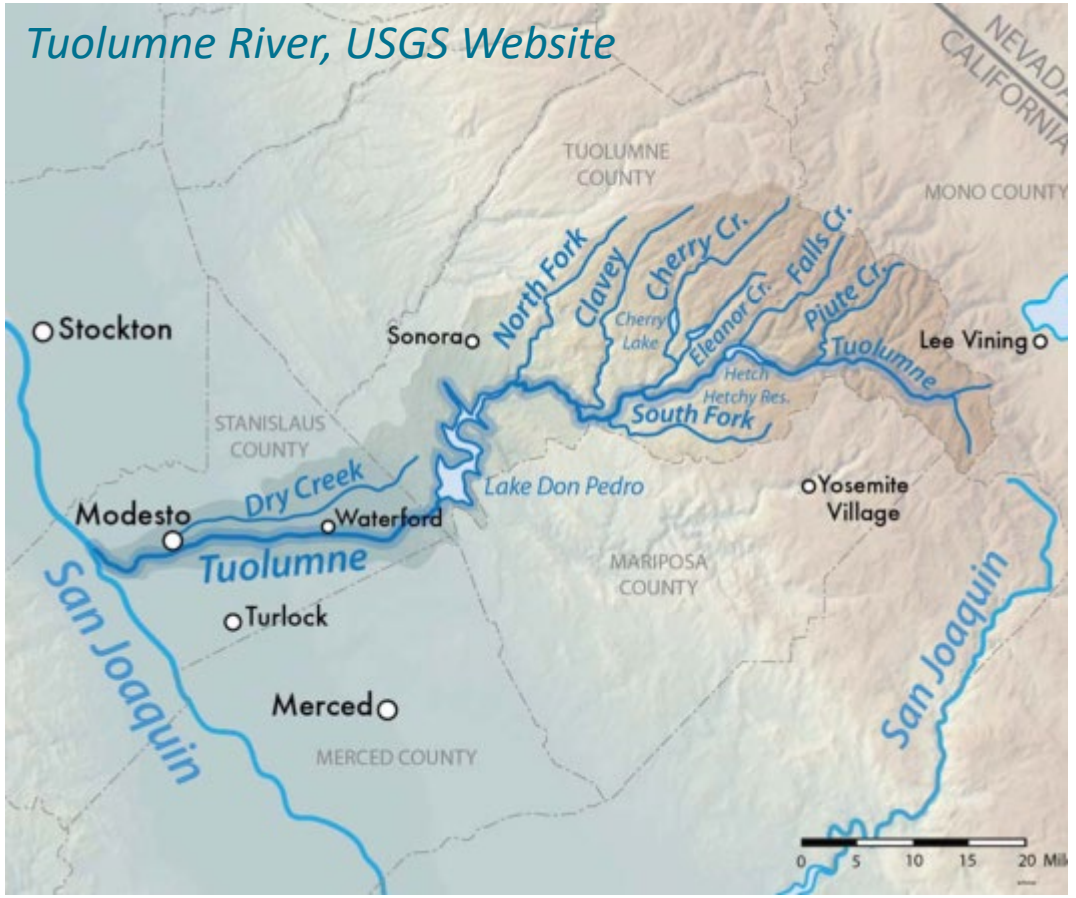
Turlock, California (Cont.)

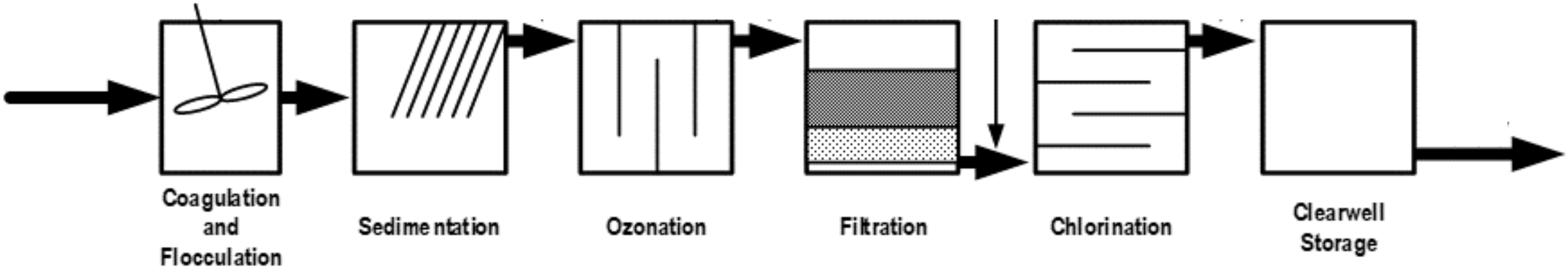
- All unchlorinated groundwater for nearly 100 years; 2020 Population of 72,700
- 18-20 Wells from 500 to 2900 gpm
- New Surface Water To Meet Growth
  - Enter at NE corner of the system



Turlock, California (Cont.)

- All unchlorinated groundwater for nearly 100 years; 2020 Population of 72,700
- 18-20 Wells from 500 to 2900 gpm
- New Surface Water To Meet Growth
  - Enter at NE corner of the system
  - Tuolumne River (Coag/floc/Sed/O_3/Filtration) *with complementary water chemistry*





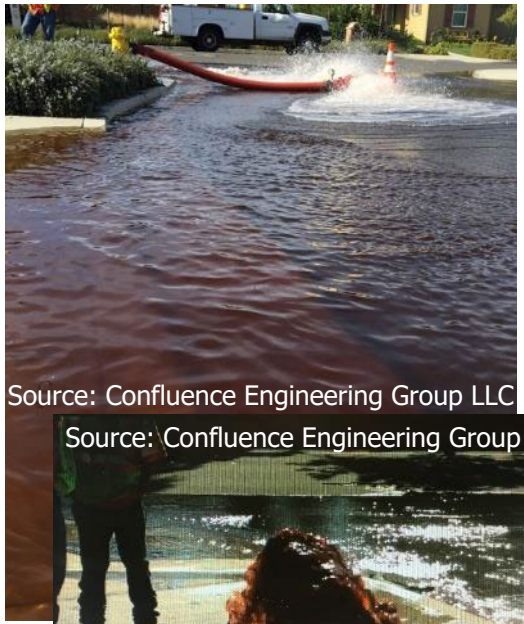
Turlock, California (Cont.)

- All unchlorinated groundwater for nearly 100 years; 2020 Population of 72,700
- 18-20 Wells from 500 to 2900 gpm
- New Surface Water To Meet Growth

- Bringing the Project Into Focus:
  - Is there water quality risk to manage during chlorination or integrating surface water?
  - Preventative measures to mitigate risk?
  - Overall: How to estimate potential for, and develop protective measures to minimize water quality upsets

Woodland, CA Case Study

- *GW with low chlorine, to SW with higher Cl_2 target*
- *Top right: UDF 5 months after integration*
- *Bottom right: Swabbing 10 months after integration*


Source: Confluence Engineering Group LLC


Source: Confluence Engineering Group LLC

Video and comment was posted to Facebook from a Woodland customer

Michael Hallett and Andrew Hill preparing for flushing and swabbing trials

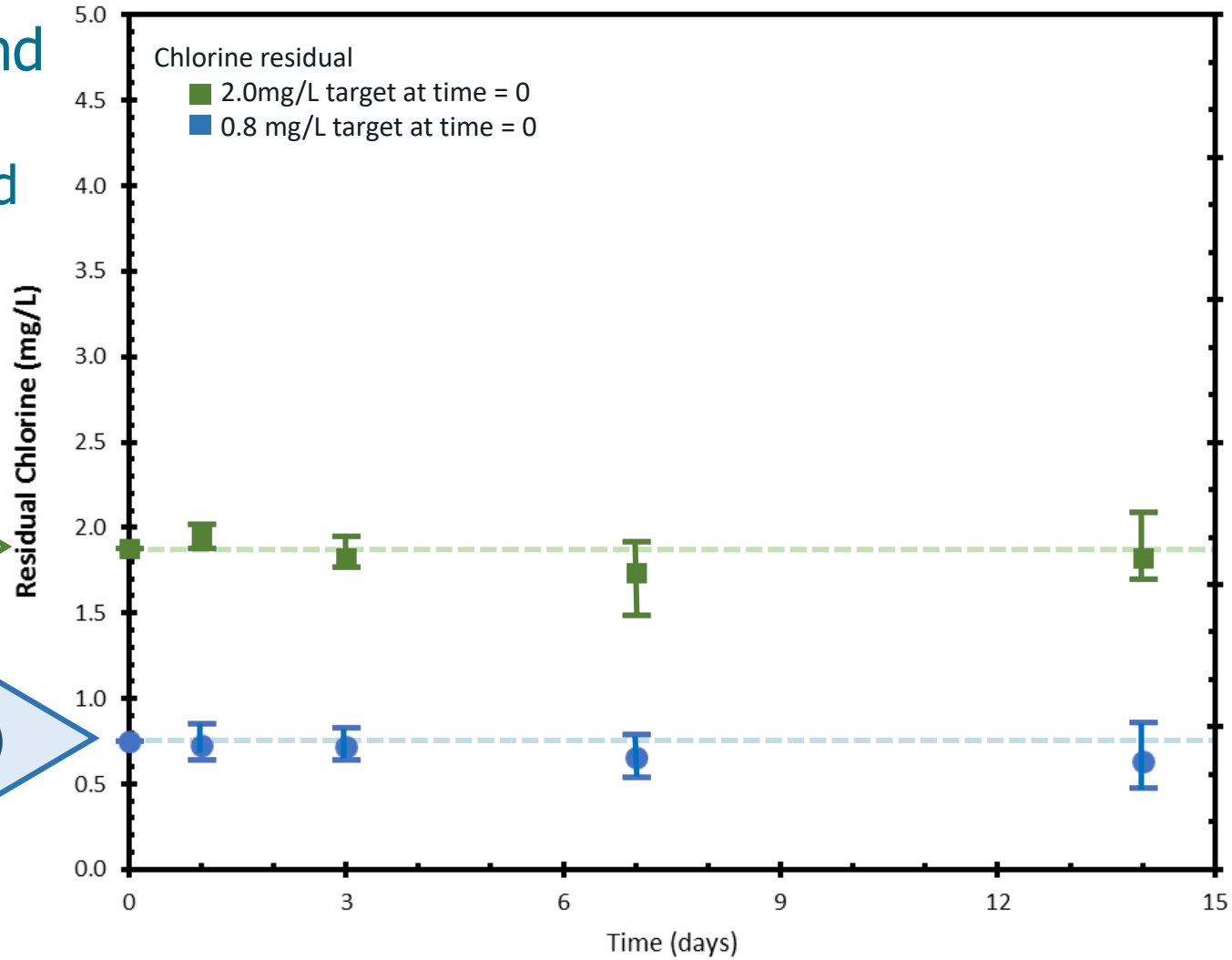
2 Characterizing the System: Field Investigations

Characterizing the System

- Chlorine Demand & Decay and DBP Formation at 14 days
  - Nearly zero chlorine demand

2.0 mg/L target at time 0 (1.9 mg/L)

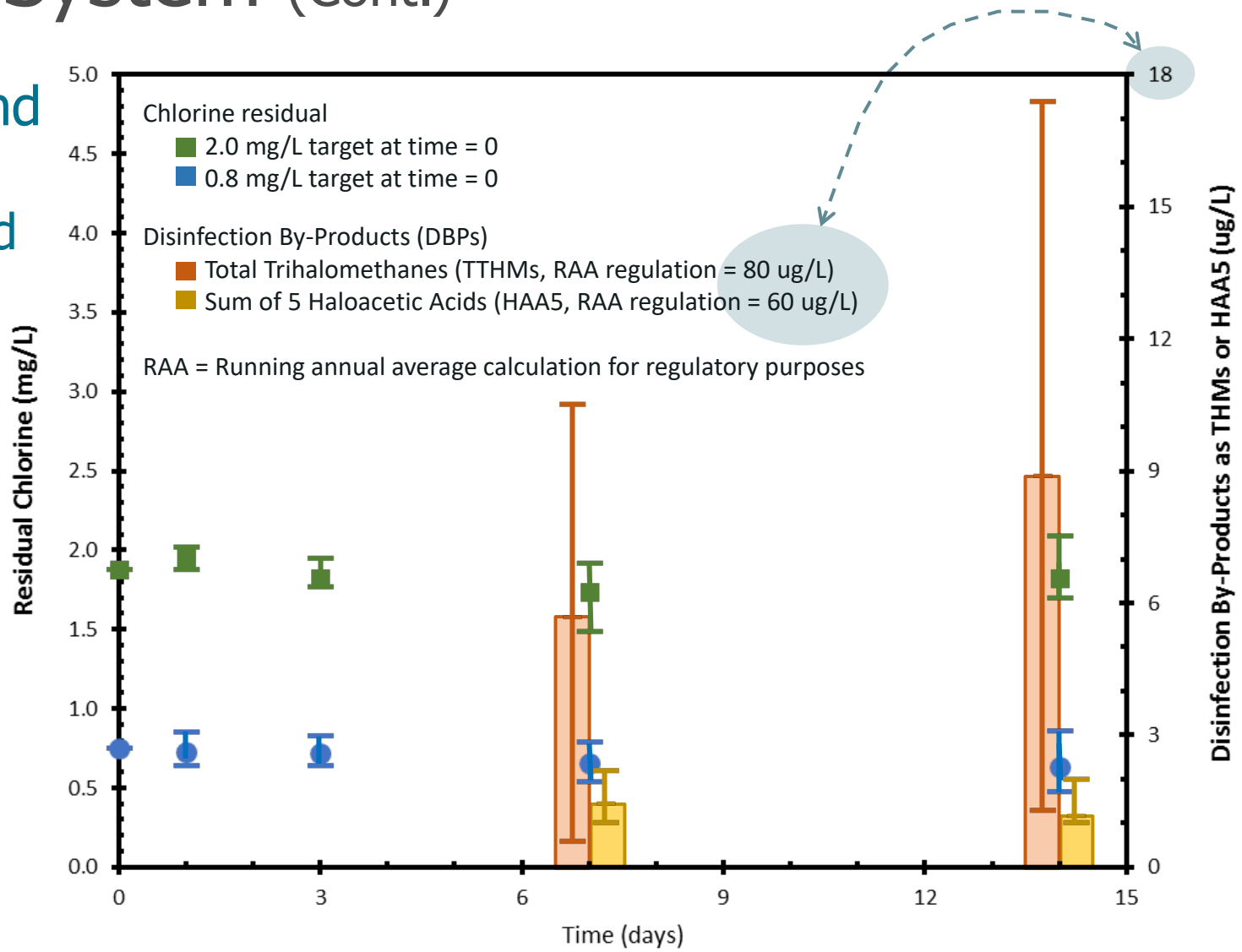
0.8 mg/L target at time 0 (0.75 mg/L)



Data represent high/low and average calculated results from 6 wells

Characterizing the System (Cont.)

- Chlorine Demand & Decay and DBP Formation at 14 days ☺
  - Nearly zero chlorine demand
  - <10 TTHMs, <20 HAA5s



Data represent high/low and average calculated results from 6 wells

Characterizing the System (Cont.)

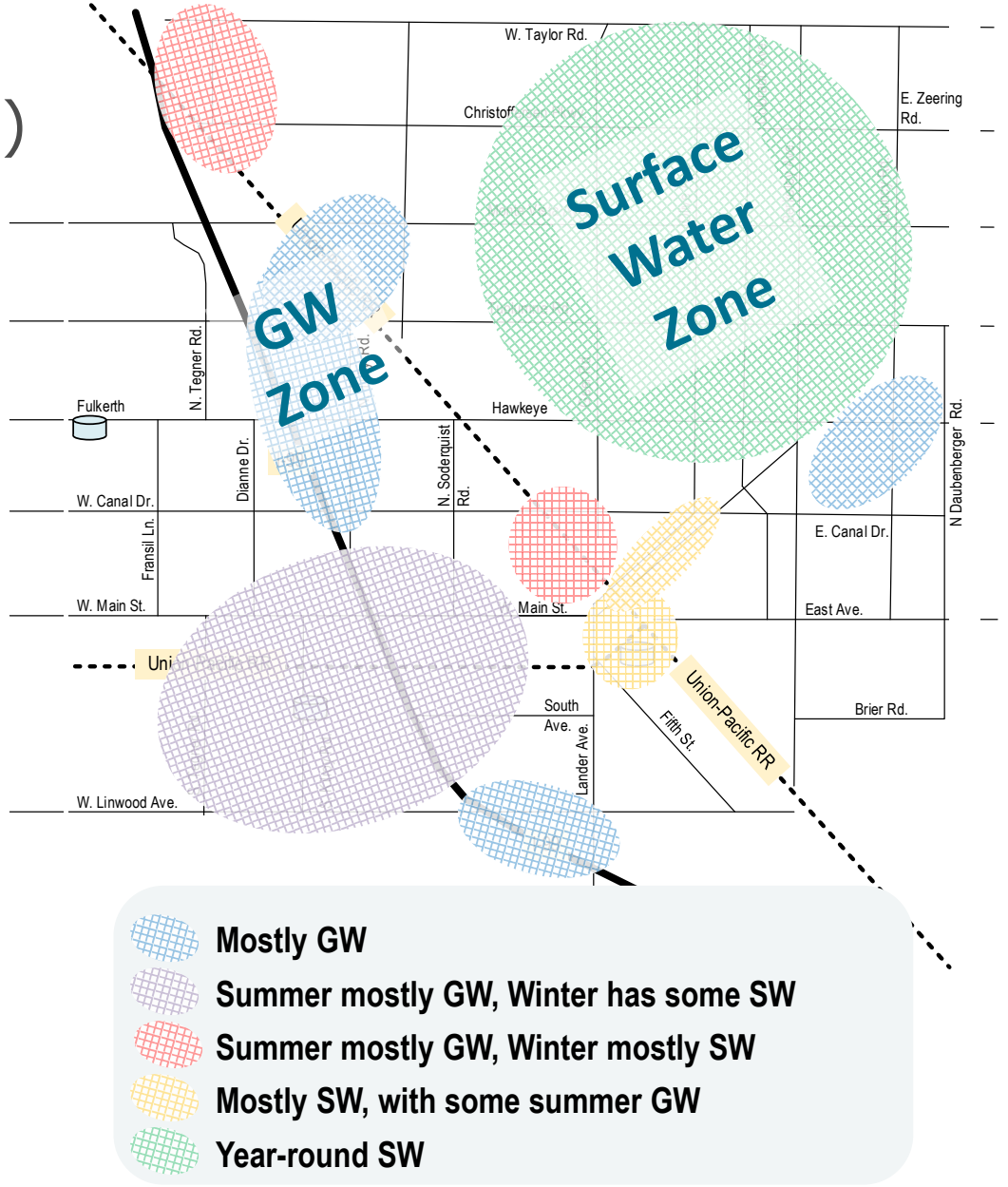
- Chlorine Demand & Decay and DBP Formation at 14 days ☺
- Pipe Tap Scale Inventory ☹
  - PVC, C900, AC, Mortar lined
  - Manganese: 24-80 mg/sq-ft (and Fe, Cr, As, Pb, Ni, Al, V)
  - Similar to Woodland

Turlock, CA Pipes

Woodland, CA Pipe experiencing recurring problems after Cl_2 increases

Characterizing the System (Cont.)

- Chlorine Demand & Decay and DBP Formation at 14 days ☺
- Pipe Tap Scale Inventory ☹
- Changes Anticipated in Blend, Age, and Water Velocity ☹
  - Surface water & blend zones
  - Water velocity change in northeast from <1 to >4 fps
  - Slight water age decrease to a 3x increase in some areas



Characterizing the System (Cont.)

- Chlorine Demand & Decay and DBP Formation at 14 days ☺
- Pipe Tap Scale Inventory ☹
- Changes Anticipated in Blend, Age, and Water Velocity ☹
- What Material is 'Available' to Events (UDF and Swabbing)
  - UDF = Hydraulically available
  - Swab = Everything else

UDF Result

Clean Start 0.5 PV 1 PV 2 PV End

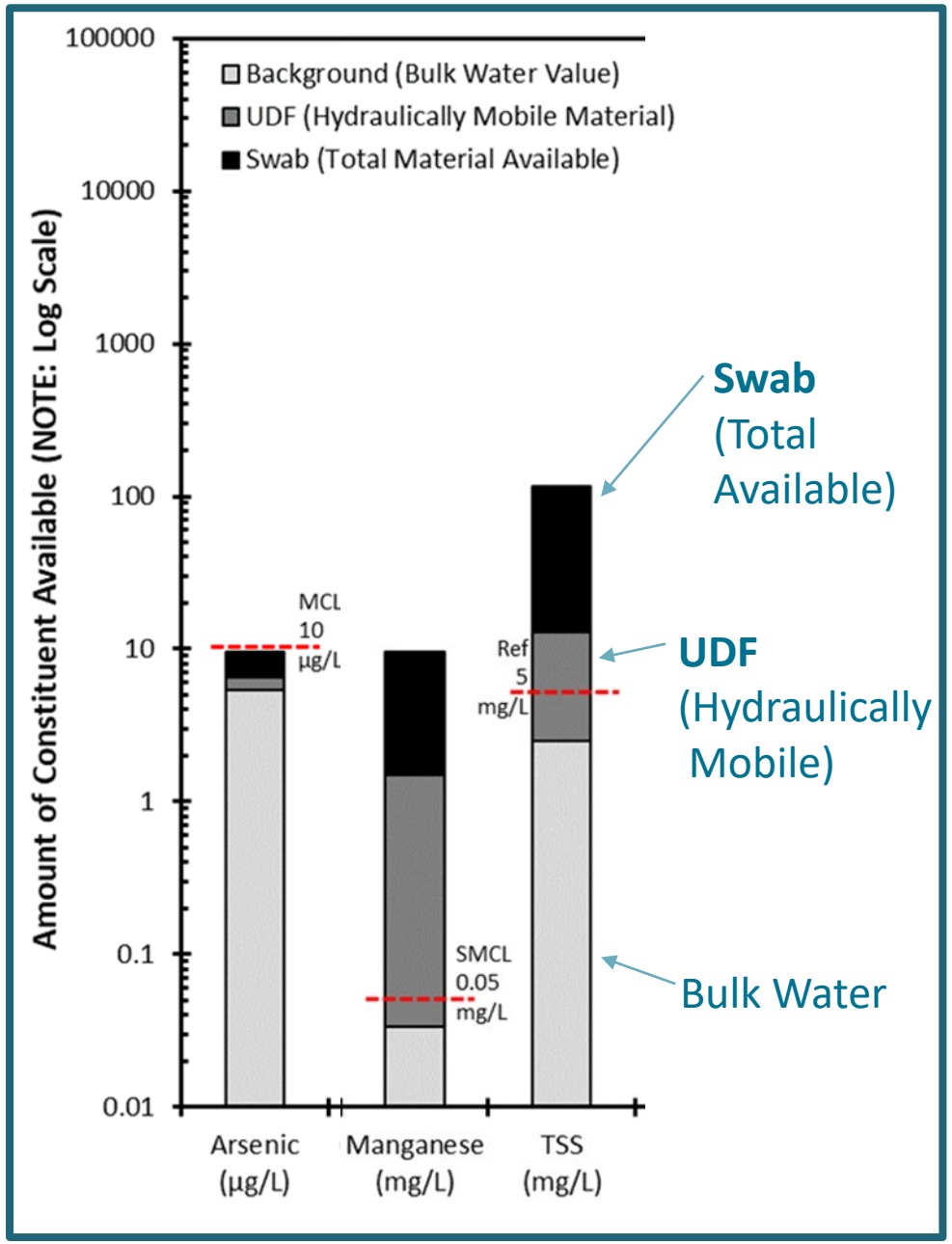
Swab Result

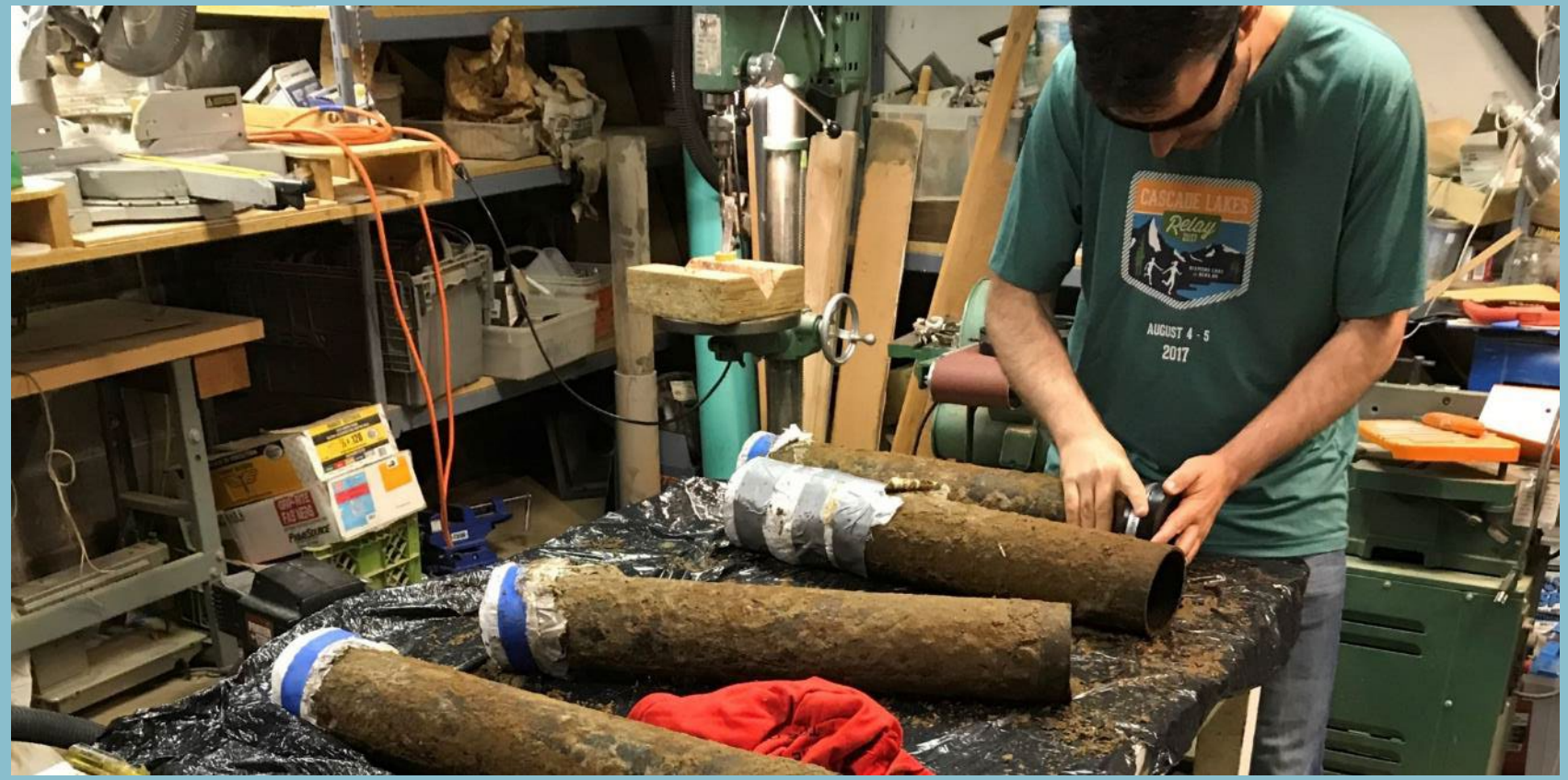
Swab #1 (2 containers) #2 #3 #4

UDF = Strict unidirectional flushing
PV = Pipe volume flushed

Characterizing the System (Cont.)

- Chlorine Demand & Decay and DBP Formation at 14 days ☺
- Pipe Tap Scale Inventory ☹
- Changes Anticipated in Blend, Age, and Water Velocity ☹
- What Material is 'Available' to Events (UDF and Swabbing) ☹
  - UDF = Hydraulically available
  - Swab = Everything else
  - Significant potential to release accumulated material with chemistry or hydraulic change (*Teams flushing now to prepare the system*)





Andrew Hill preparing pipe samples in the Confluence shop/lab

3 Bench Testing

Bench Test Pipe Harvesting

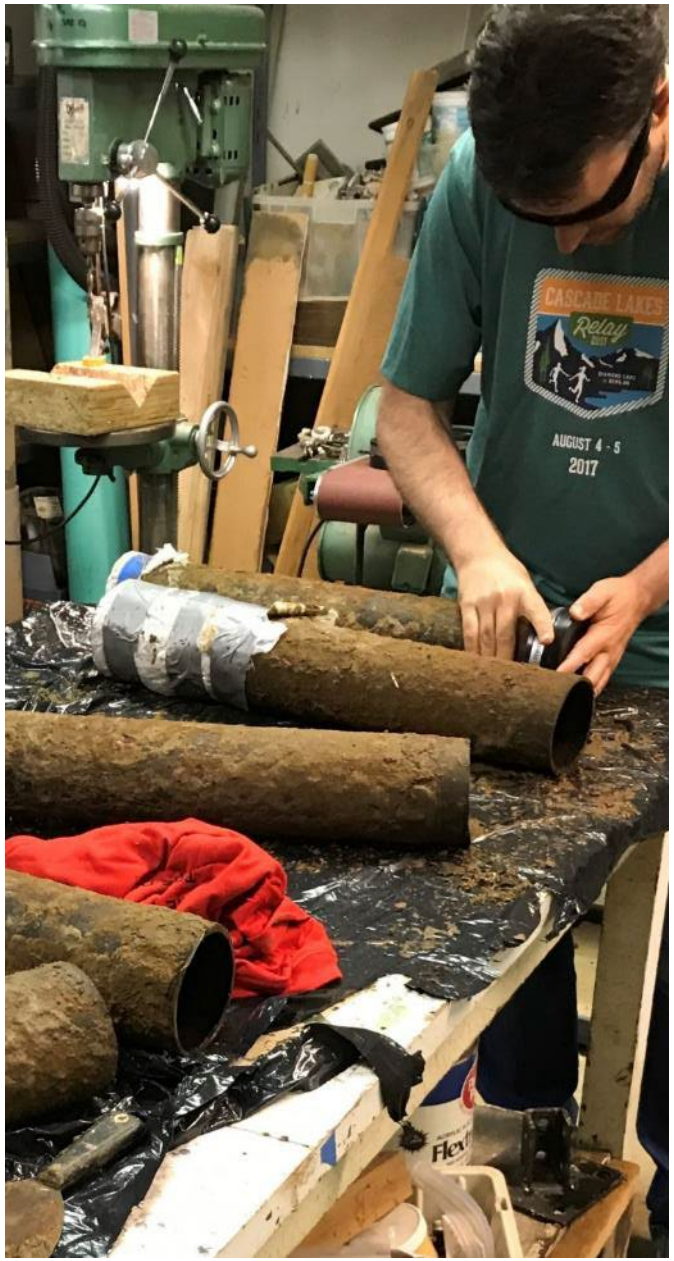
- 4-in dia. Galvanized Steel Pipe (several decades old)
- Challenges with harvested metal pipe
  - Fragile pipe wall 'lining'
  - Oils and petroleum hydrocarbons present, likely from (typical) industry linings placed in metal pipes
  - Impact of material on bench tests?
    - Metal pipe conditions may be 'worst case' vs plastic
    - Scale adherence to a lining may be weaker than adherence to metal surfaces (so it may be a worst-case condition)
    - Unclear of representative nature or how it applies throughout the system (especially to non-metal pipe)

Material Prep

- Identified best pipes
  - Surfaces consistent
  - Lining intact

Material Prep

- Identified best pipes
  - Surfaces consistent
  - Lining intact
- Prepare
  - Cut to length
  - Sample taps; seal rims
  - Base installation



Material Prep

- Identified best pipes
  - Surfaces consistent
  - Lining intact
- Prepare
  - Cut to length
  - Sample taps; seal rims
  - Base installation

Stabilize before testing with gentle mixing and fill/dump sampling 2x/week

Pre-test pipe acclimation period

Test Approach

- Lab stands with variable-speed mixers (120 rpm); achieved stability after 3 months (some scale lost during acclimation)
- Activities: Observe during 3 months of introducing chlorine and integrating surface water (low/no hydraulic disturbance)
- Details
  - 2x/week fill and dump w/ mild rinse
  - Physical/chemical water quality parameters
  - Surface water shipped from CA (including Modesto Irrigation District WTP; adjust pH)

Mixers with small paddles were used for testing

Test Approach (Cont.)

- At the Confluence Lab in Ballard
  - 163 days (84 days acclimation + 79 days testing)
  - Unchlorinated GW, to chlorinated GW, to chlorinated SW
  - Chlorine at 0.03 mL/min (result = 1 to 1.6 mg/L residual)

Test Phase	Pipe A	Pipe B	Pipe C	Pipe D	Test Description and Duration
1	UGW	UGW	UGW	UGW	Acclimation Period 84 d total testing
2	UGW	UGW	UGW	UGW	Baseline Conditions 16 d total testing
3	UGW	CLGW	CLGW	CLGW	Chlorinating Groundwater 33 d total testing
4	UGW	CLGW	CLSW	CLSW	Integrating Surface Water 30 d total testing

UGW Unchlorinated groundwater
CLGW Chlorinated groundwater
CLSW Chlorinated surface water

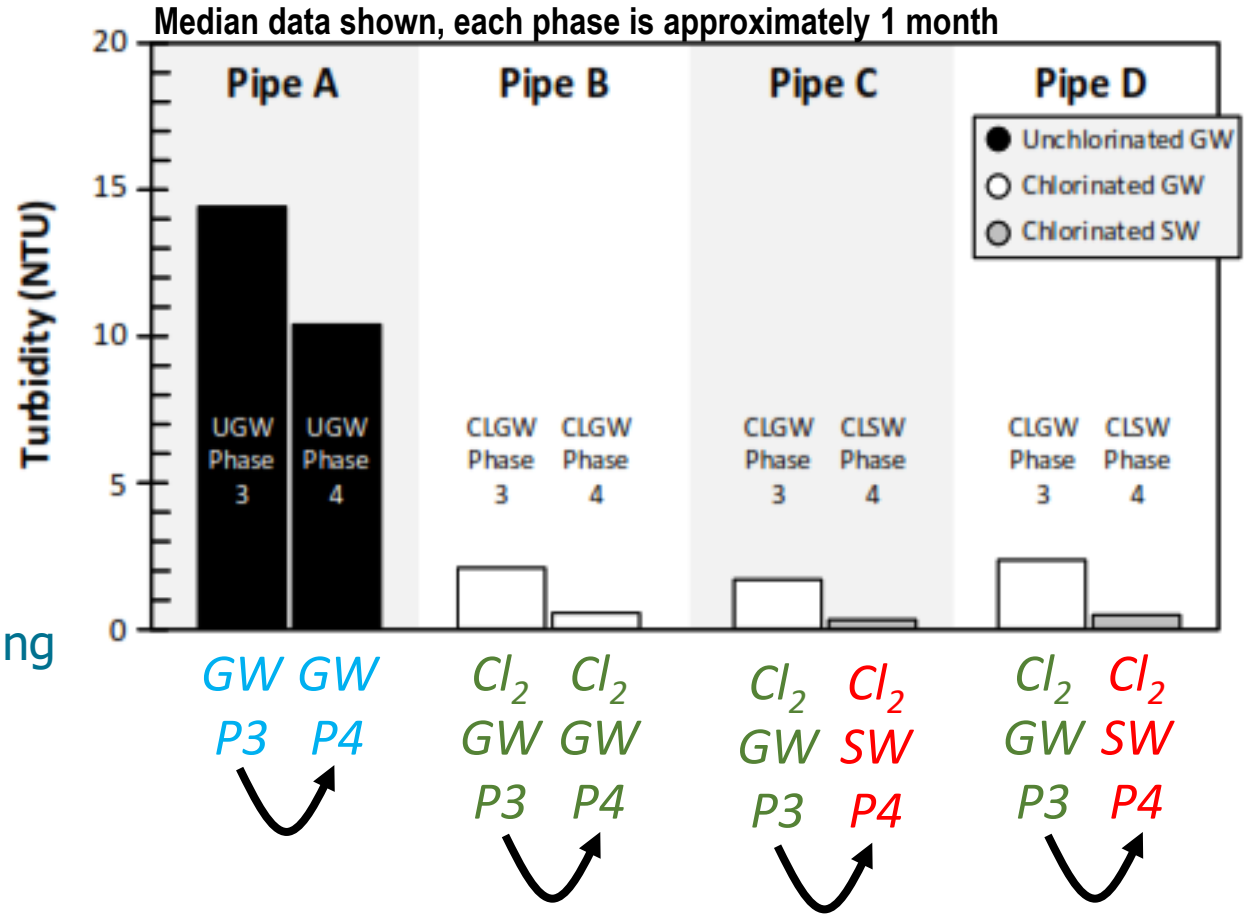
GW = Groundwater
SW = Surface water

Chlorine dosing

Mixers with small paddle size

Results

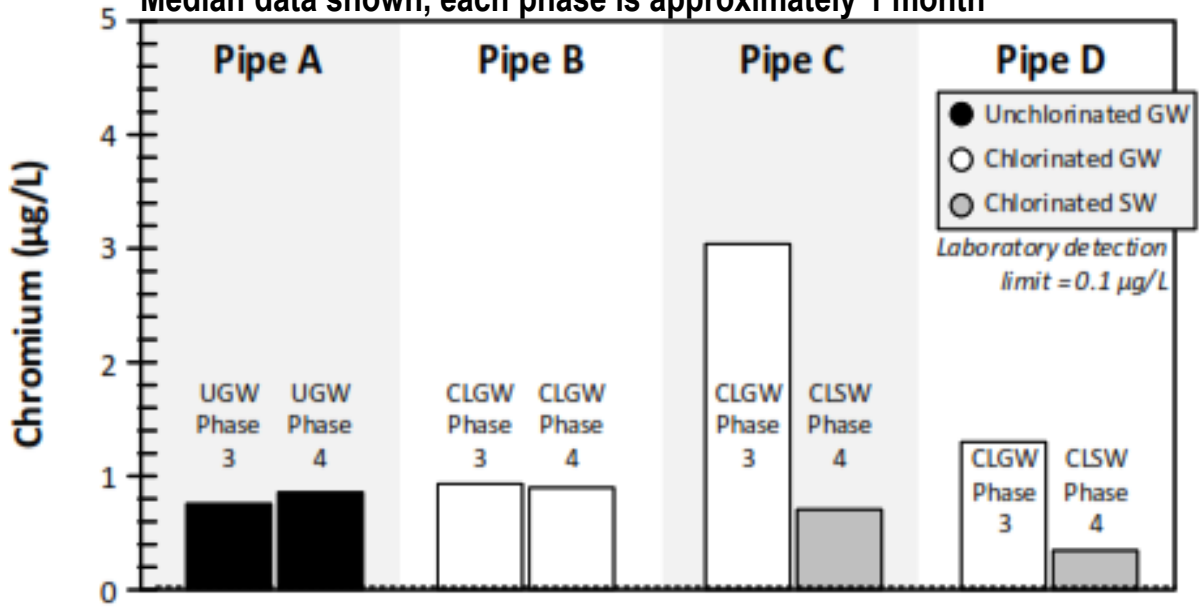
- Pipes stable (turbidity, iron)
  - Chlorine reduced turbidity in Phase 3
  - Chlorine alone continued to reduce turbidity in Phase 4
  - Turbidity continued to remain low during Phase 4 surface water introduction

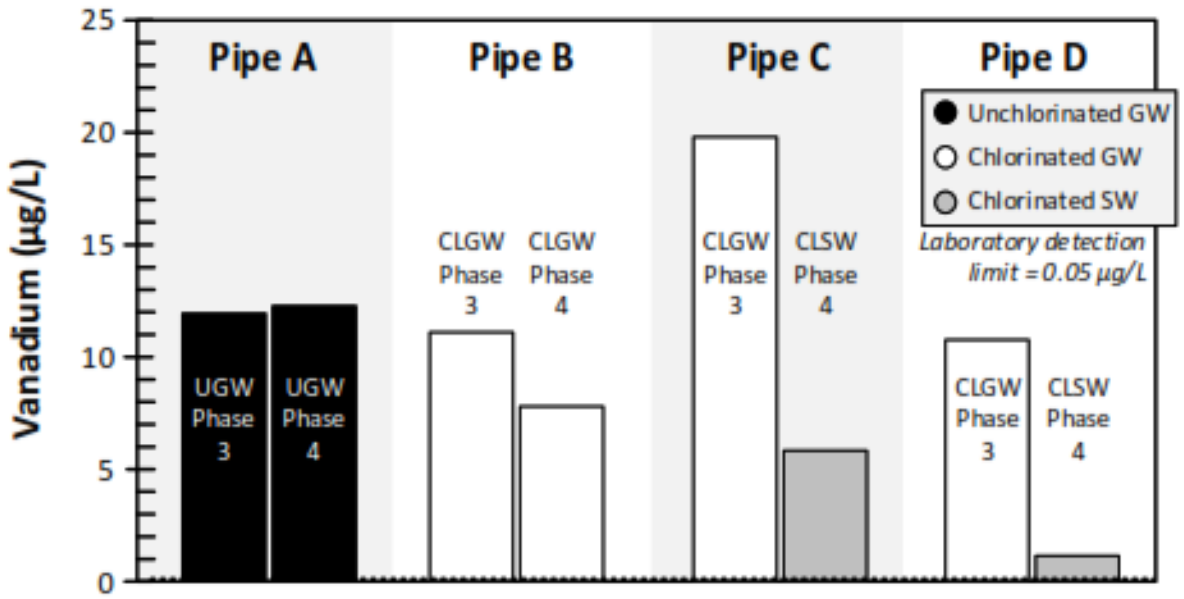


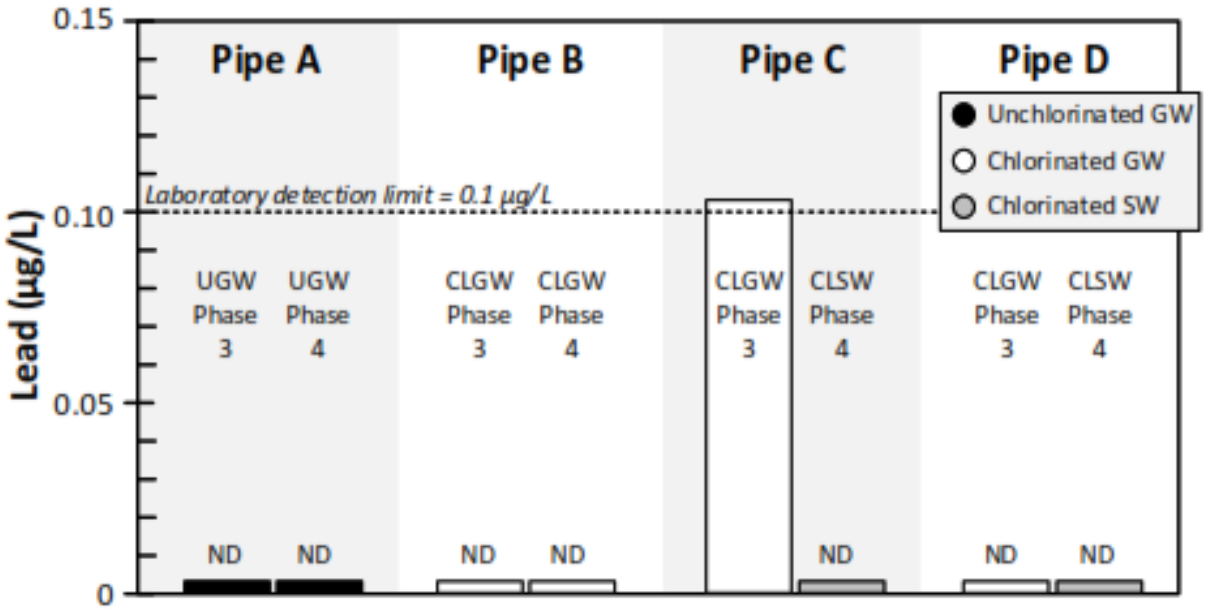
Results (Cont.)

- Pipes stable (turbidity, iron)
- Chromium, Lead, Vanadium, Arsenic seemed stable (release only in one of three pipes)

Median data shown, each phase is approximately 1 month

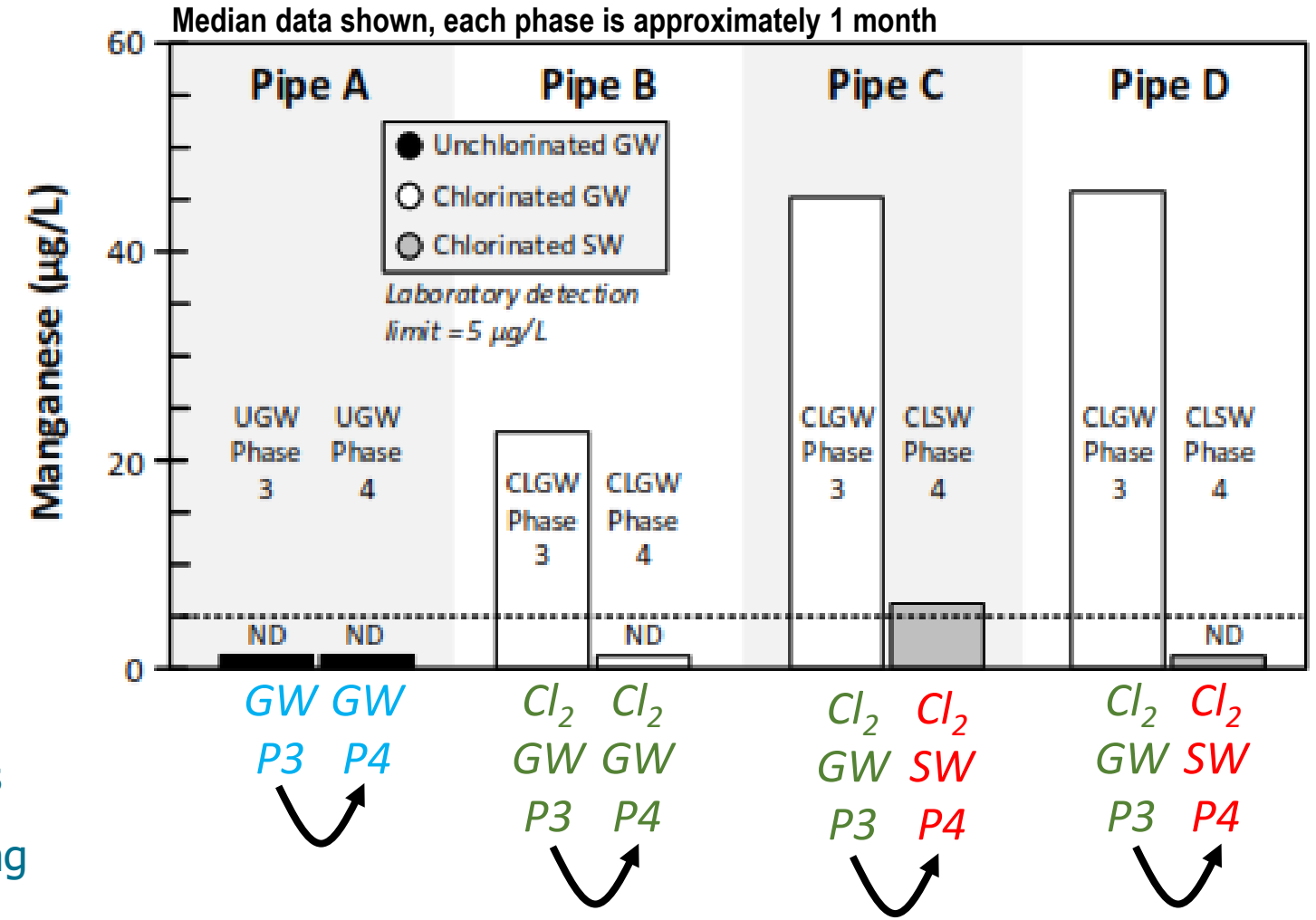






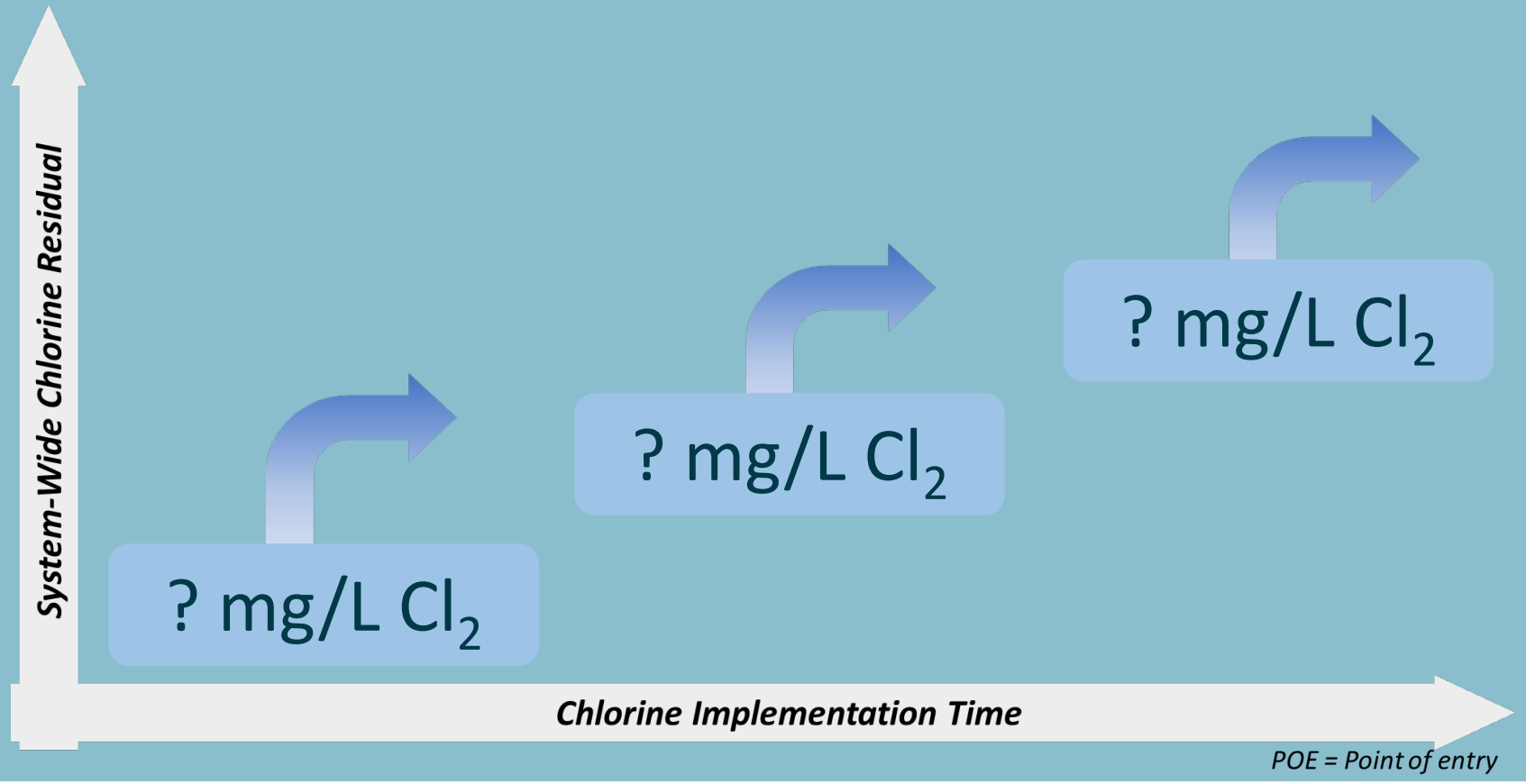
Results (Cont.)

- Pipes stable (turbidity, iron)
- Chromium, Lead, Vanadium, Arsenic seemed stable (release only in one of three pipes)
- Manganese:
  - Increase during Phase 3 testing with chlorine in two pipe segments
  - When continuing chlorination during Phase 4, levels stabilized (?)
  - Stability was observed during surface water integration



Overall Results:

- *Potential Mn release with initial chlorination (at ~1 mg/L free chlorine)*
- *Surface water did not indicate scale instability*


System-Wide Chlorine Residual
? mg/L Cl_2
? mg/L Cl_2
? mg/L Cl_2
Chlorine Implementation Time
POE = Point of entry

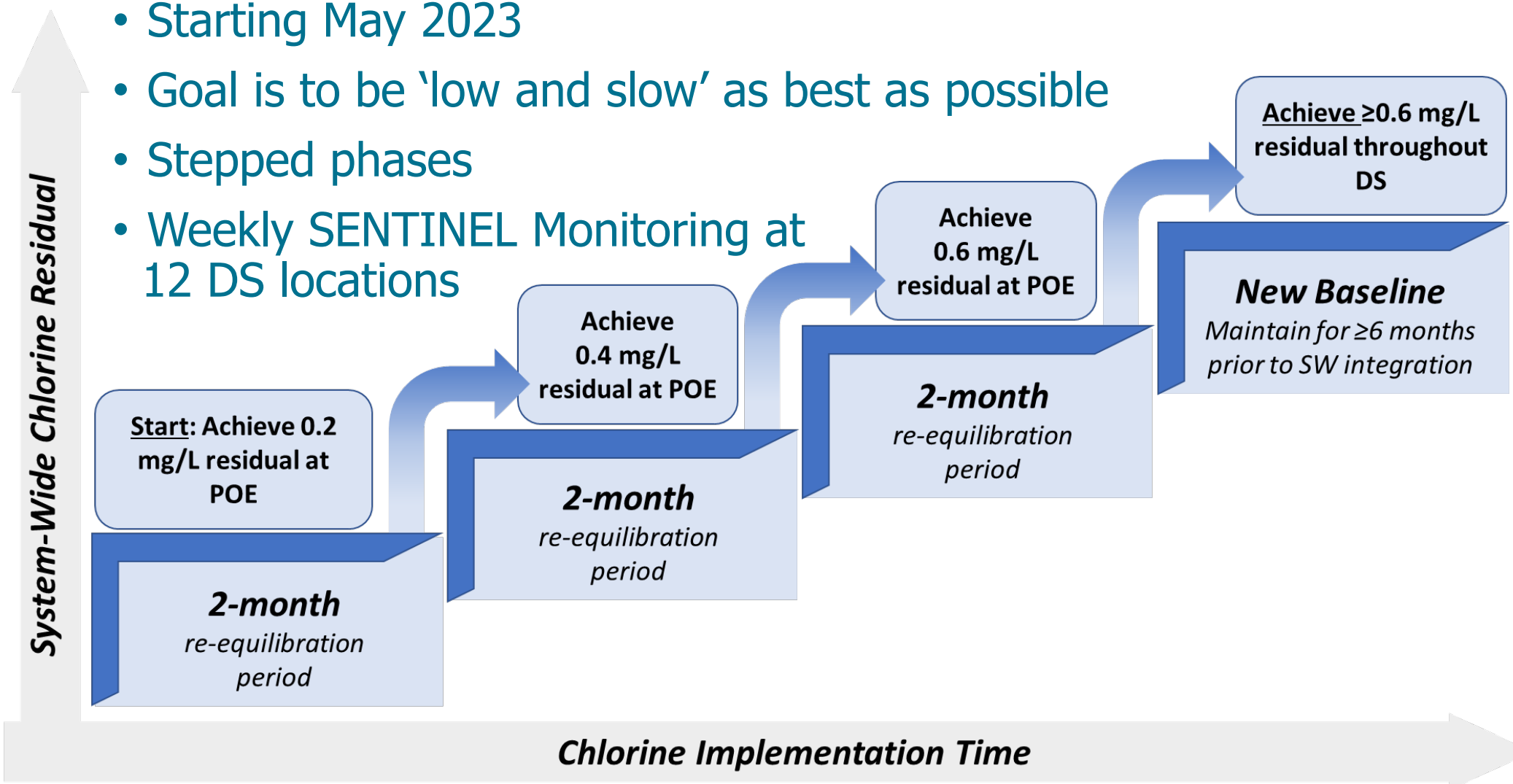
4 Next Steps

What Do We Know?

- Multi-Faceted Study to Assess Potential for Water Quality Destabilization Events
- Metals Present In Pipe Scale Even Though Very Low Levels In Well Water
- Scale is Highly Mobile When Exposed to Hydraulic or Chemistry Shifts (Chlorine)
- Need to Implement Chlorination and Integrate Surface Water While Minimizing These Disturbances

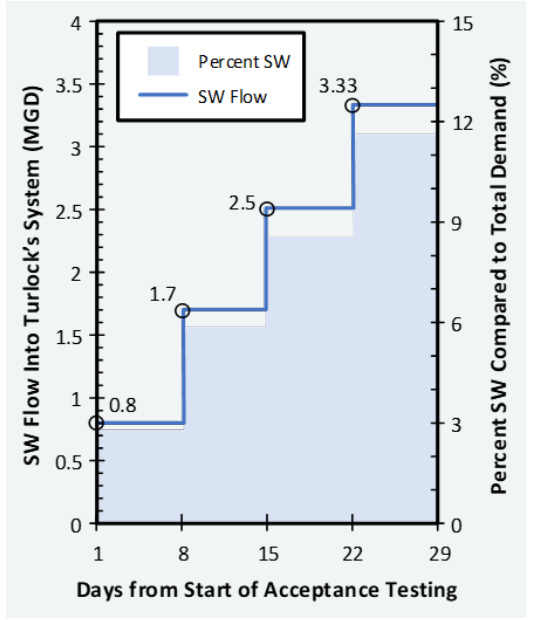
Next Steps: Chlorination

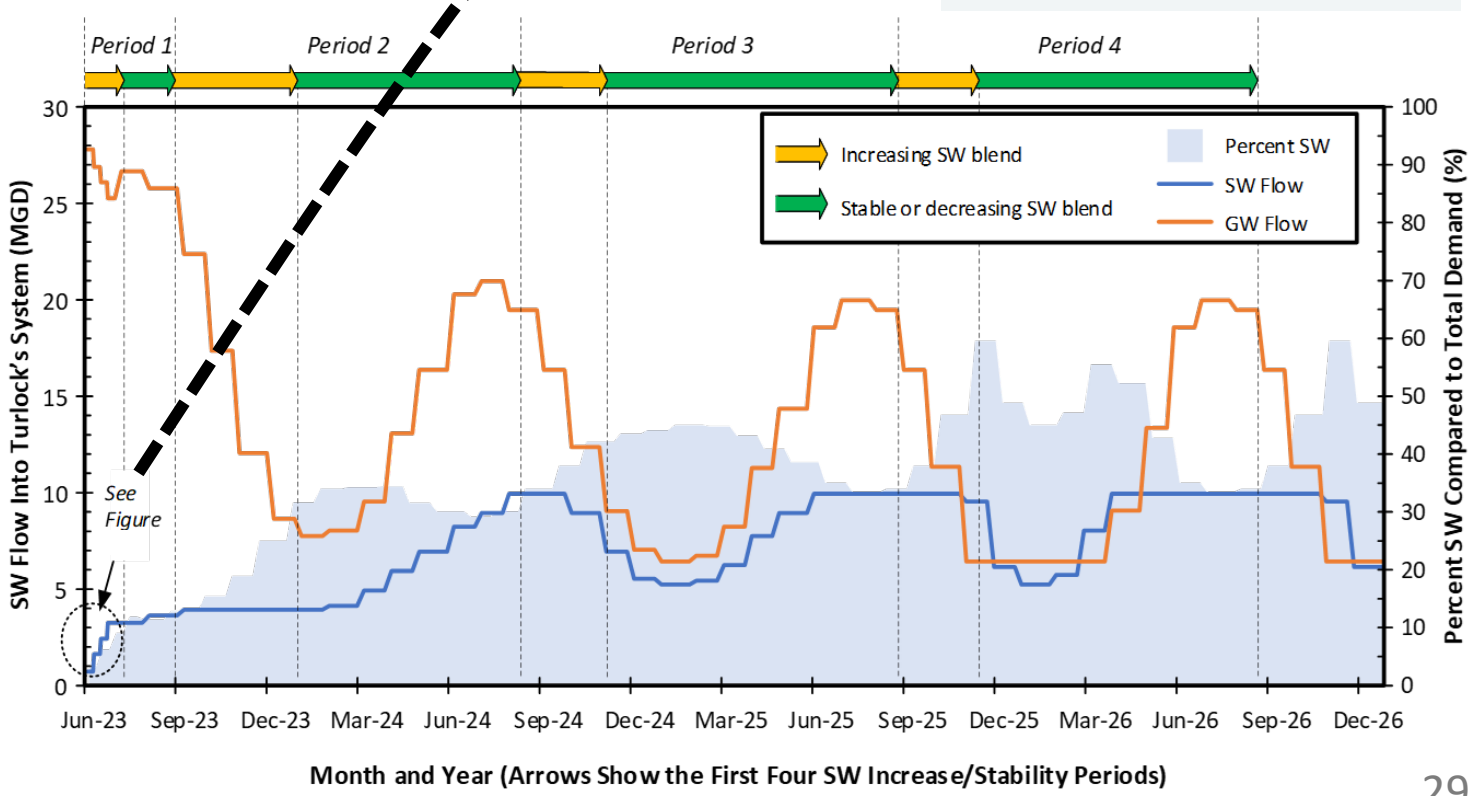
- Starting May 2023
- Goal is to be 'low and slow' as best as possible
- Stepped phases
- Weekly SENTINEL Monitoring at 12 DS locations



Next Steps: Surface Water Introduction

- Starting at End of 2023
- Step hydraulic increases to minimize hydraulic disturbance
- Gently blend chemistry during first two years of surface water integration





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Thank You!

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