Hemmera
An Ausenco Company

In-Situ Remediation of Dissolved Metals Plume From Concept to Full-Scale Remediation

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RemTech 2021

Values Moment

- Collaborative Approach
- Worked with various groups
- Open and Honest
- Continued conversations with key parties
- Thanks for taking the time to listen and provide feedback!

Introduction & Outline

- Project Introduction/Challenges
- Phase 1 – Bench Scale
- Phase 2 - Pilot
- Phase 3 – Full Scale
- Post-Injection Verification
- Lessons Learned

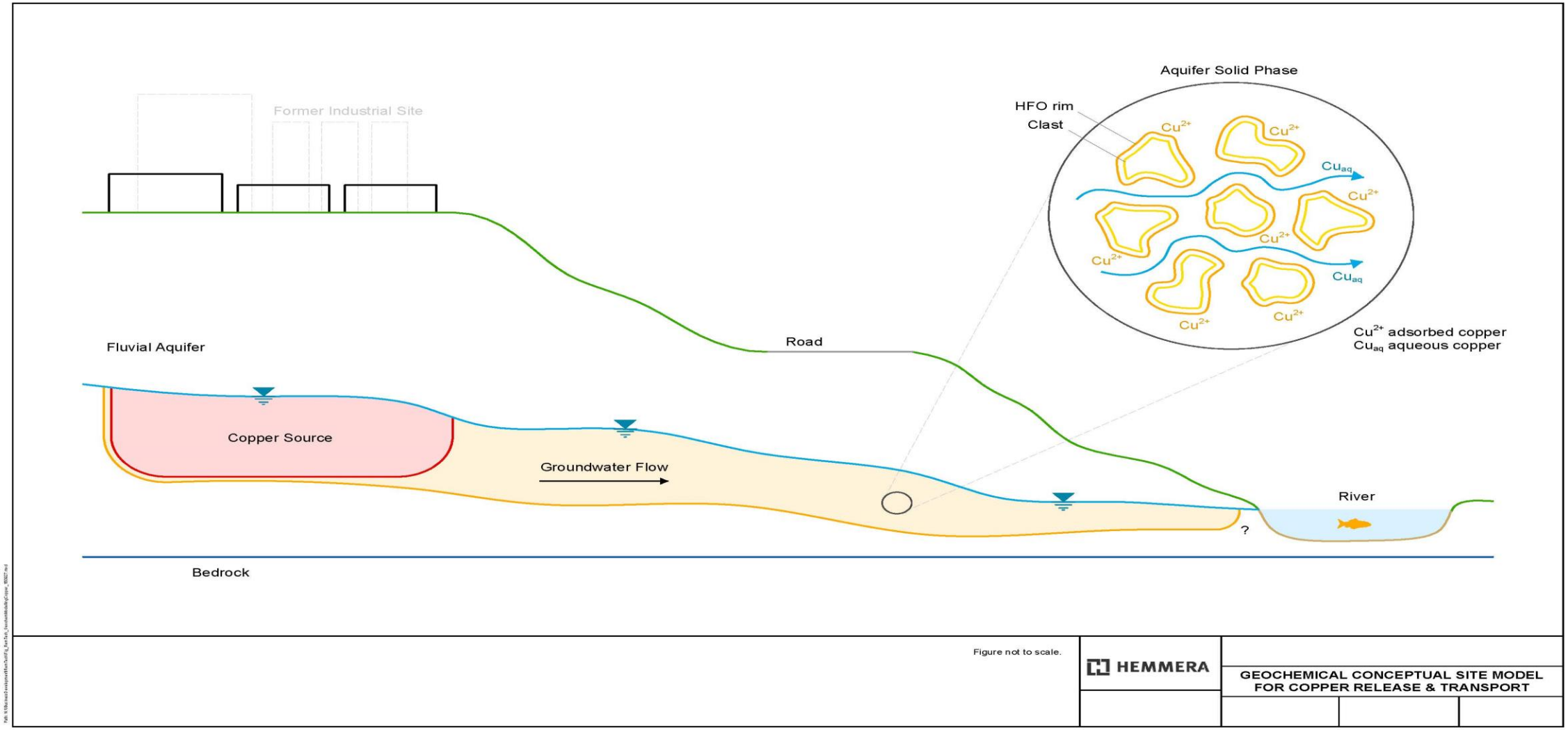
Project Introduction and Challenges

1. Former Industrial and currently Commercial
2. Source Zone Inaccessible
3. Modeled to continue discharging with increased concentrations up to 700 years
4. Aquifer Conditions
5. Limits on Working Time On-Site

Project Sequence

- Phased/Iterative Approach
  - Developed CSM & ROE
  - Phase 1 (2018)
    - Additional investigation and Bench Scale testing
  - Phase 2 (2019)
    - Pilot Scale Remediation
  - Phase 3 (2020)
    - Full Scale Remediation
  - Ongoing
    - Post-Remediation Verification

Conceptual Site Model

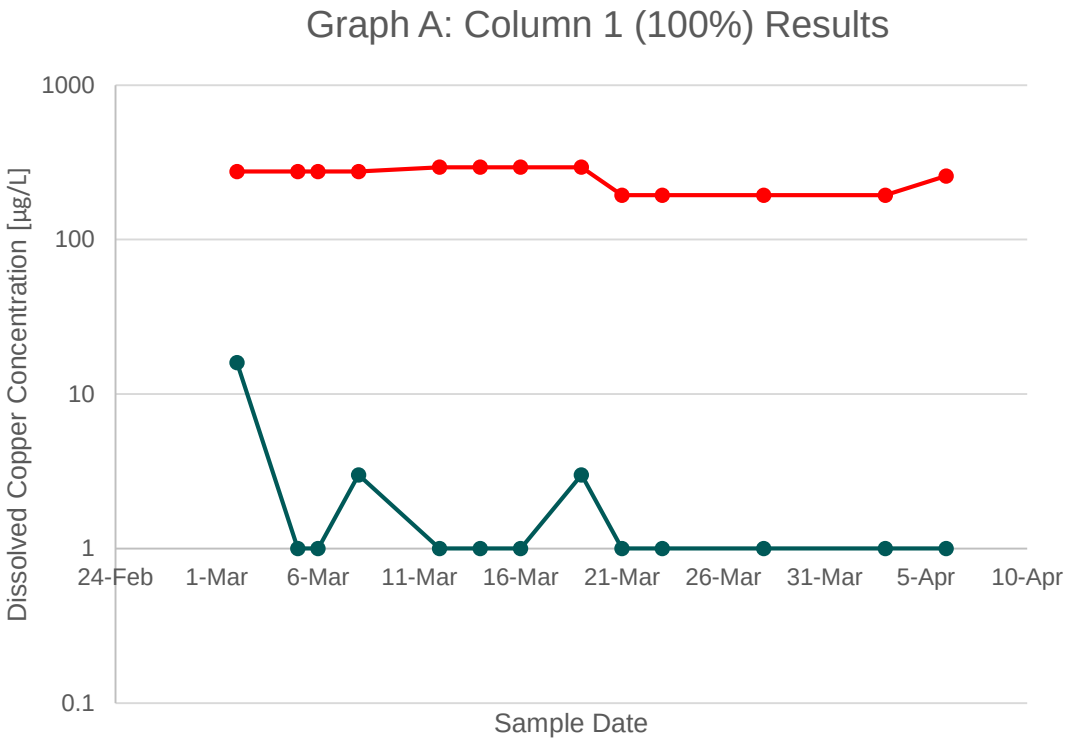


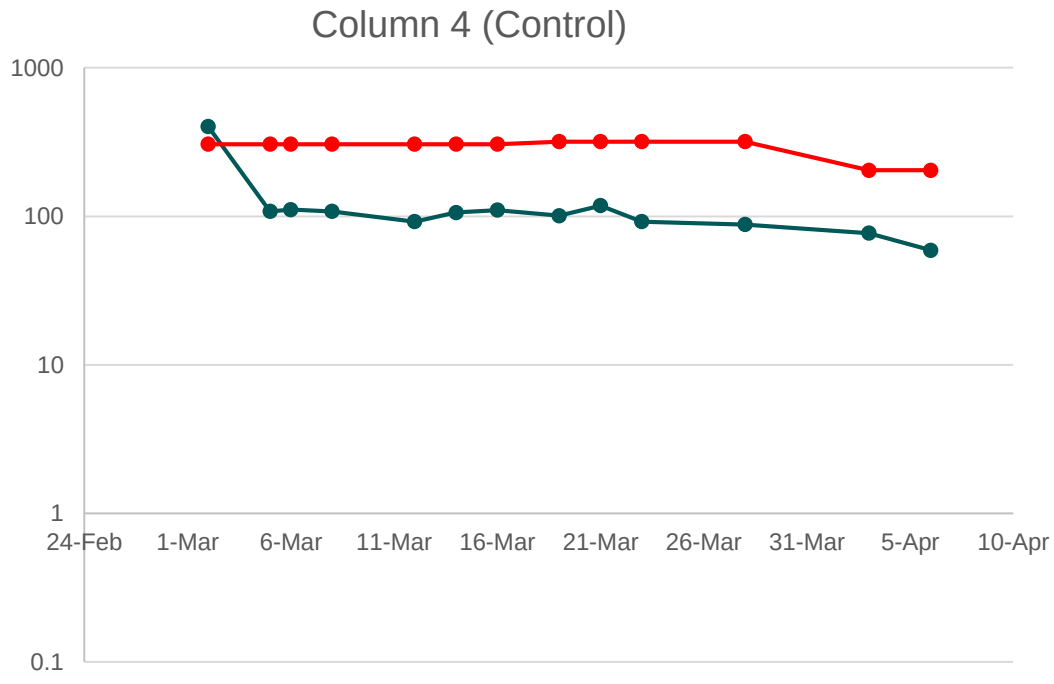
Remedial Options Evaluation

- Injection and sequestration via HFO
  - HFO has been shown in lab settings to remove Copper
  - HFO is an acid-generating reaction
    - Calcite present in aquifer to buffer
  - Cost effective and possible to inject at select areas
    - Selection of rxn and materials

Phase 1 - Bench Scale (2018)

- Increased HFO in Aquifer Solids
- Injected Site groundwater for 1-day residence time
- Dissolved Copper decrease from 0.35 mg/L to <0.007 mg/L



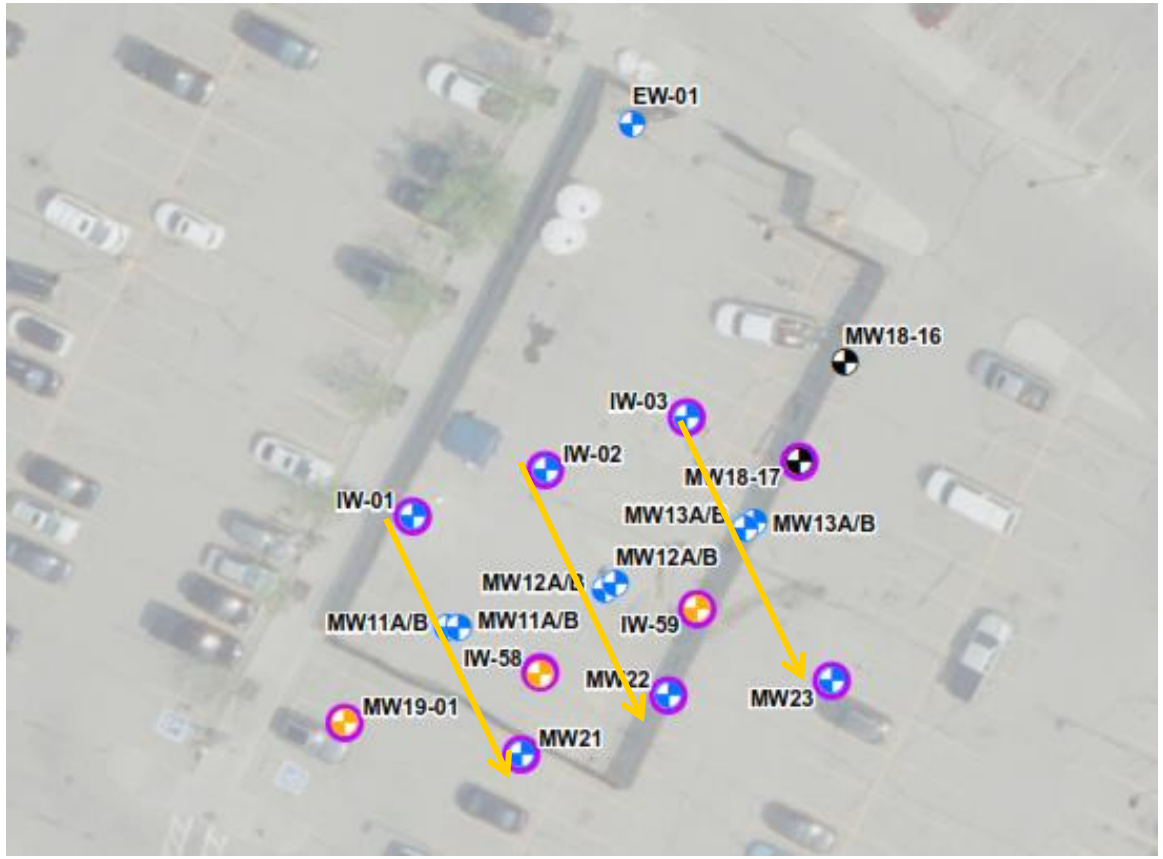


Phase 1 - Bench Scale (2018)

- Outcomes
  - Baseline HFO in Aquifer is about 500 mg/kg
    - Tested HFO of 3,750 mg/kg, 5,000 mg/kg and 6,250 mg/kg
  - BCR Test Results
    - HFO is not water soluble
    - Copper will be sequestered on HFO surfaces over the long term once remediation has been completed
  - HFO is an effective mechanism for sequestration of Copper in Site soil and groundwater

Phase 2 - Pilot Scale (2019)

- Tested 3 MW transects
- Injected Amendments to precipitate HFO
- Batch style injections
- Monitored downgradient of injection well

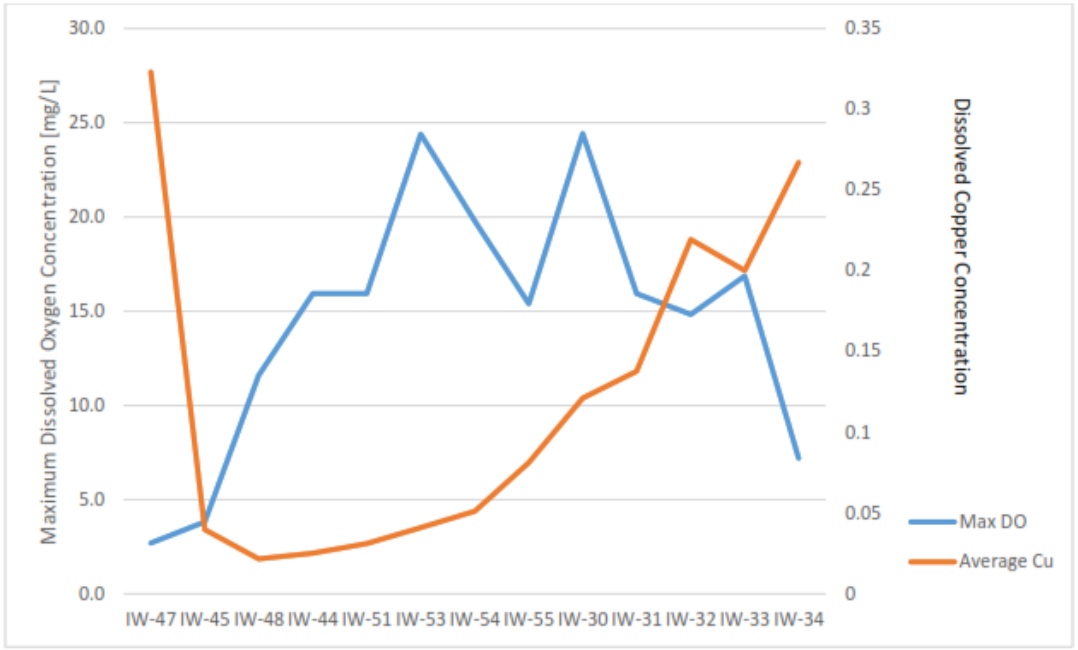


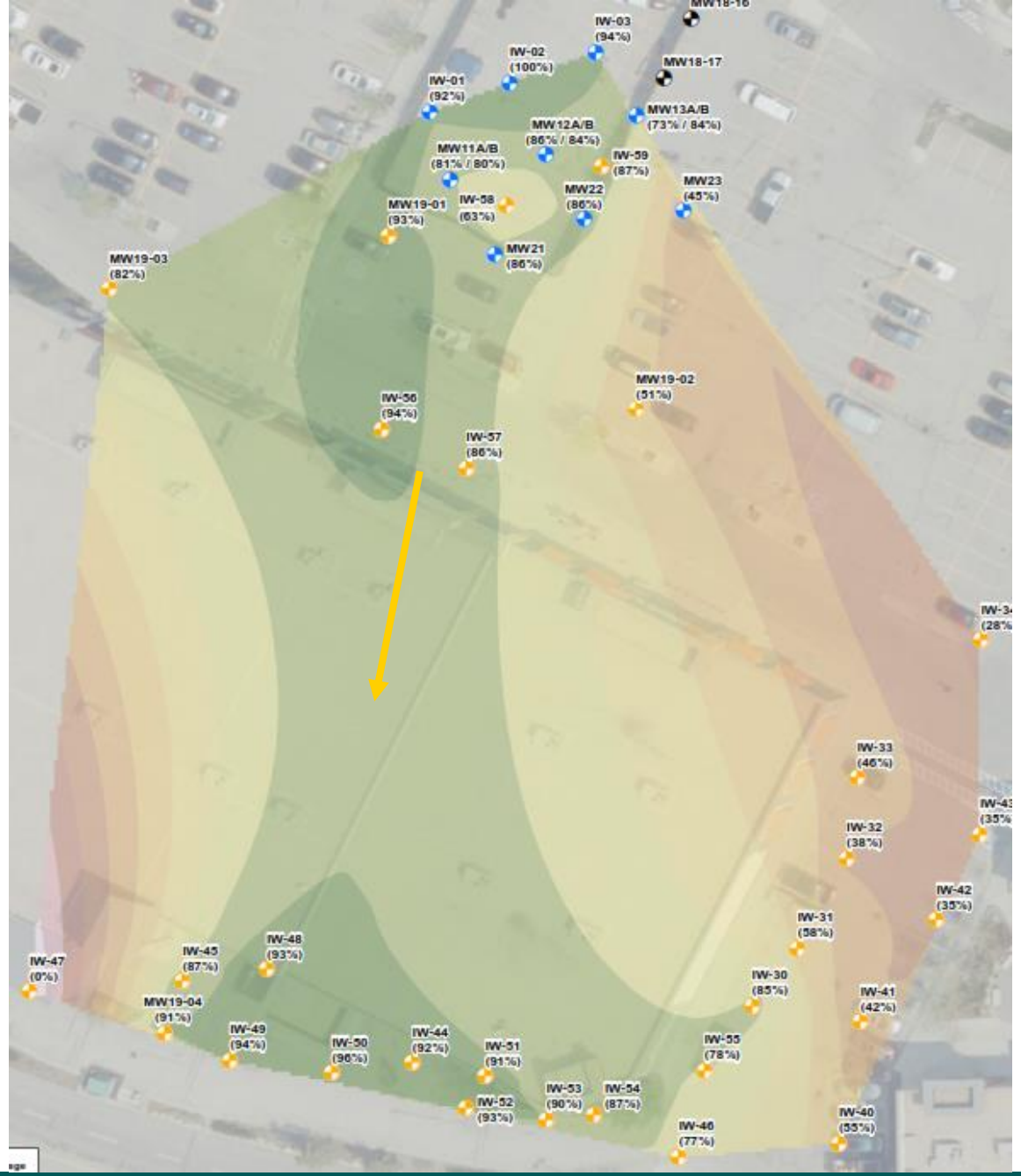
Phase 2 - Pilot Scale (2019)

- Alternated amendment injections under hydrostatic pressure
- Mixing in aquifer, HFO precipitation

- Lessons Learned:
  - GW Flow Direction Varied
  - Target dosage determined
  - Oxidant change
  - Develop Injection Method and Design

Phase 2 - Pilot Scale (2019)



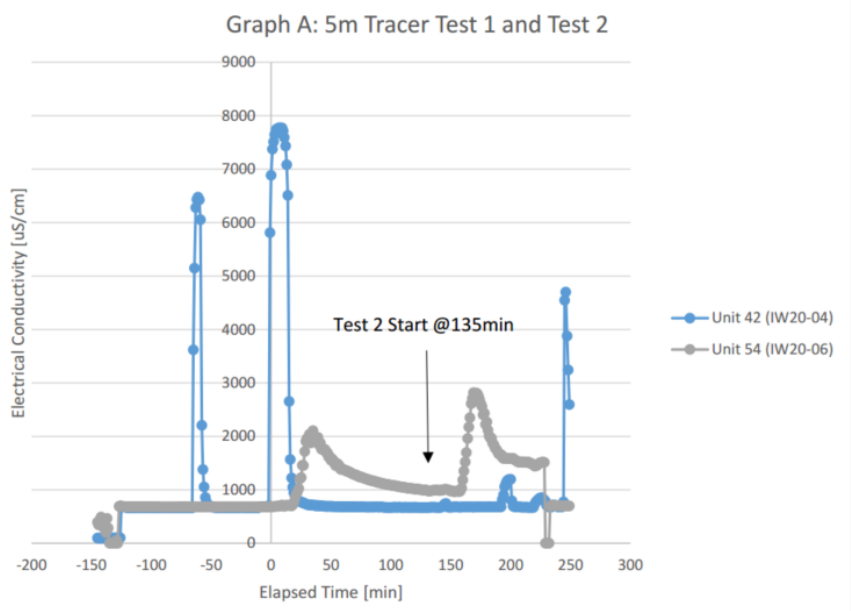


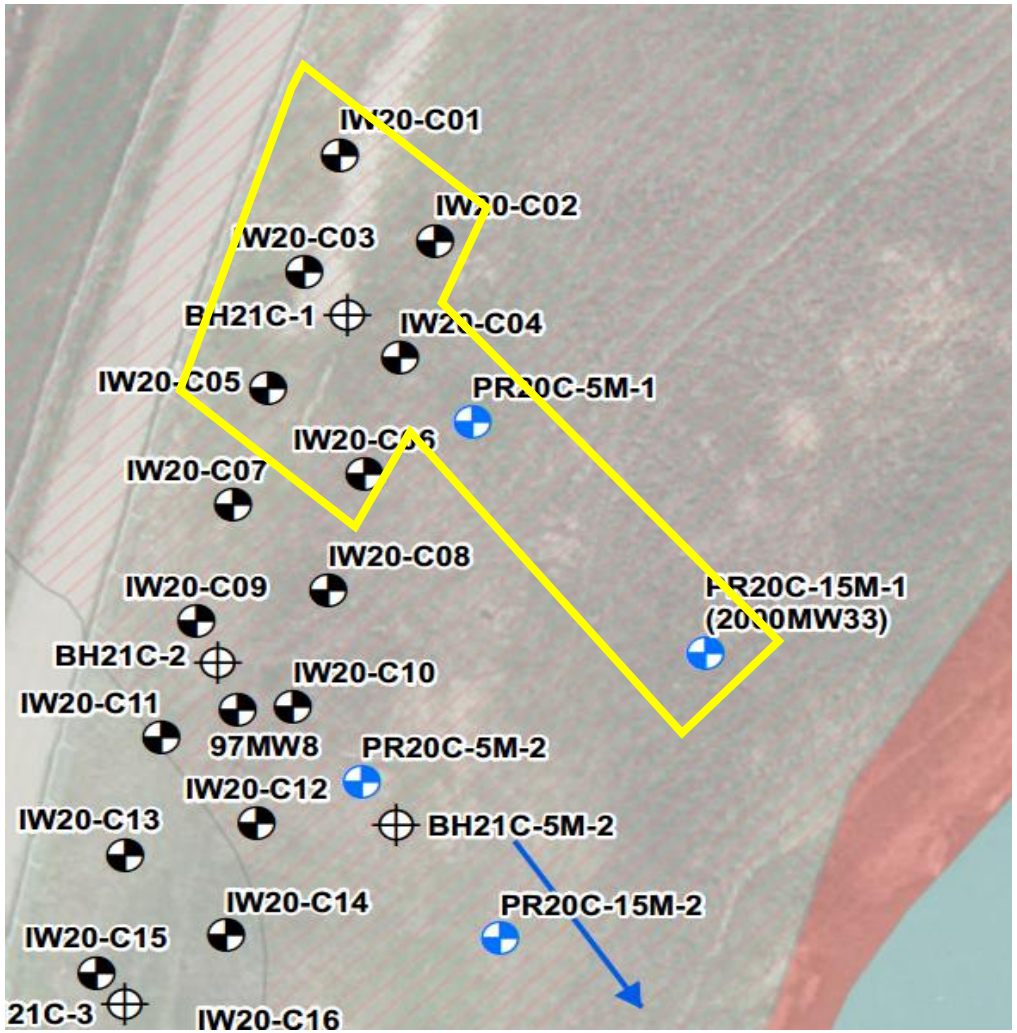
Phase 3 – Full Scale (2020)

- Three injection Areas:
  - Source Zone
  - Transect A
  - Transect C
- Stabilize source
- Minimize further downgradient migration of copper
- Protect Freshwater Aquatic receiving environment

Phase 3 – Full Scale (2020)

- Replaced CaO_2 with H_2O_2
- Tracer Tests for PRB Design
- Injection methodology via Recirculation



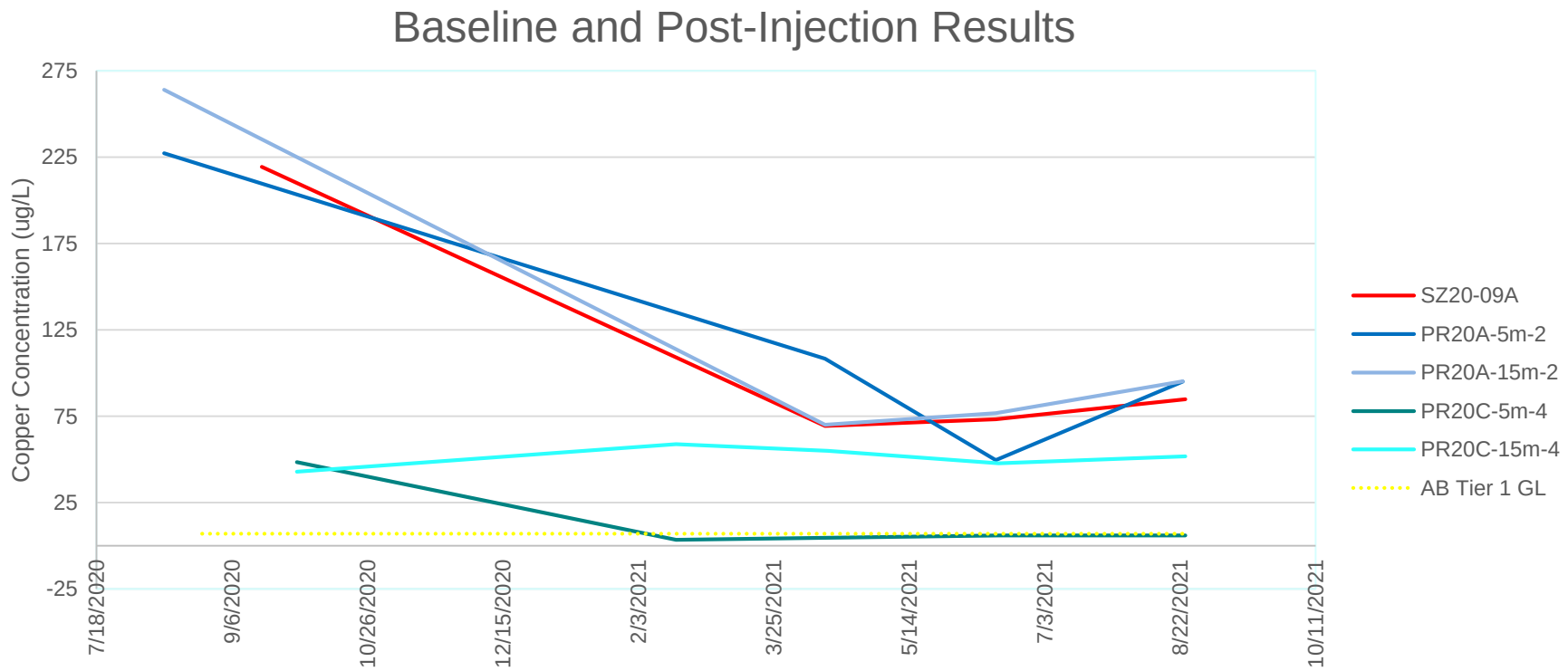


Phase 3 – Full Scale (2020)

- Real Time data collection via data sondes and test strips to ascertain full HFO precipitation
- GW Control achieved during injections
- Up to 99% dissolved copper decrease
- Preliminary data indicate dissolved copper concentrations continuing to decrease with time

Post-Injection Verification (2021)

- Collected samples 4 times in 2021 to confirm results
- Fe Mass Injected influenced Cu results
  - Target Fe Injected = Cu decreased from baseline by average 37%
  - Target Fe <100% = Cu decreased by average of 10%



Lessons Learned

- Understand Site conditions – good baseline data is vital
- Engage with stakeholders at the start and don’t let up
- Build program iteratively
- Be ready for setbacks
- HFO is an effective method for removal of dissolved Cu

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Thank you

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