PCE and Daughter Remediation in Limestone Bedrock

Bill Brab, CPG, PG
Senior Geologist
AST Environmental, Inc.

R. William Johnston, PG
Principal Geologist
Linebach Funkhouser, Inc.

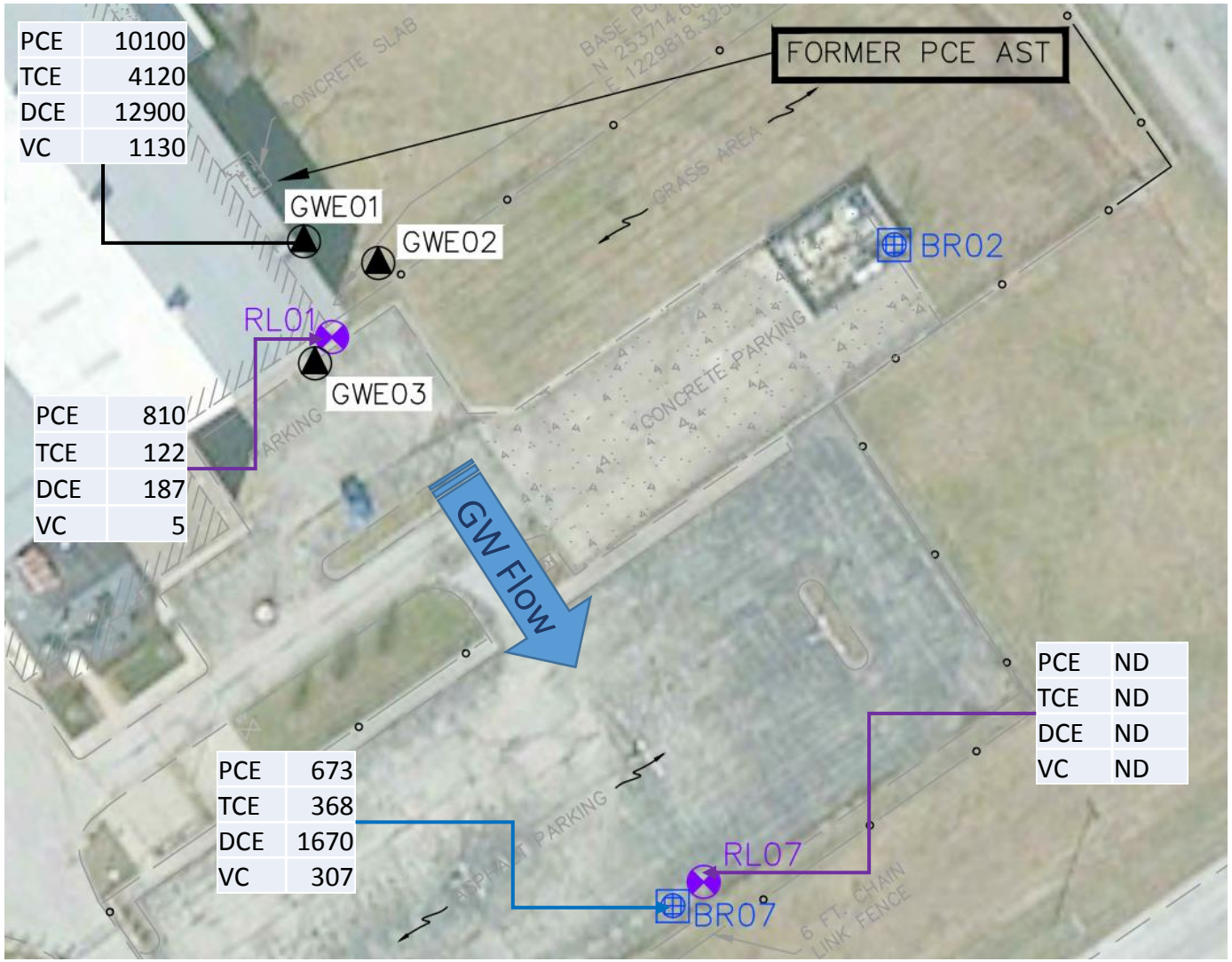
Site Background

- Former Tubing Manufacturing Facility
  - Virgin PCE used for parts cleaning stored in an AST
  - Release discovered in 2002, PCE and degradation products identified in perched overburden and shallow bedrock aquifers
  - DPE operated between 2007-2014, MNA 2014-2016
  - Linebach Funkhouser hired as environmental consultant for potential buyer

Site Background (cont.)

- Geology
  - Outer Bluegrass Physiographic Province of Kentucky
  - Predominantly fine-grained (clay and silt) varying 10’ to 15’ thick
  - Sellersburg and Jeffersonville Limestone
    - Naturally occurring petroleum
  - Groundwater 5’ to 10’ bgs
    - Unconsolidated sediment aquifer
    - Shallow bedrock aquifer

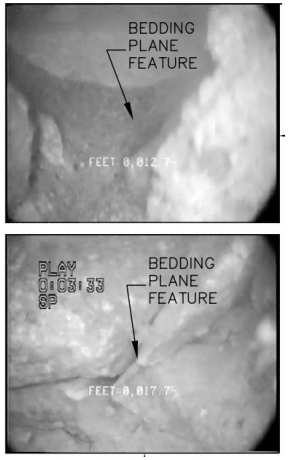
Site Background (cont.) – CSM 3Q2015

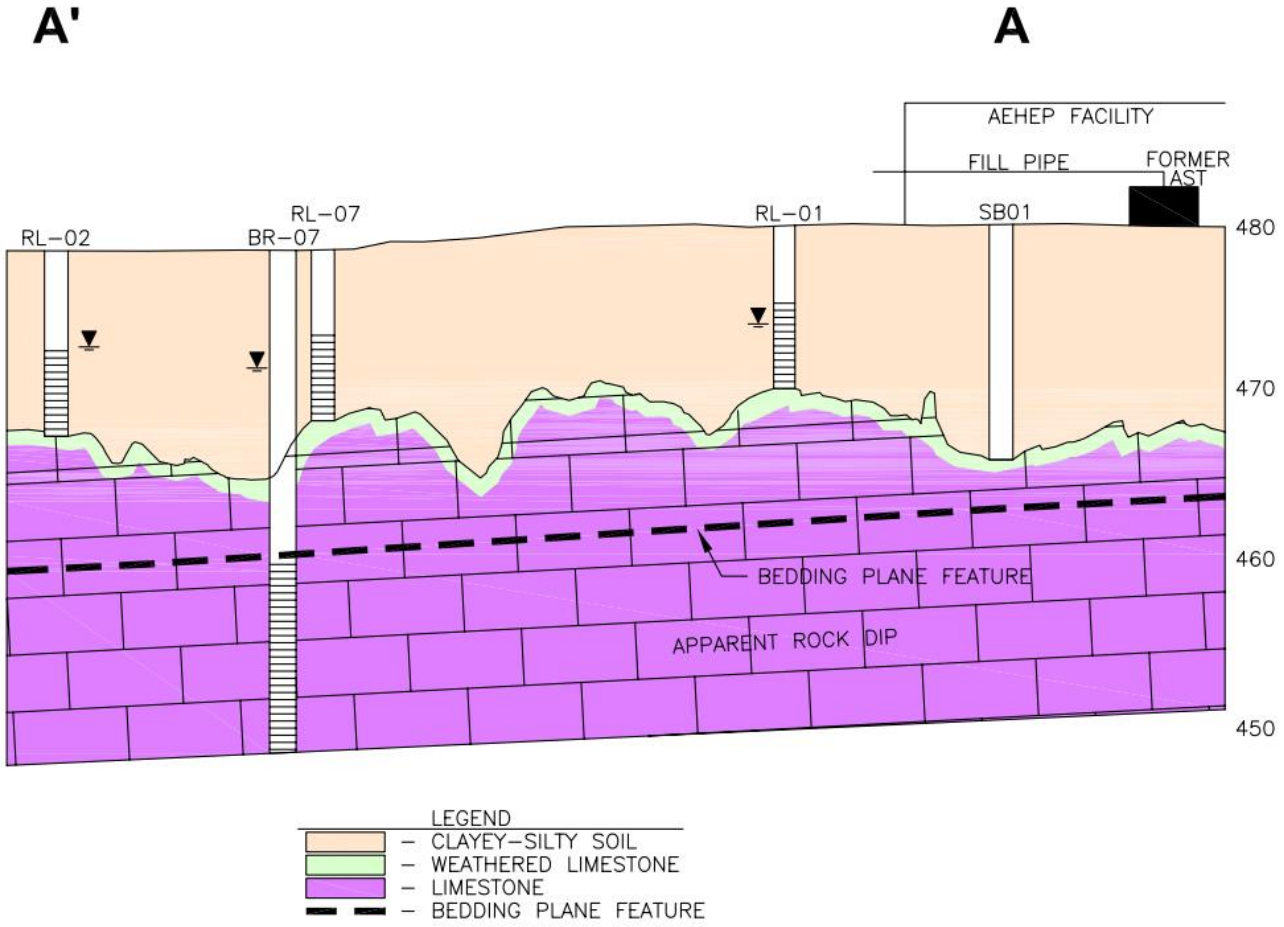


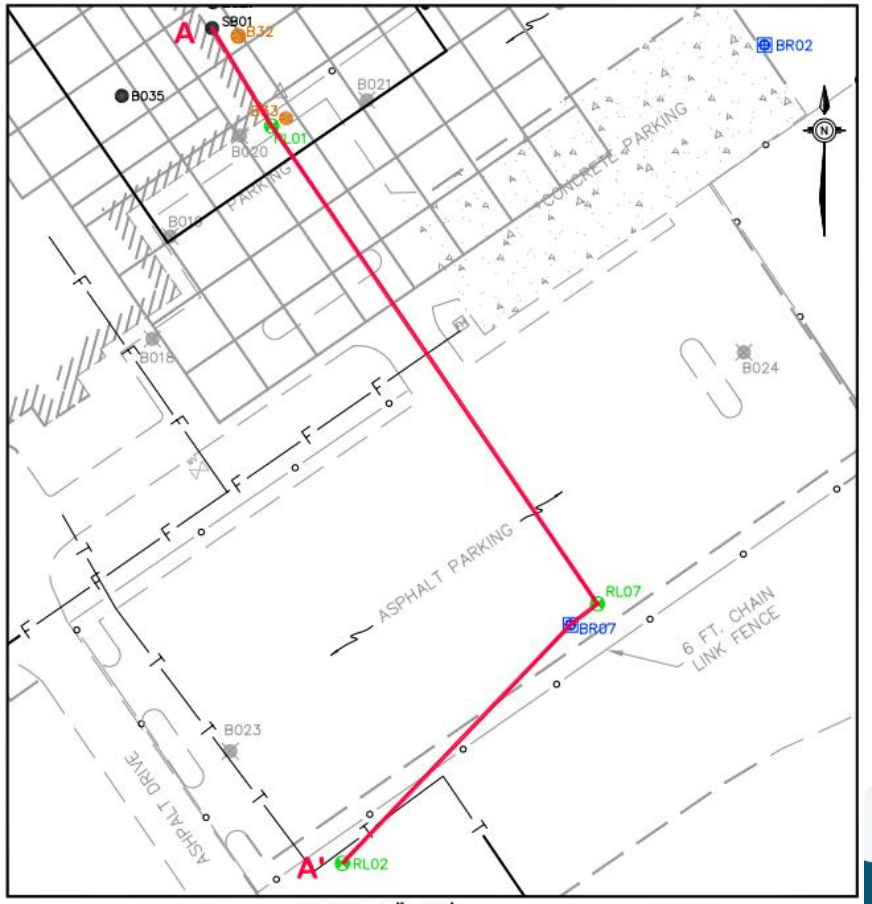
- GWE had mitigated CVOCs impacts to extent possible
  - GWE-01 as high as 43,000 ppb PCE
  - RL-01 as high as 93,000 ppb PCE
  - BR-07 as high as 12,000 ppb PCE
- CVOCs concentrations began to rebound following system shutdown
- Daughter generation increasing in source area

Site Background (cont.) – CSM 3Q2015

Side View of Borehole







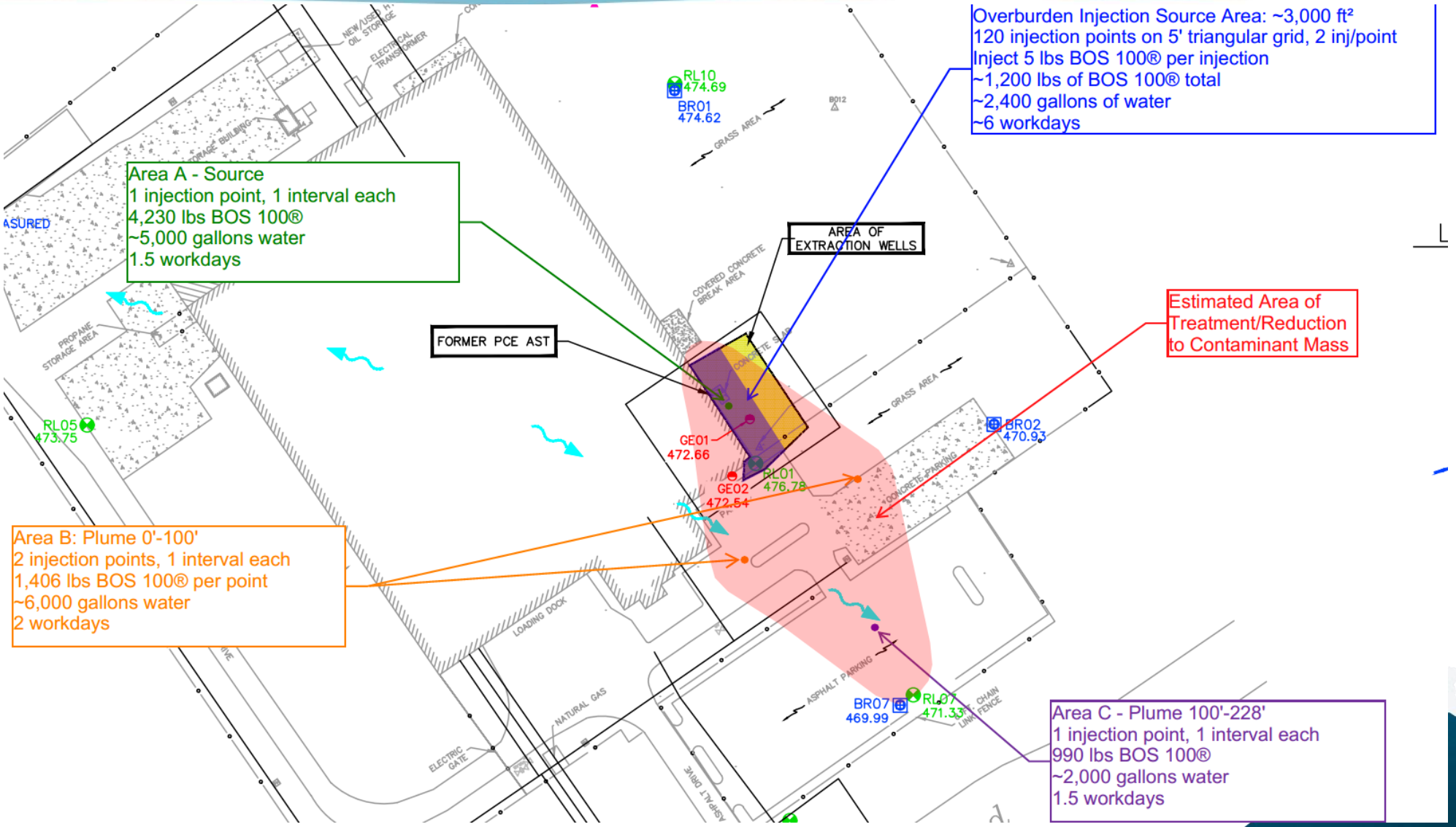
INSET: 1"=60'

Remedial Objectives

- KDWM requested an updated Remedial Action Plan
  - No specified soil remediation goal
  - Significant reduction in groundwater CVOC concentrations
  - Protection of GW near the property line (RL/BR-07)
  - Seller and Buyer common objective to remediate the site via shared escrow

- AST contacted in 2015 to provide a remedial option
  - Design based on existing CSM for budgeting
  - Source Area Injections in Overburden – Trap & Treat® BOS 100®
  - Source Area Injections in Bedrock – Trap & Treat® CAT 100
  - Solute Plume Treatment Bedrock – Trap & Treat® CAT 100

Remedial Design



Unique Equipment – Straddle Packer Design

Pressure Transducer Above Discrete Interval

Pressure Transducer w/in Discrete Interval

Grundfos Rediflo 2

Pressure Transducer Below Discrete Interval

Unique Equipment – The Triplex

165 HP Triplex Pump

Pick a Flow Rate:

- 8 gpm to 320 gpm

Pressures to 2,500 psi

Triplex – Varied Flow Rates

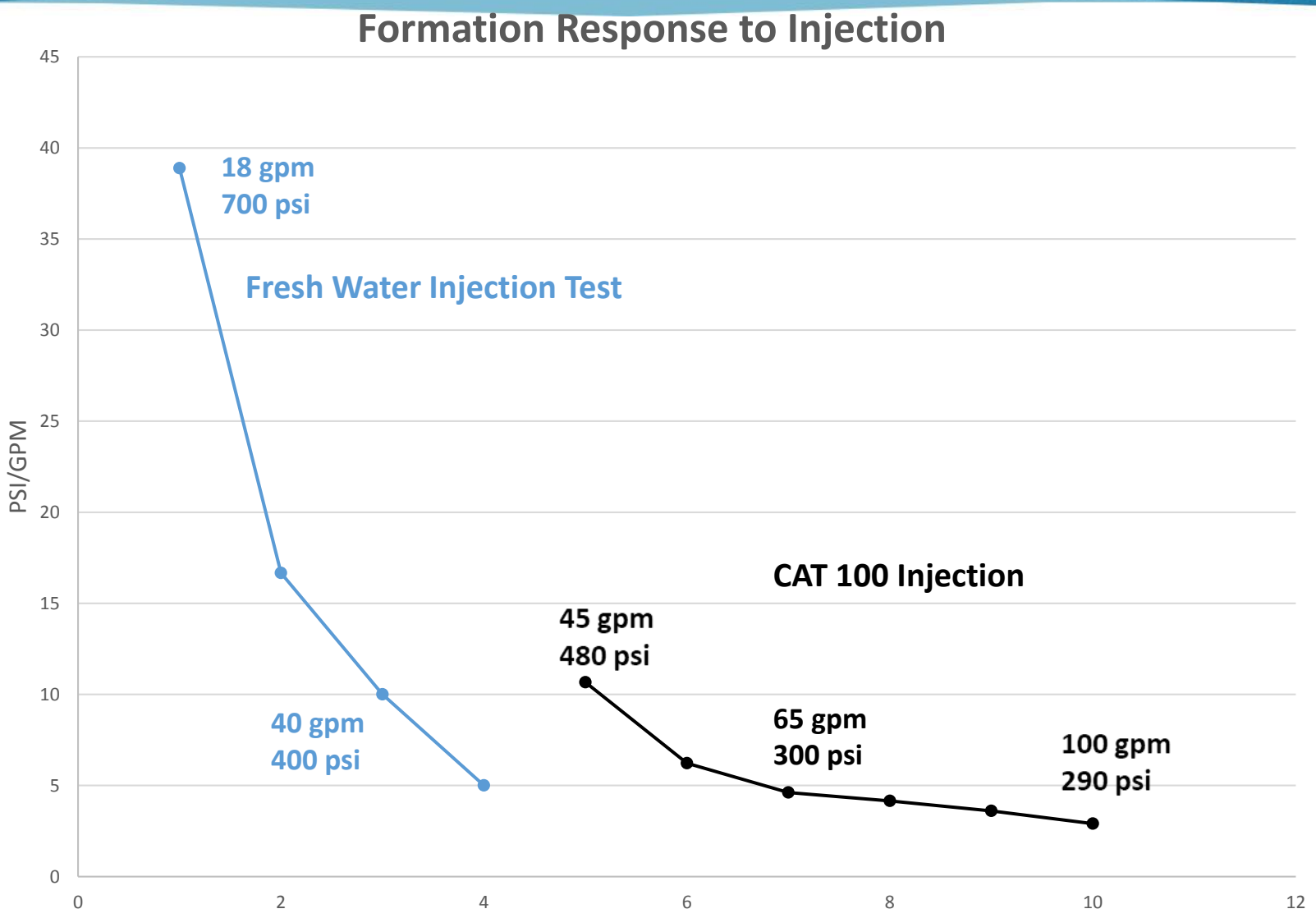
Various Flow Rates

1. 20 gpm
2. 60 gpm
3. 120 gpm
4. 250 gpm

What's the Downside?

Packer and Pump Demo

Need a high flow rate
but
Need to be Gentle



Typical volume of CAT 100 slurry installed during each injection at this site was 300 gallons.

CAT 100 Implementation – 1Q2017

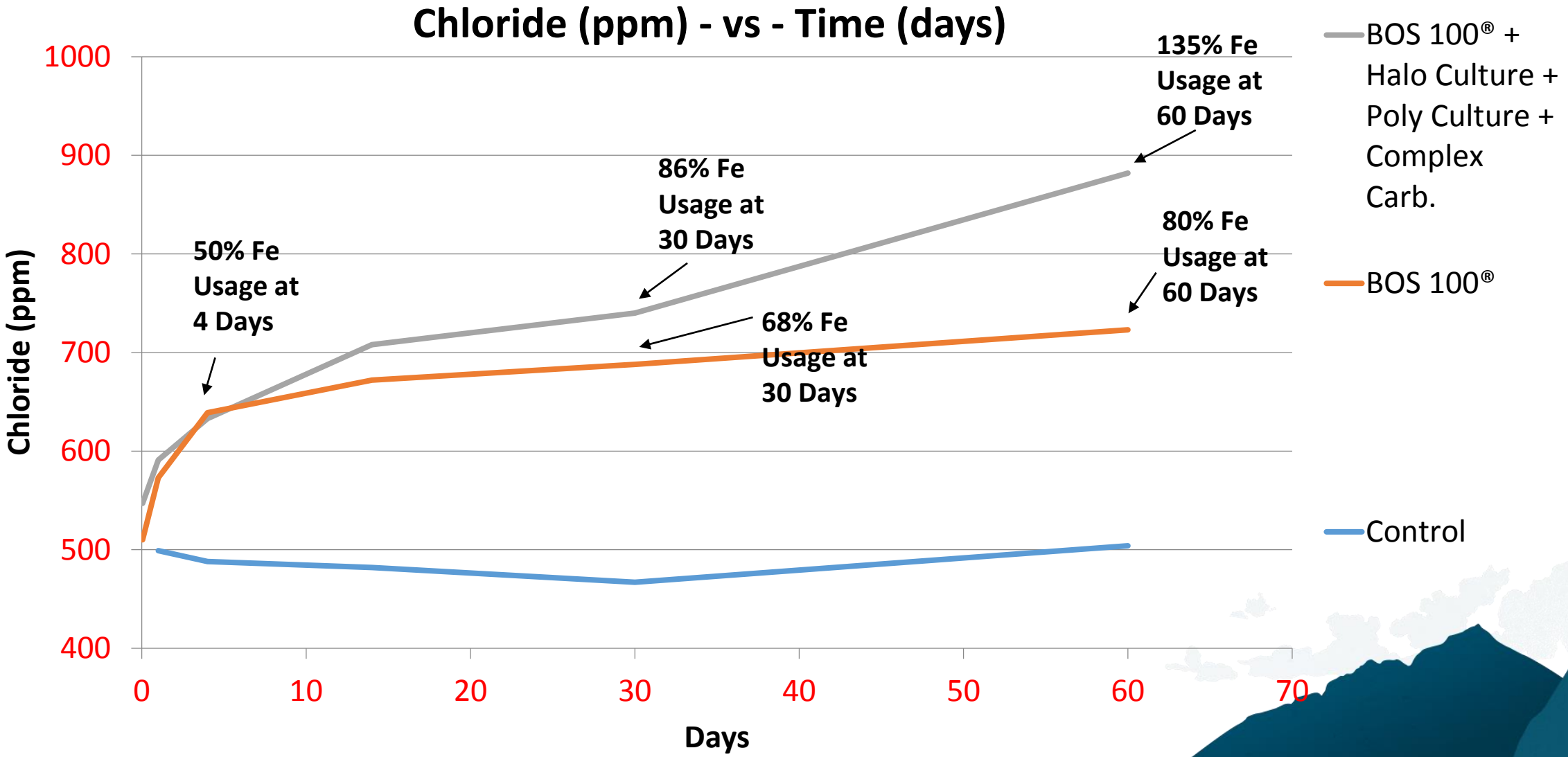
Key Elements

- Activated Carbon Impregnated with Metallic Iron (BOS 100®)
- Complex Carbohydrate – Food Grade Starch
- One Set of Microorganisms Designed to Degrade COCs
- Second Set of Microorganisms Designed to Degrade the Carbohydrate

Why?

- Exploit Characteristics of Carbon
- Capitalize on the Unique Activity of the BOS 100® Metallic Iron
- Profit from Microorganisms Attraction to Activated Carbon
- Gain Enhanced Reductive Dechlorination on Steroids
- Preserve the Metallic Surface that Electrifies the Process
- Low Maintenance – Extended Performance
- Naturally-Occurring Petroleum in Formation Could Compete With Carbon Adsorption

Bench Study Data – CAT 100 Effectiveness



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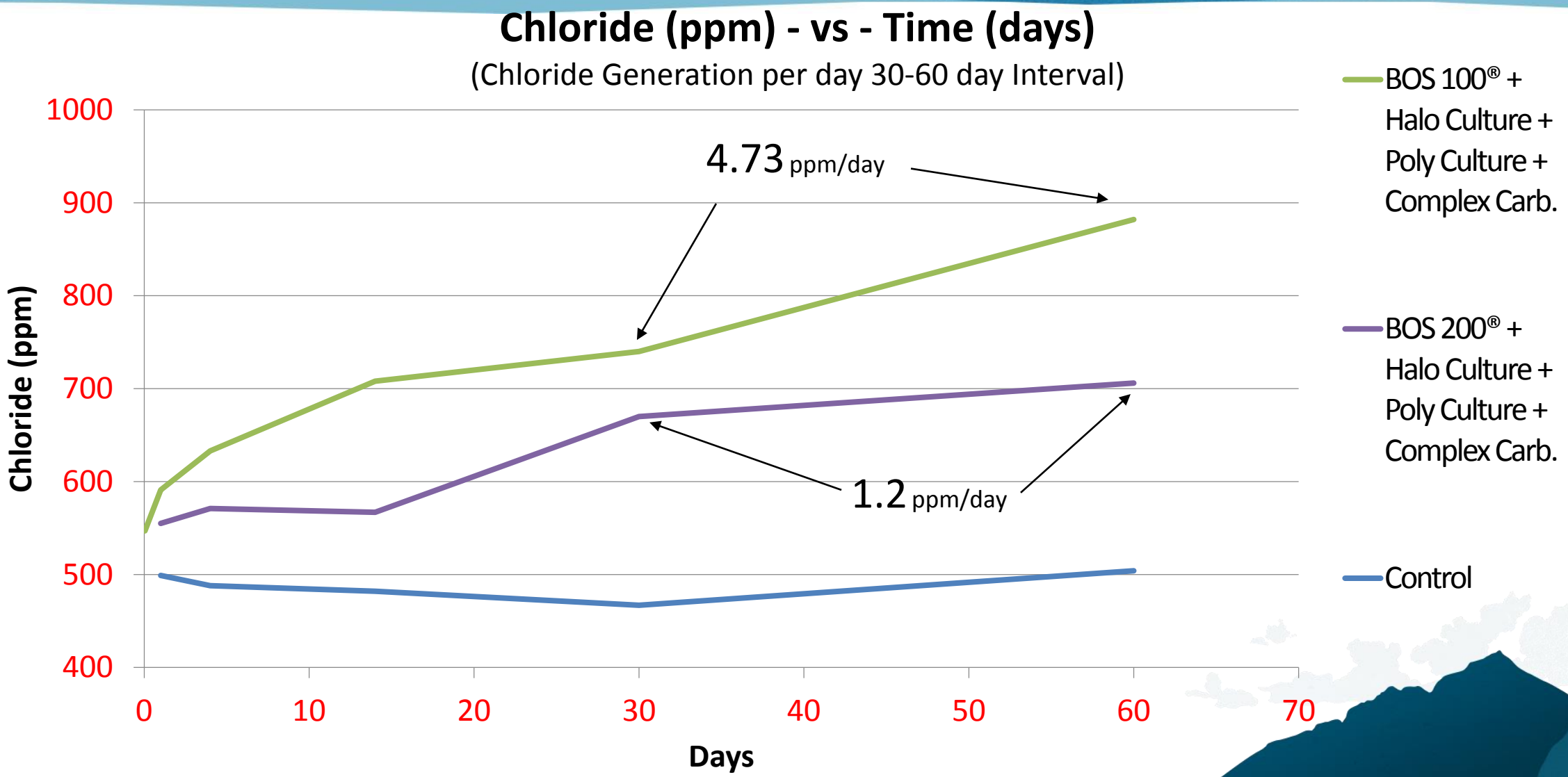
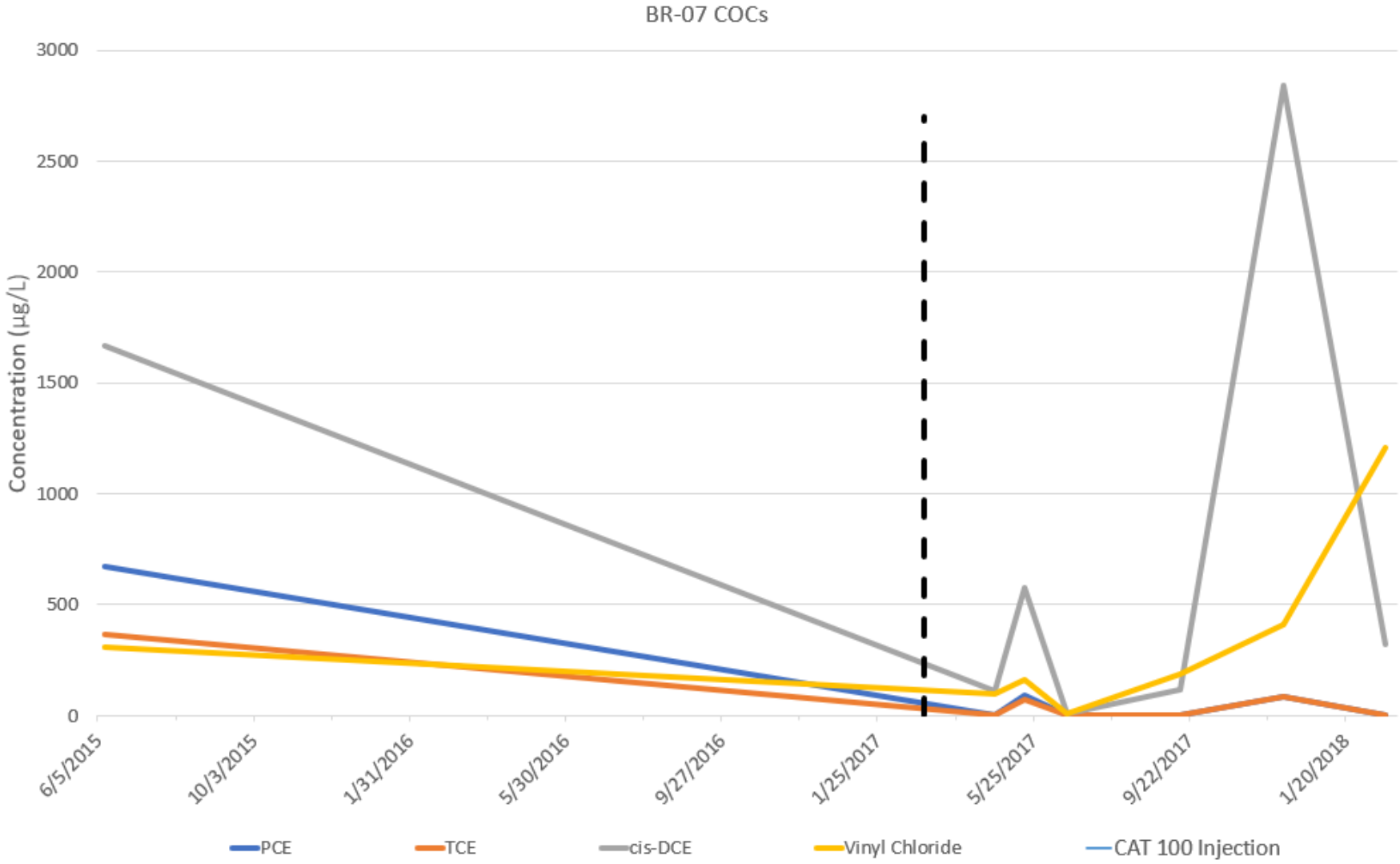
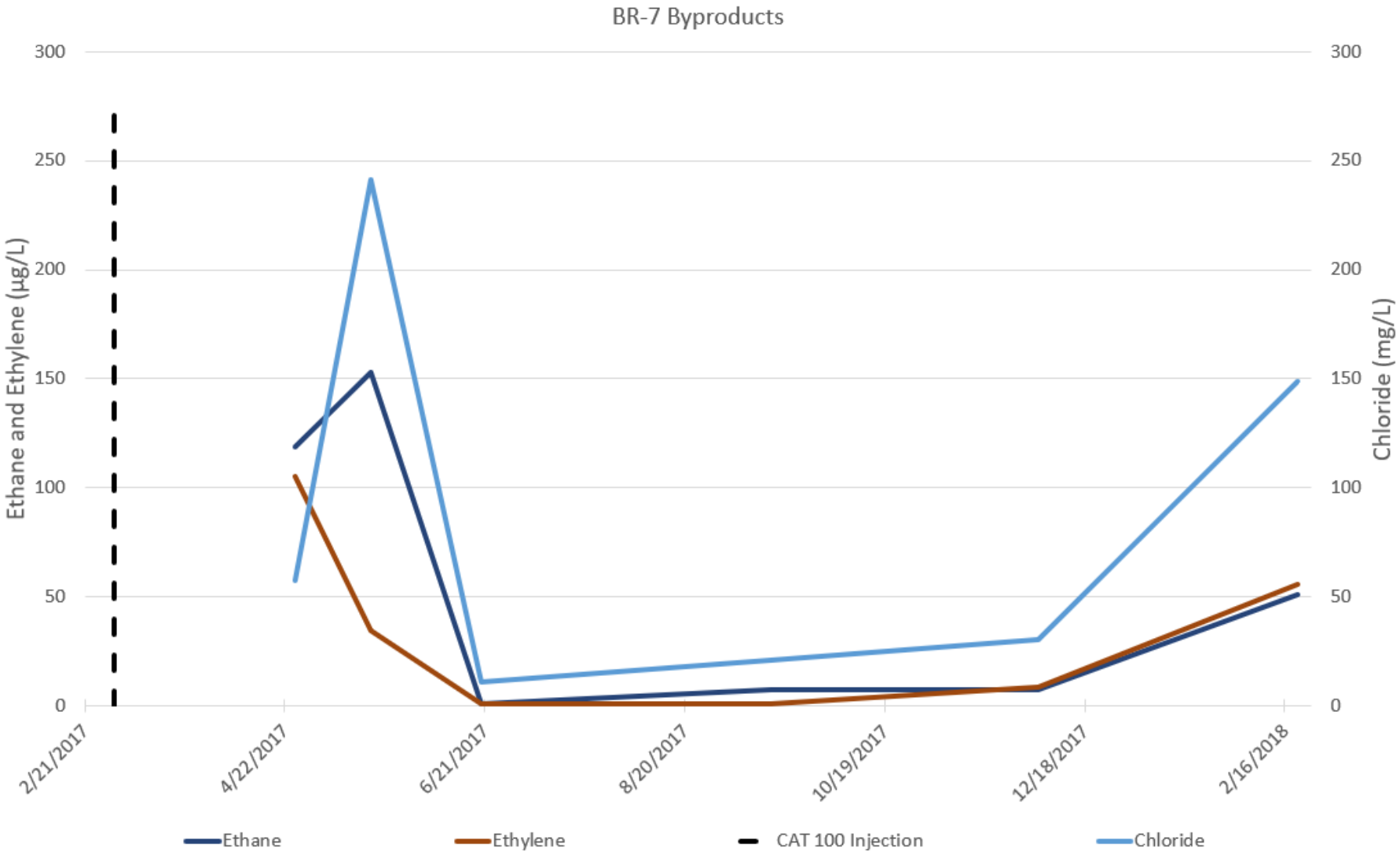


Sapa COCs BR-07



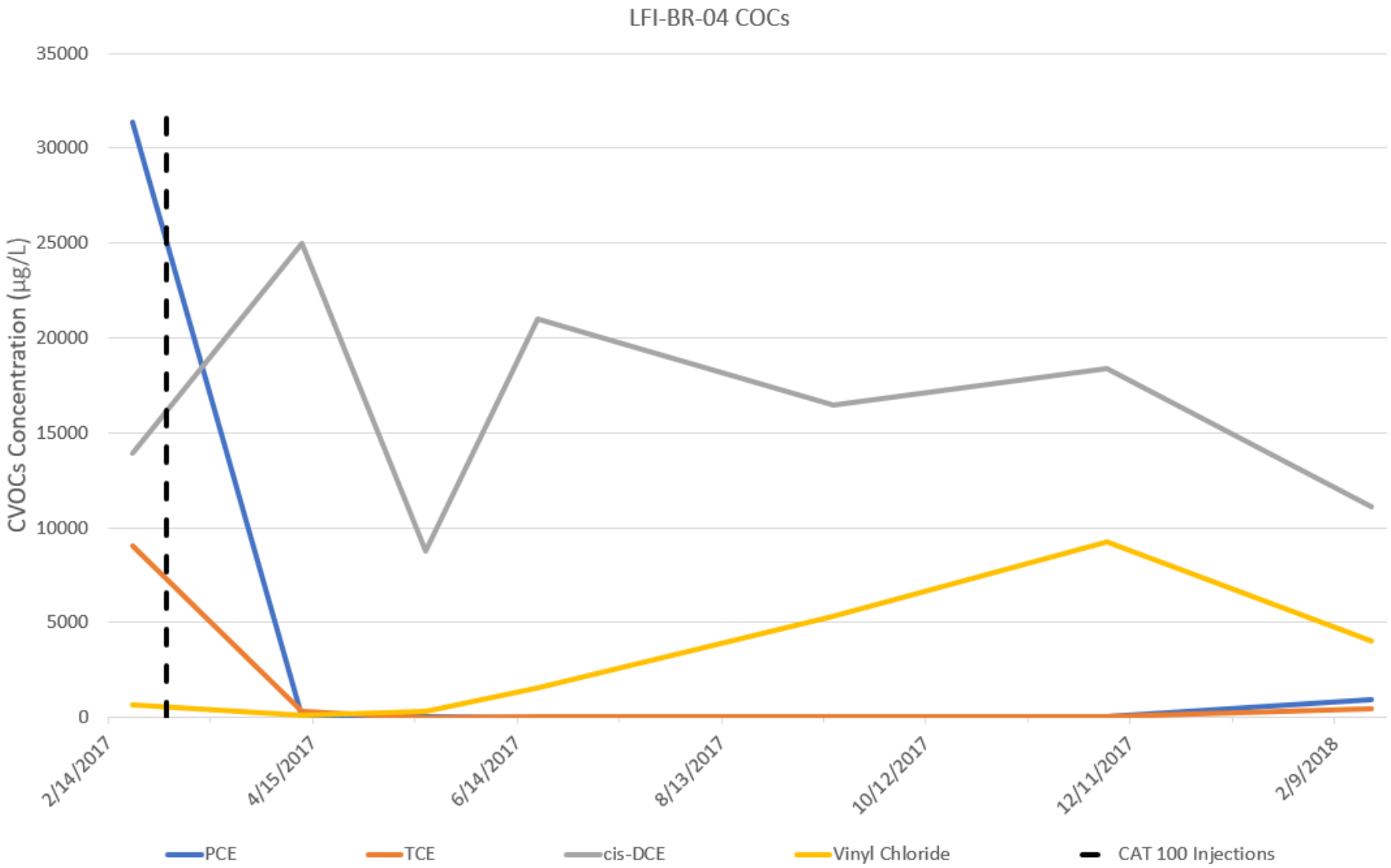
Sapa Byproducts BR-07



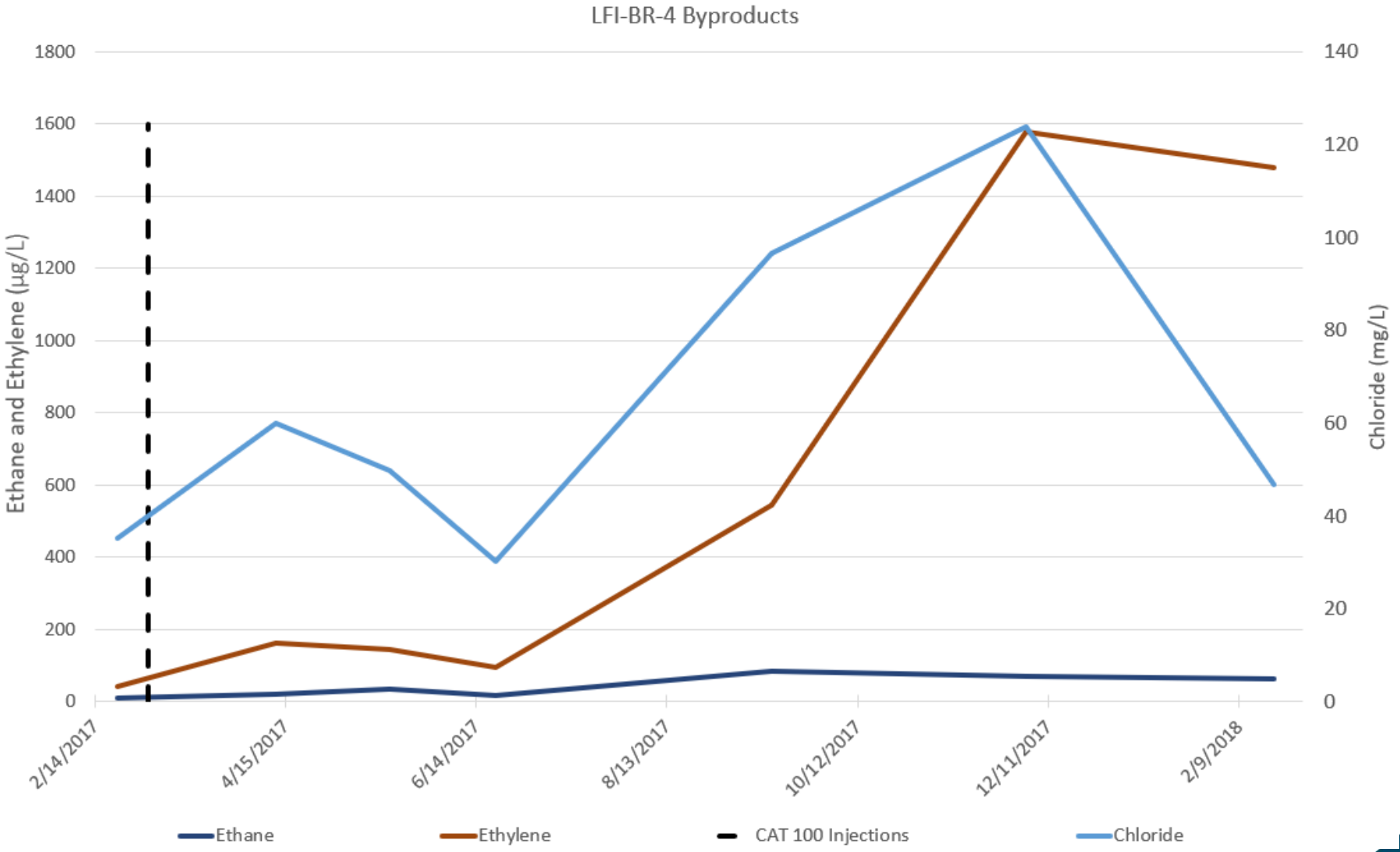
Predicted Chloride from pre-injection analytical: 2.27 mg/L

Actual Chloride generated during most recent sampling: 149 mg/L

Sapa COCs LFI-BR-4



Sapa Byproducts LFI-BR-4



Predicted Chloride from pre-injection analytical: 44.7 mg/L

Actual Chloride generated during 12/2017 sampling: 124 mg/L

Interesting Points…

Chloride Generation

- >3-Times Amount Predicted From Pre-Injection Baseline

Contaminant Mass Removal

- ~75% total mass removal from the treatment area <12-months post injection

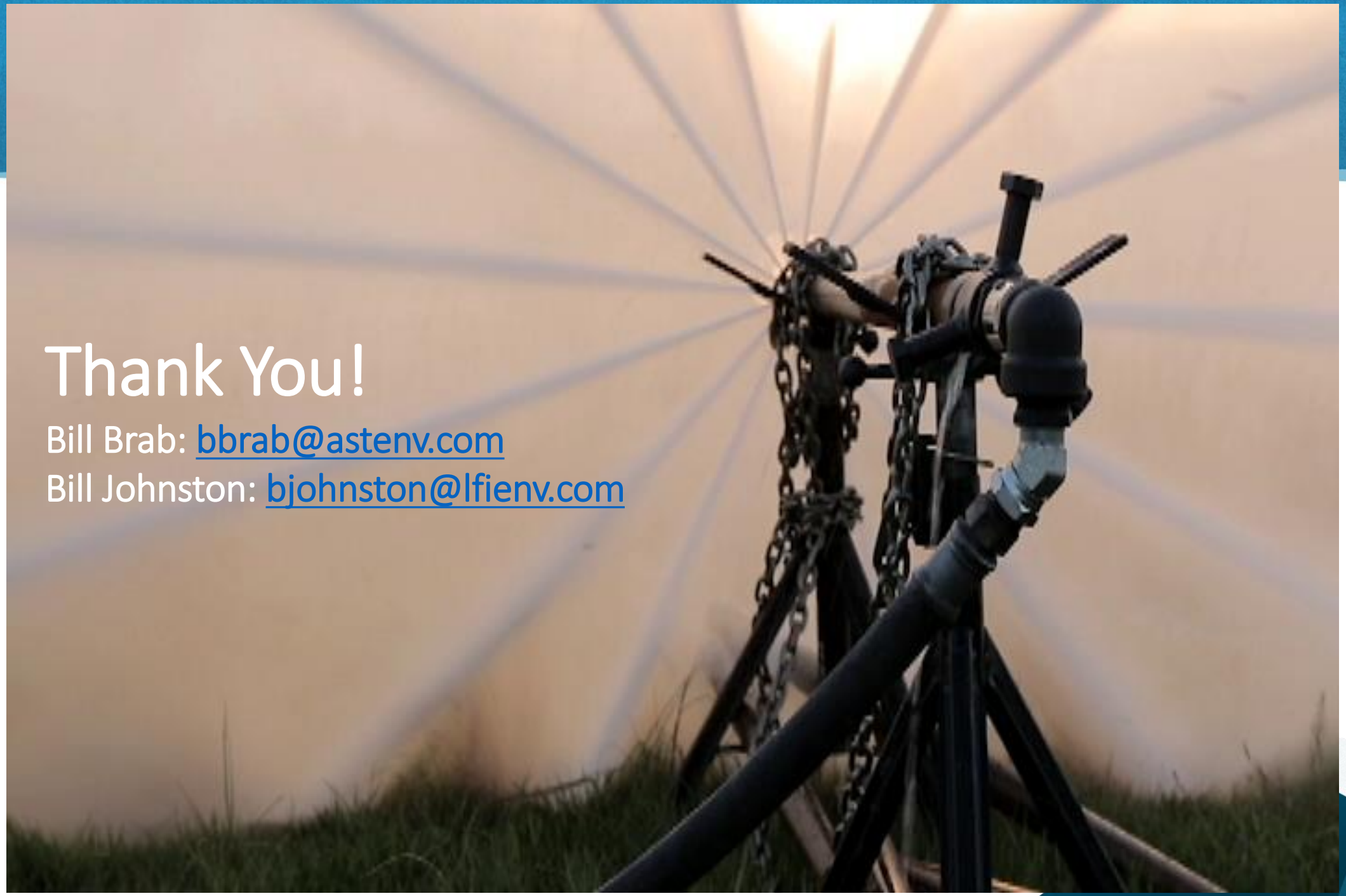
CAT 100 Design and Life

- 10-year barrier life from design calculations
- No quantifiable indications of Fe consumption in BOS 100®, all ERD

Closing Comments…

- Corrective Action Plan approved and implemented
- Environmental Covenant recorded
- Groundwater Plume Reduced to w/in source extents
- Monitoring well network and sampling schedule significantly reduced to annual with 5-year review
- Mechanical System approved for removal from facility
- New owners achieved financing and site redevelopment begins May 2018

Questions?



Thank You!

Bill Brab: bbrab@astenv.com
Bill Johnston: bjohnston@lfienv.com