

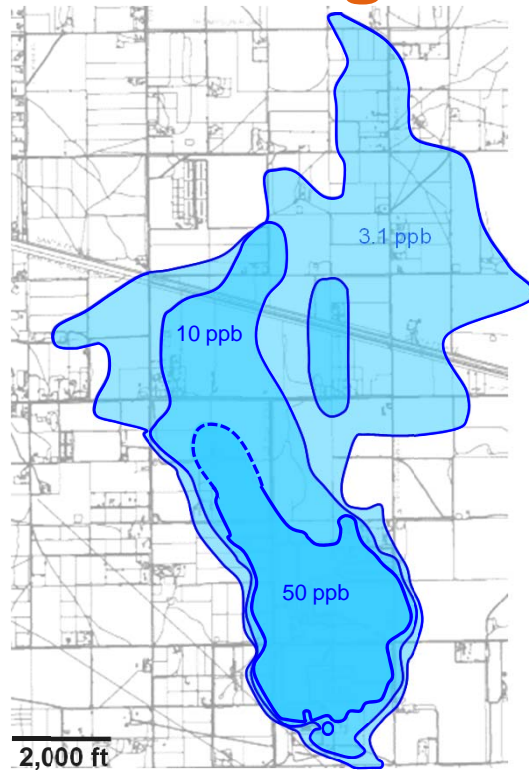
EVALUATION OF STORED REDUCING CAPACITY TO OPTIMIZE OPERATIONS AND MAINTENANCE FOR IN SITU BIOLOGICAL TREATMENT OF CR(VI) IN GROUNDWATER

Margaret Gentile, Isaac Wood, Lauren Weigt, Frank Lenzo
Arcadis US, Inc.

Battelle 2018 Chlorinated Conference, Palm Springs, CA

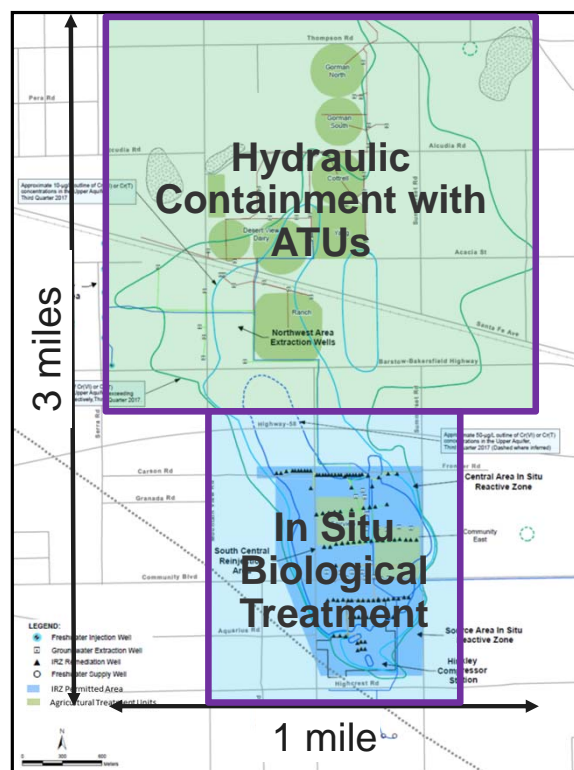
April 12, 2018

Site Background



- Cr(VI) in groundwater due to historical release of cooling water
 - Residual between 3 and ~9,000 ppb Cr(VI)
- Hydrogeologic Conditions
 - Depositional environment generated by lake shore deposits, deltas and Mojave River flows → complex and heterogeneous lithology
 - Depth to Water: ~80-90 ft
 - Saturated thickness: ~30-70 ft
 - Groundwater velocity: ~1-4 ft/d

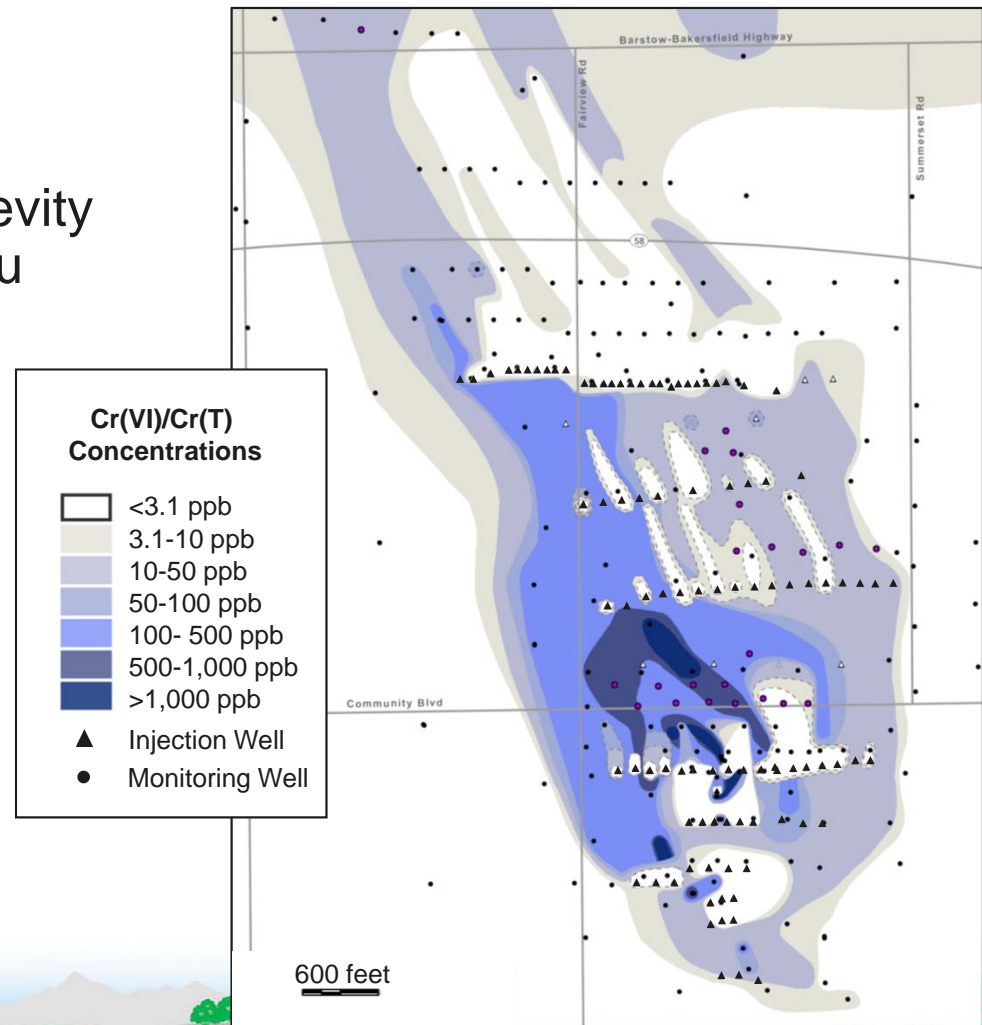
Remedial Approach



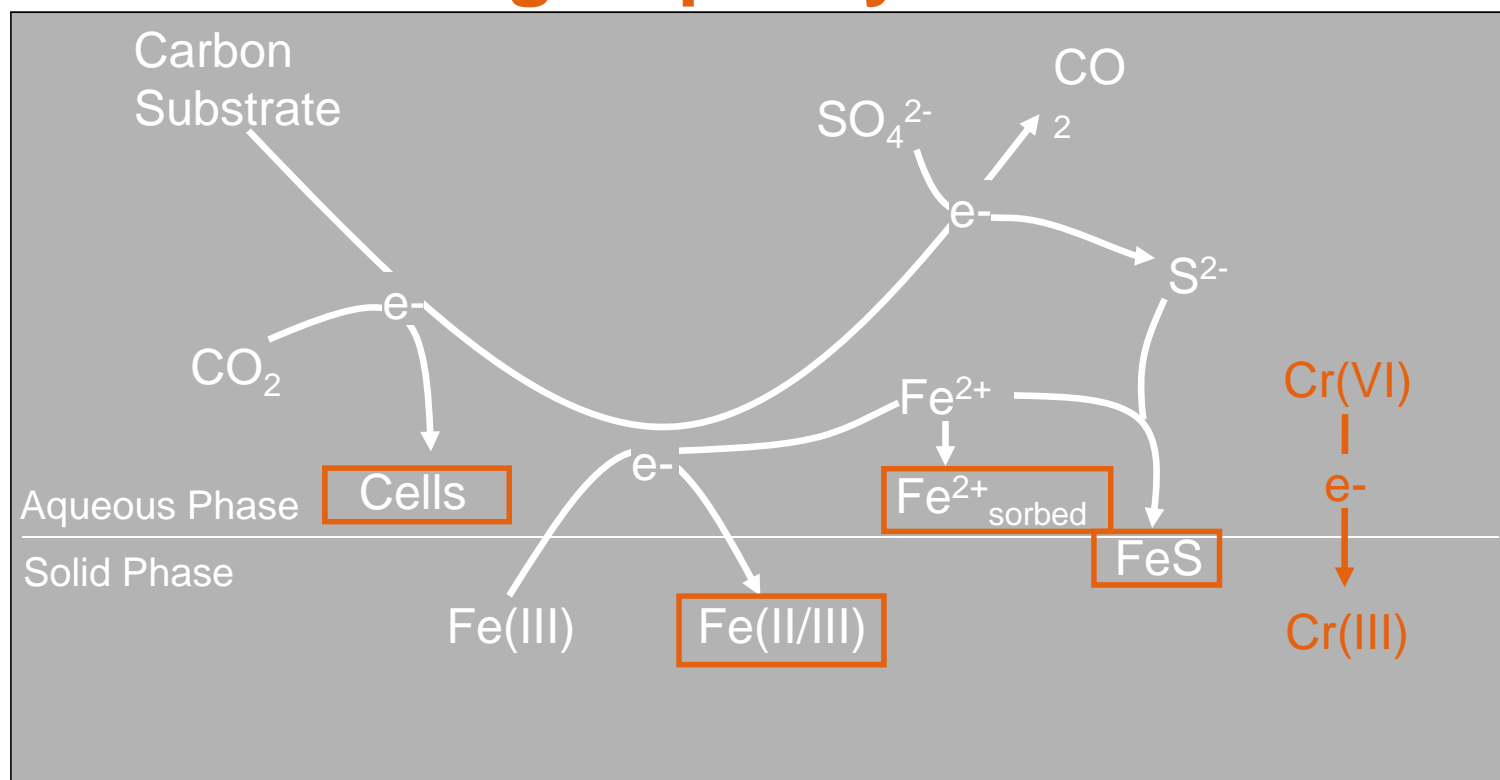
- Required cleanup timeframes:
 - 2025: < 50 µg/L across 90% of the plume
 - 2032: < 10 µg/L across 80% of the plume
- Remedial Strategy:
 - Hydraulic Containment with ATUs of distal plume
 - In-situ Biological Treatment targeting plume core
- Historic Remedial Actions:
 - Pre-2004: Pump and agricultural treatment
 - 2004 – Present: Hydraulic Containment with ATUs and in-situ biological treatment

Problem Statement

Evaluate factors that influence longevity of stored reducing capacity for in situ biological Cr(VI) treatment

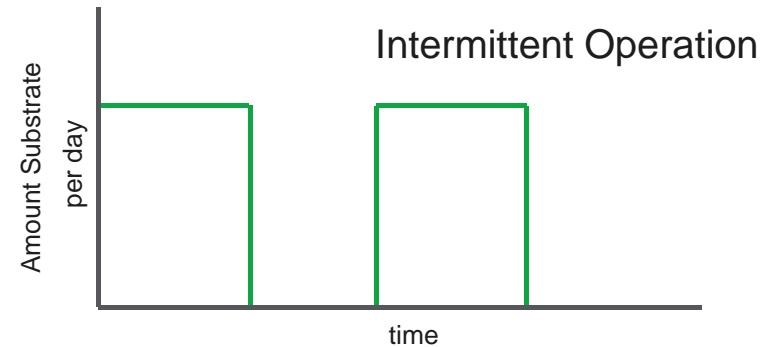
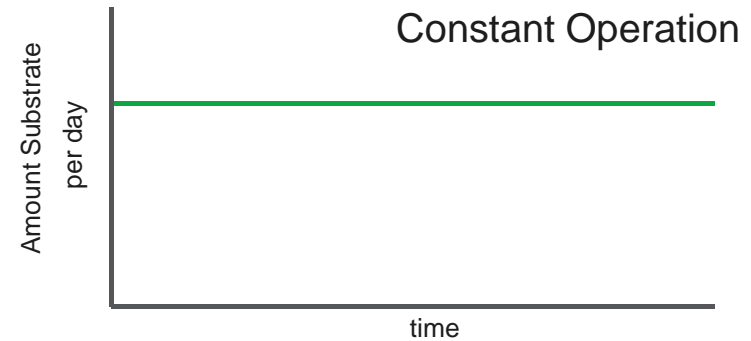


Stored Reducing Capacity

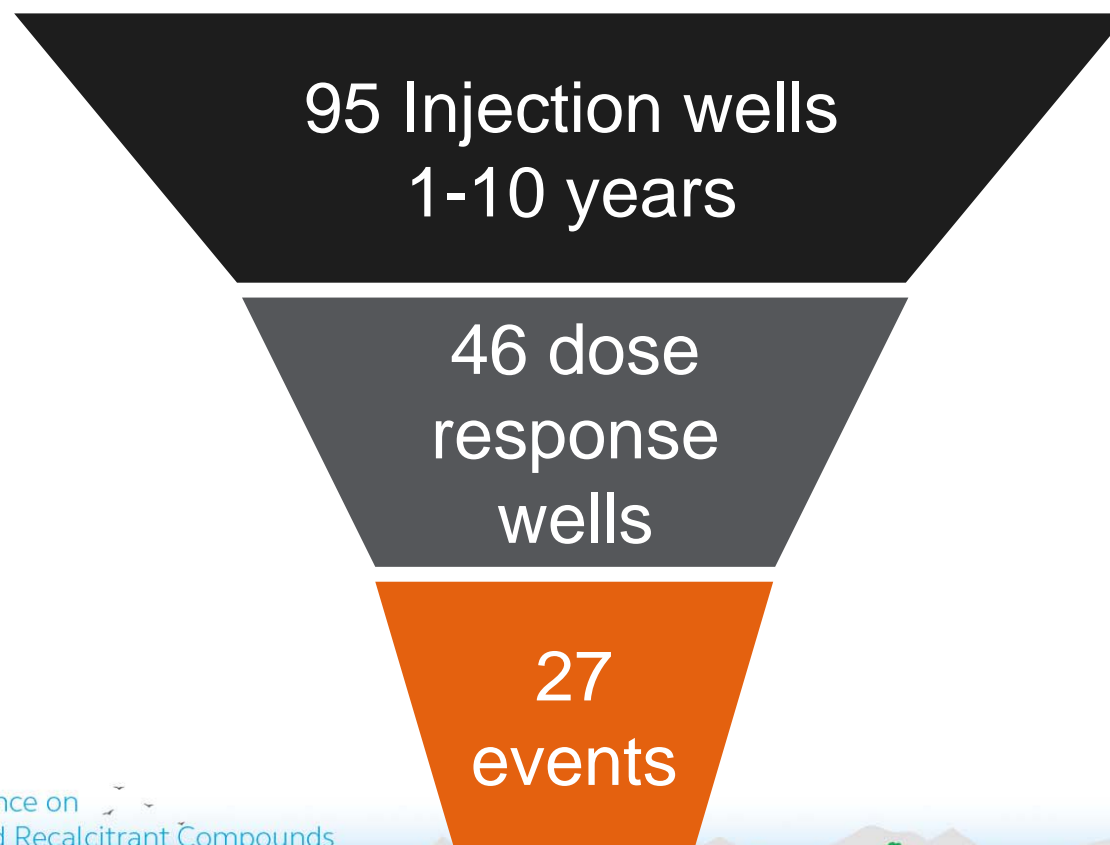


Impact of Longevity on O&M

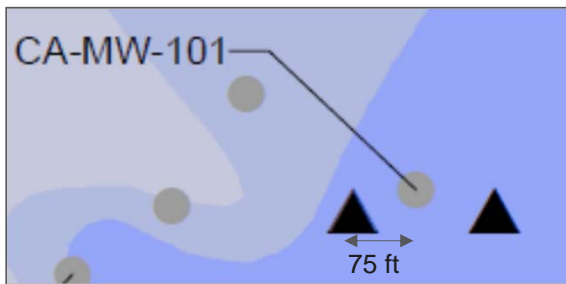
- Stored reducing capacity allows for reduced active operation
- At increasing scale, capitalizing on stored reducing capacity creates opportunity for efficiencies



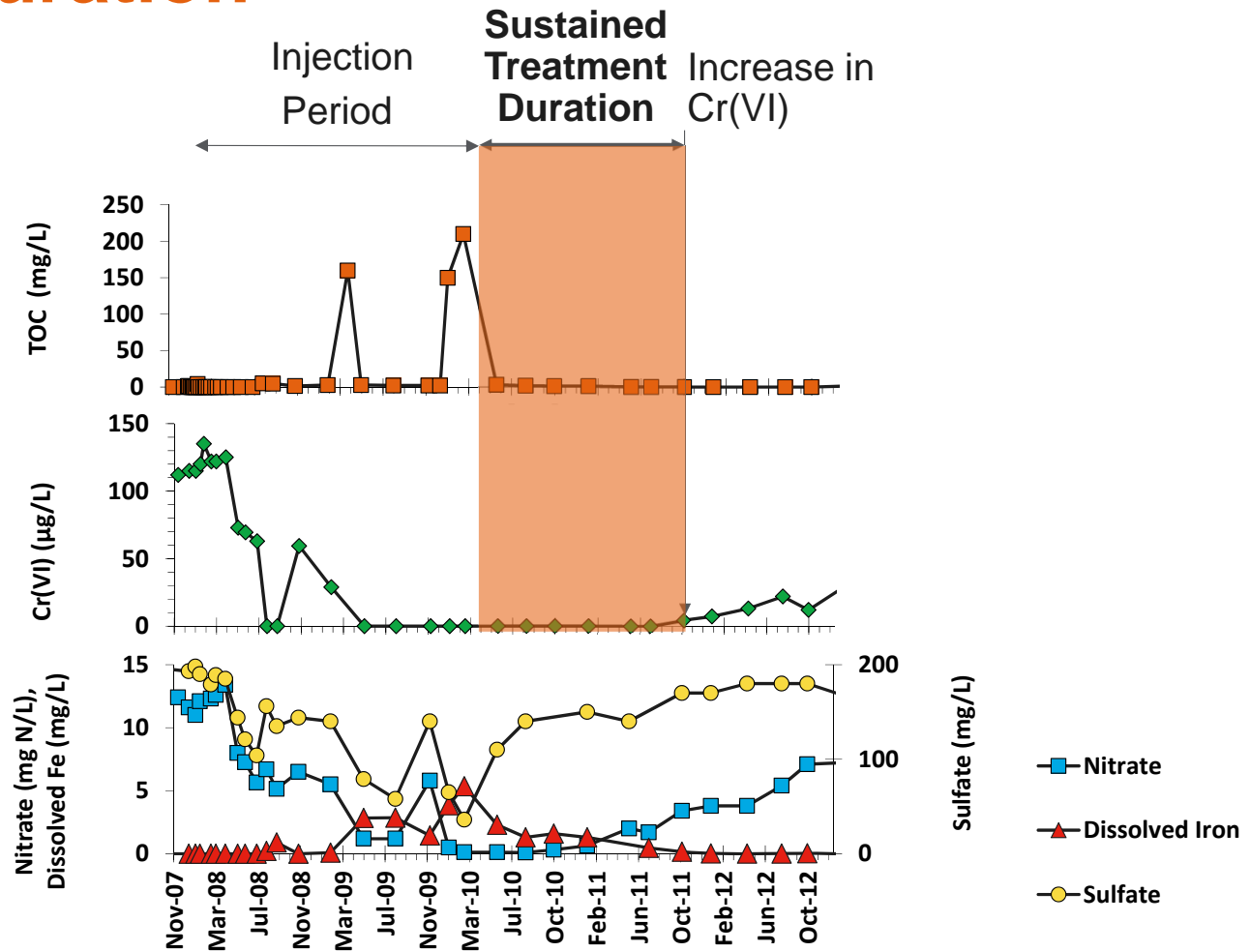
Dataset Evaluated



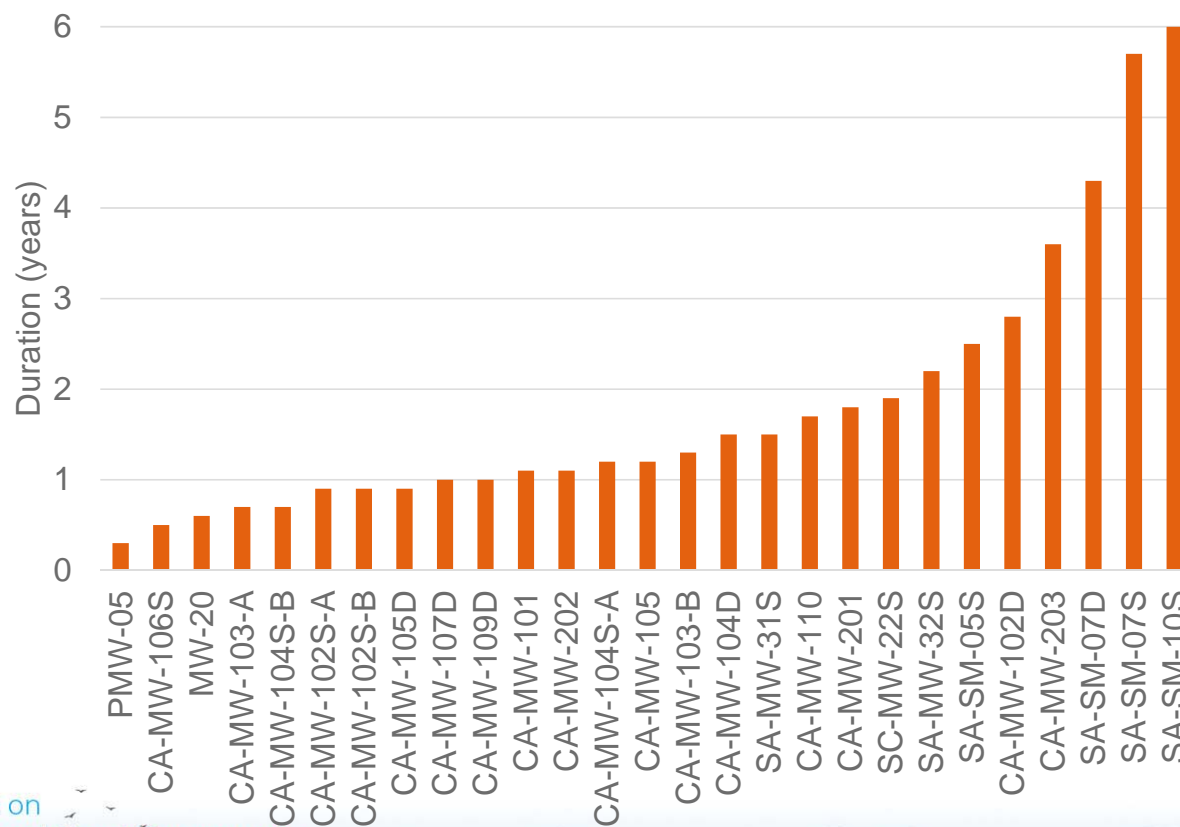
Analysis of Duration



- ▲ Injection Well
- Monitoring Well

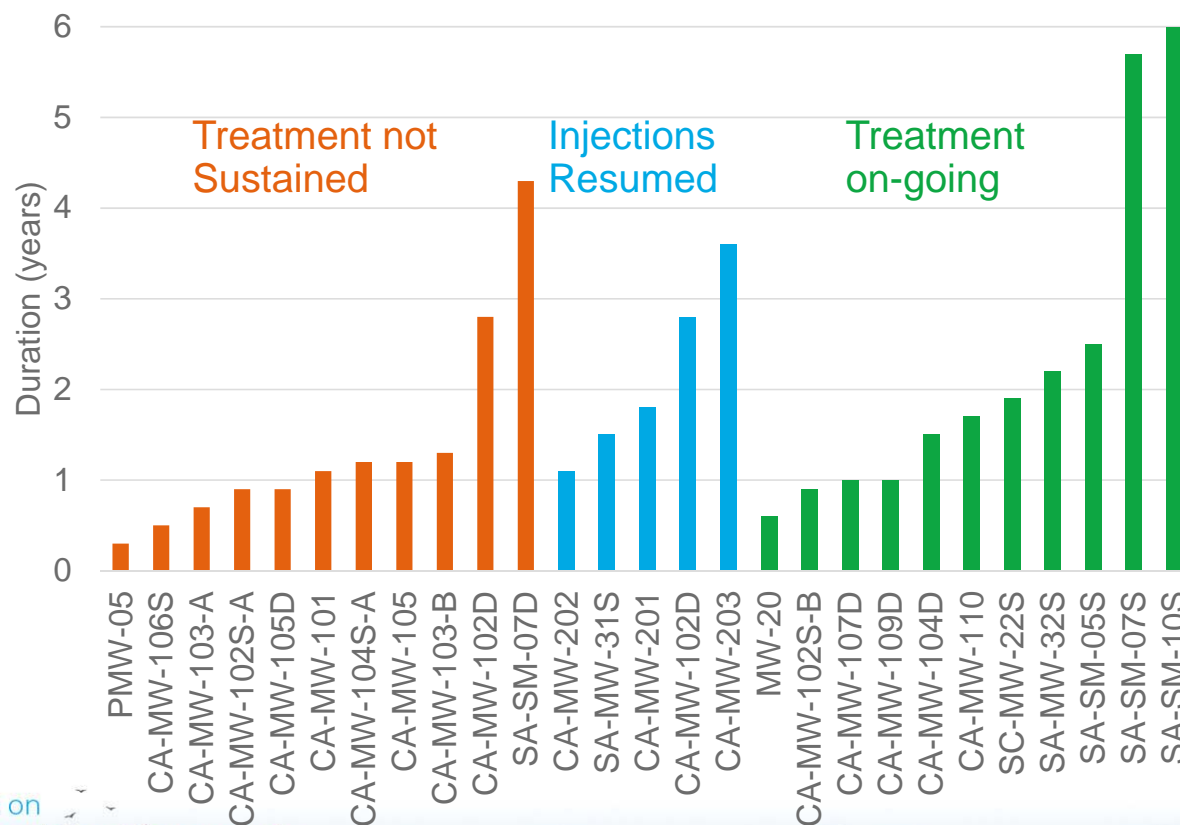


Sustained Treatment Durations



Eleventh International Conference on
Remediation of Chlorinated and Recalcitrant Compounds

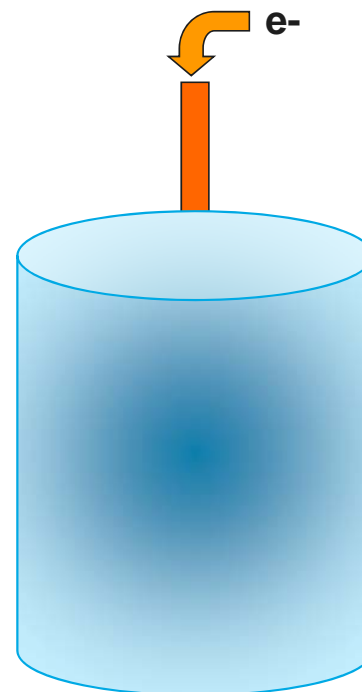
Range of Sustained Treatment Durations



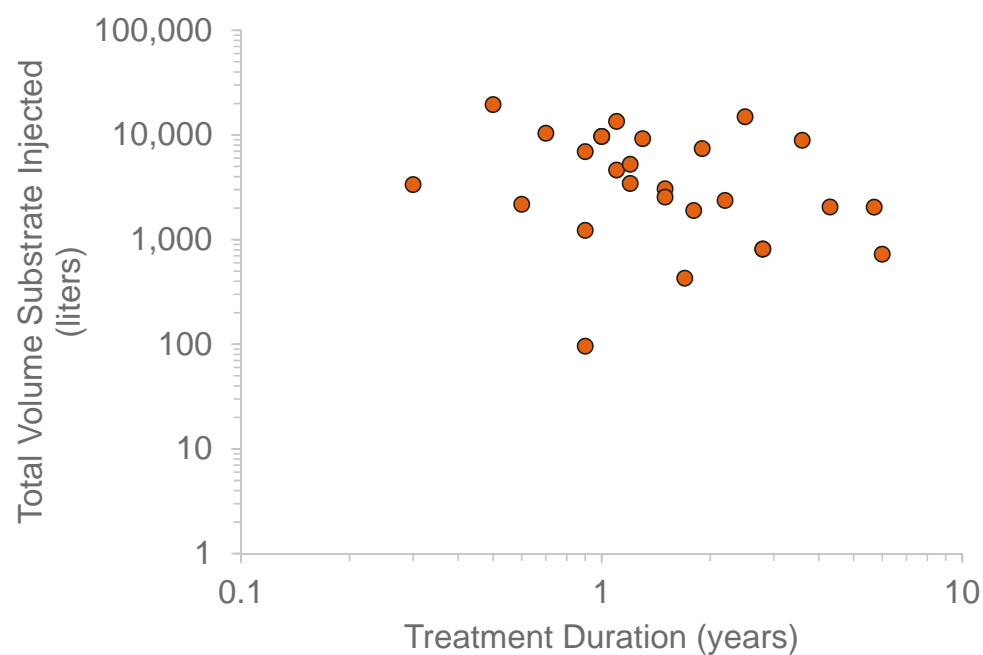
Potential Factors Affecting Longevity

How many electrons are stored

Amount of
substrate injected



Amount of Substrate Injected



No clear relationship

Potential Factors Affecting Longevity

How many electrons are stored

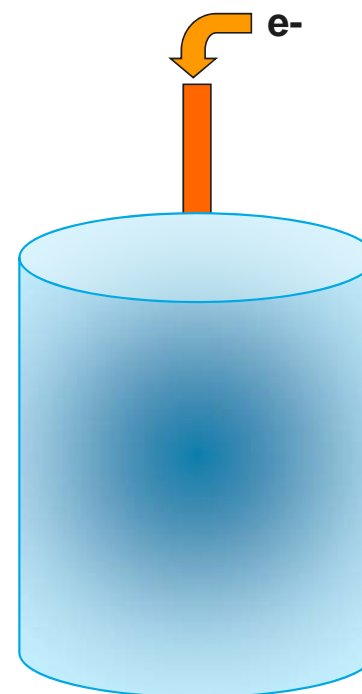
Amount of
substrate injected

Position within the
injection zone

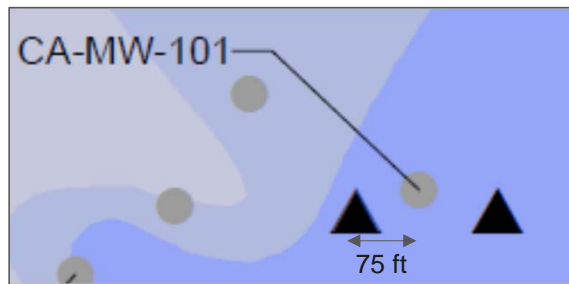
Reducing
conditions

Availability of
iron

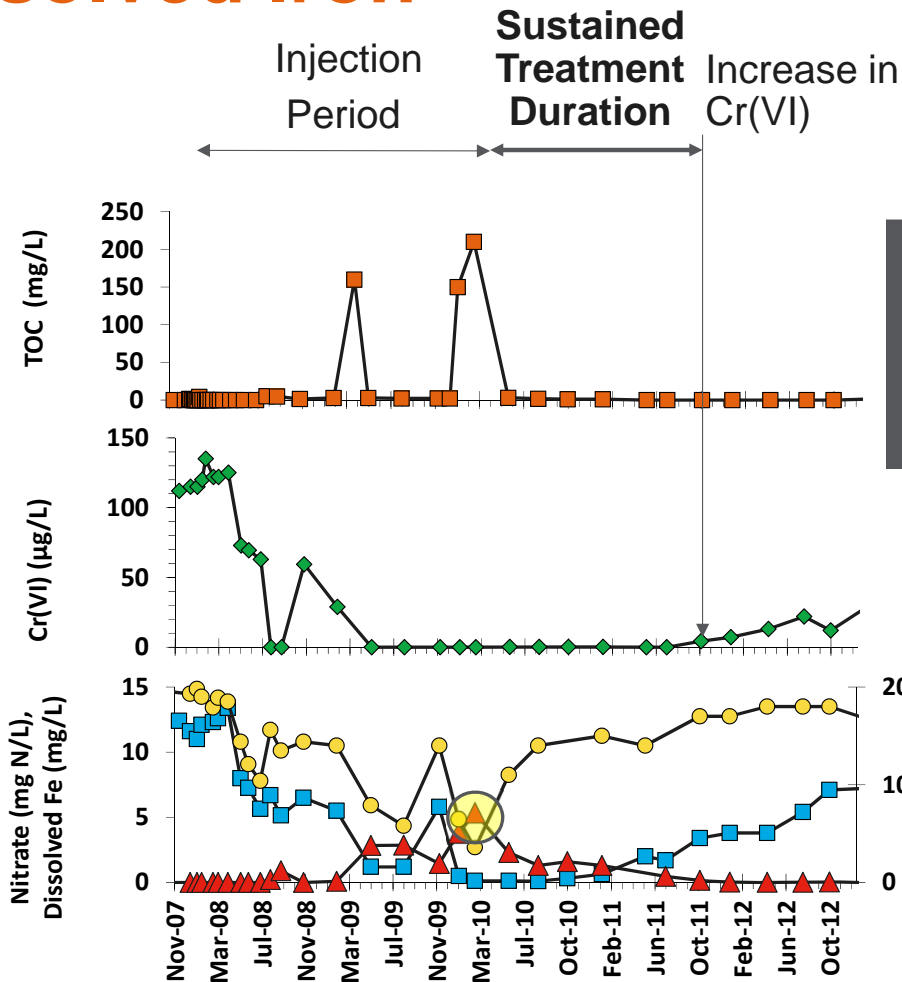
Geology



Maximum Dissolved Iron

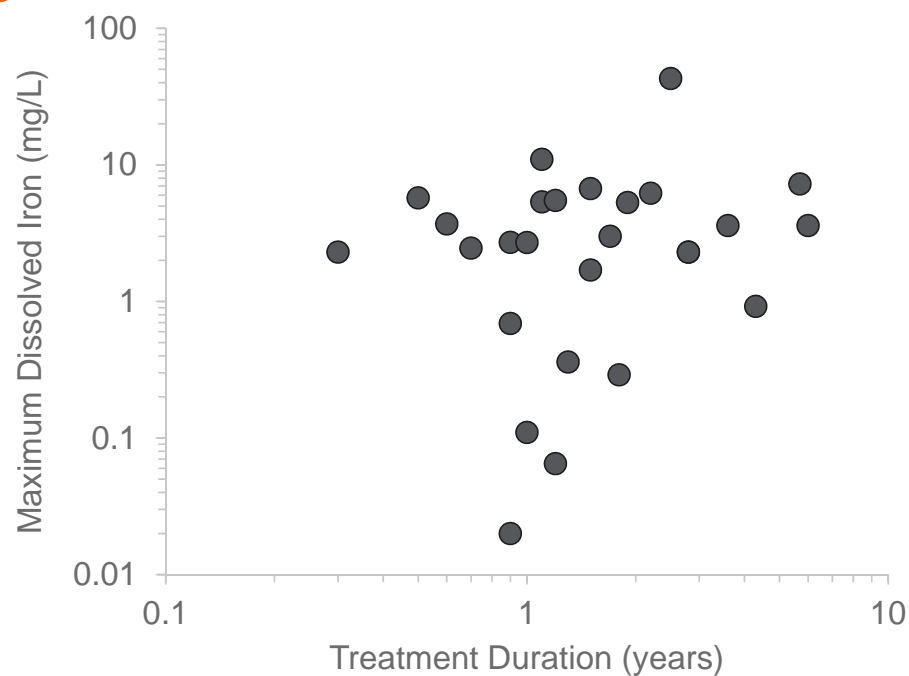


- ▲ Injection Well
- Monitoring Well

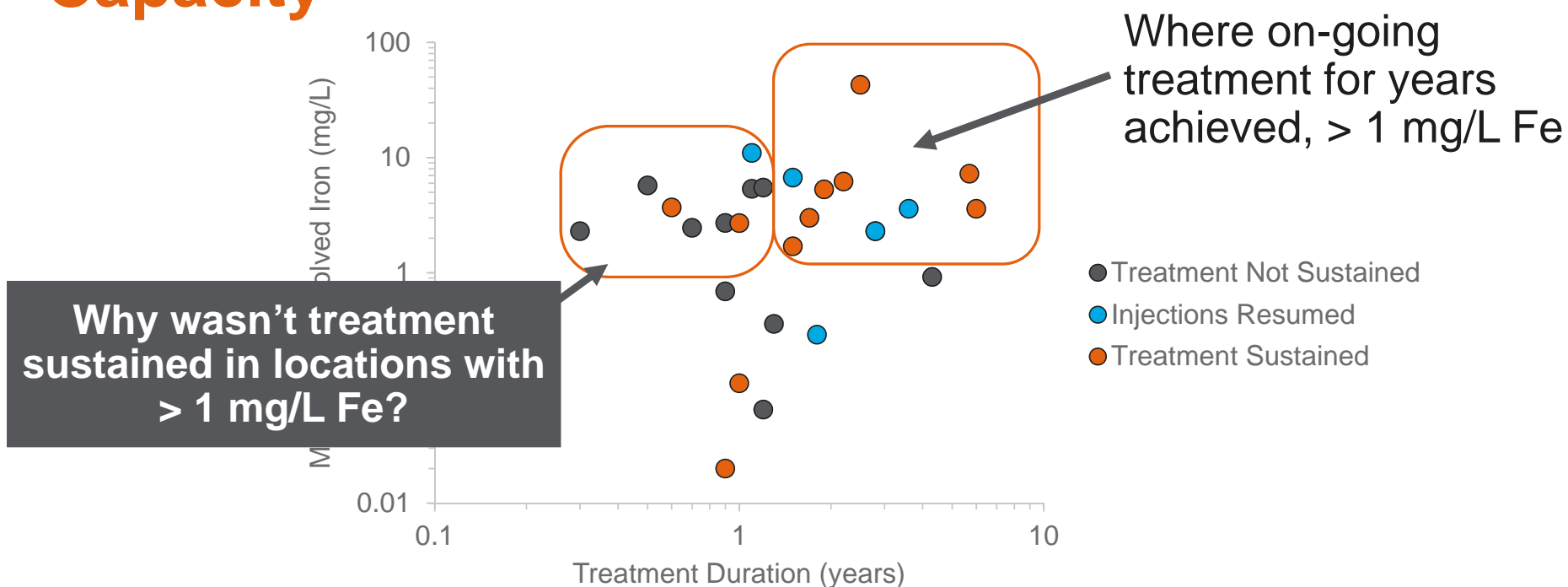


Used maximum dissolved iron as indicator of reducing conditions

Iron as an Indicator of Sustained Reducing Capacity

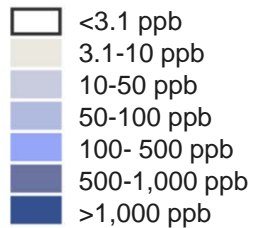


Iron as an Indicator of Sustained Reducing Capacity



Spatial Variability

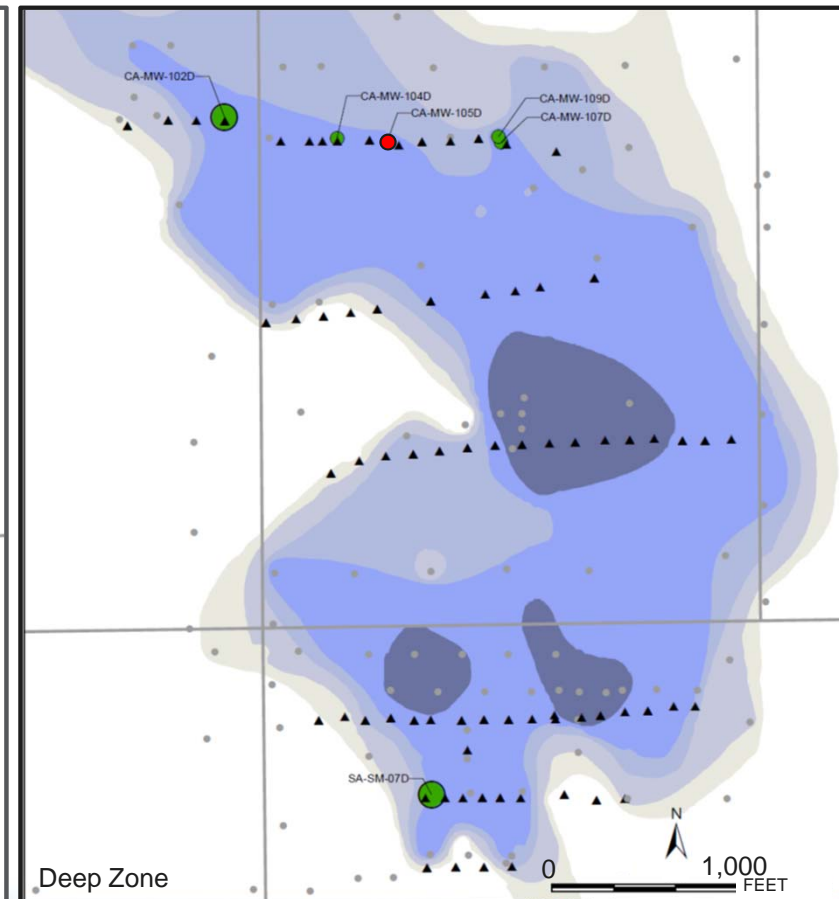
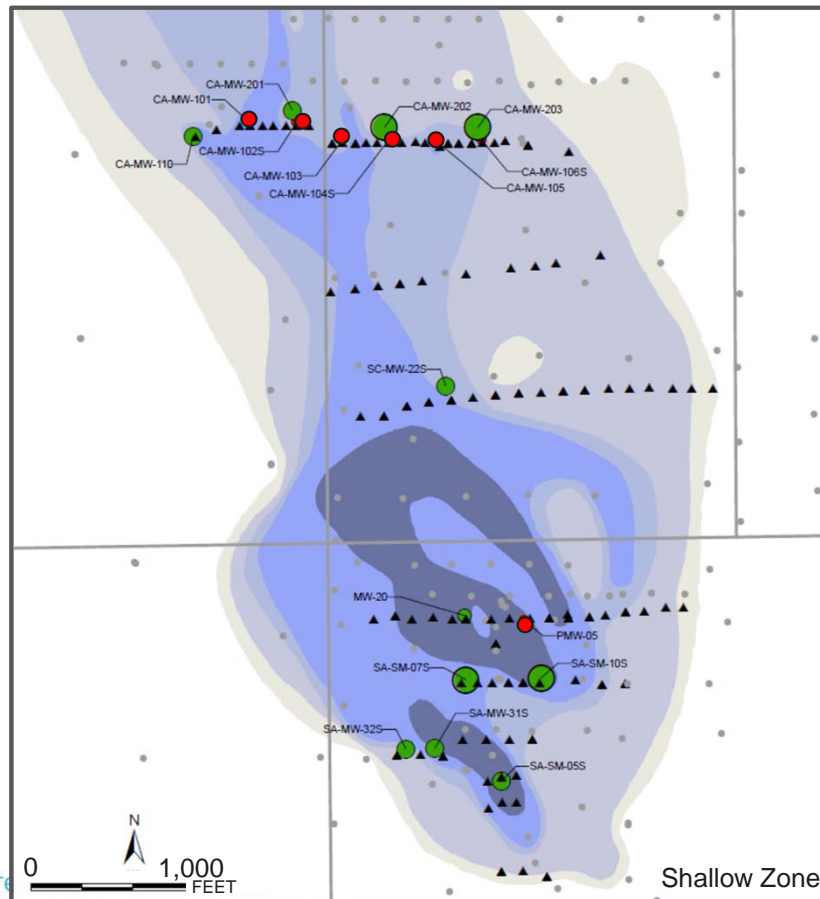
Cr(VI)/Cr(T) Concentrations



- ▲ Injection Well
- Monitoring Well

Sustained Treatment

- Loss of Treatment 0.3-1.4 yrs
- Sustained < 1.4 yrs
- Sustained 1.4-2.7 yrs
- Sustained >2.7 yrs



Potential Factors Affecting Longevity

How many electrons are stored

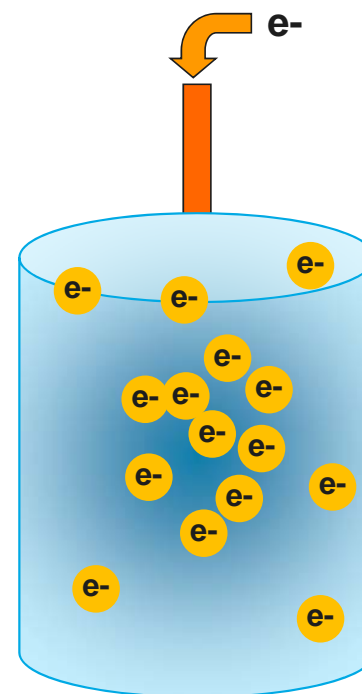
Amount of
substrate injected

Position within the
injection zone

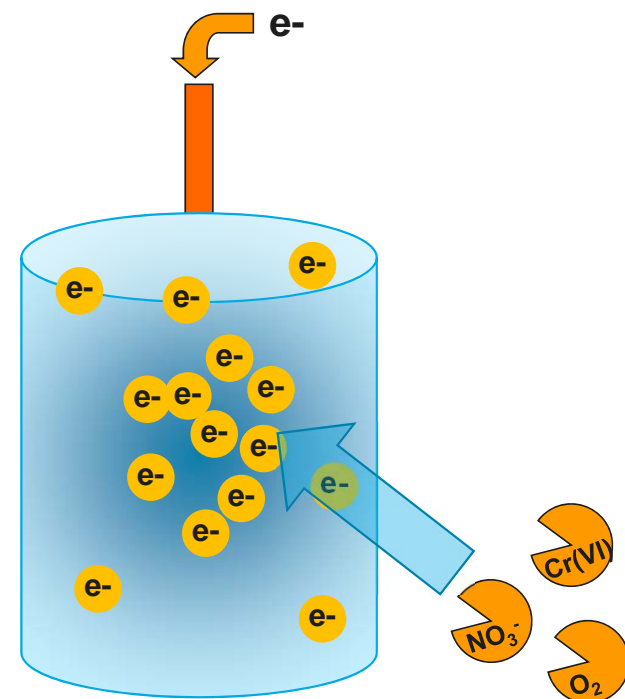
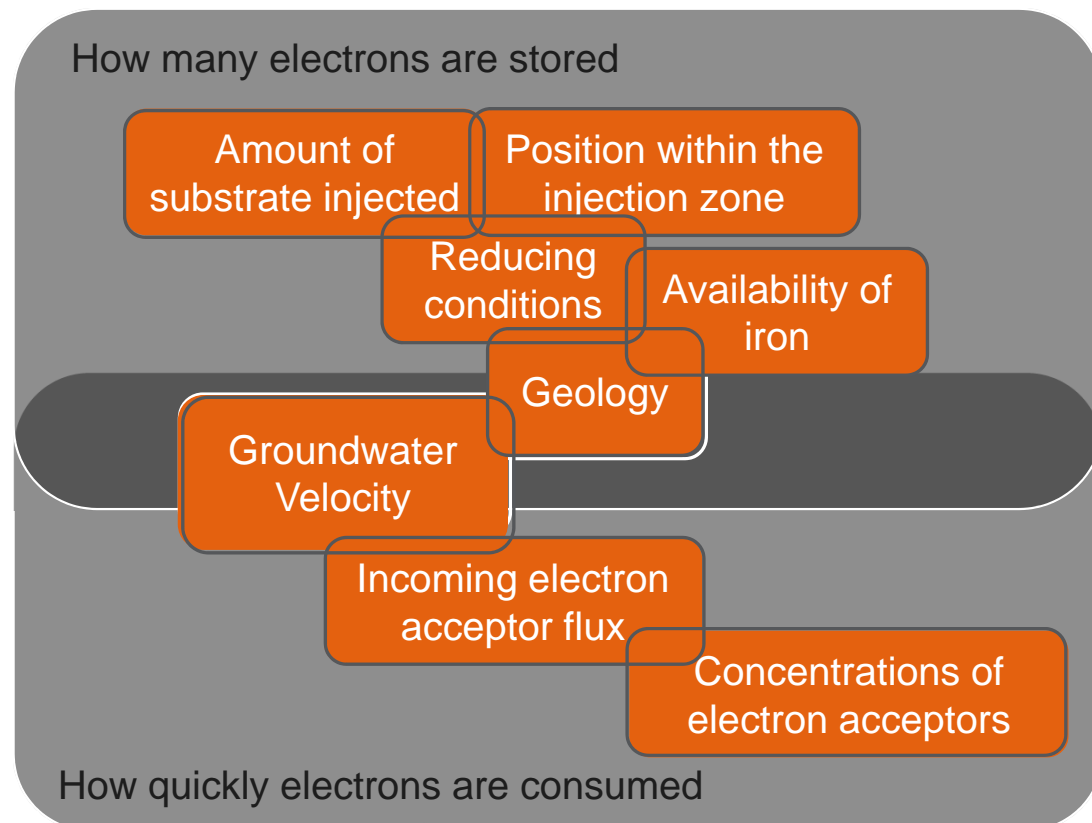
Reducing
conditions

Availability of
iron

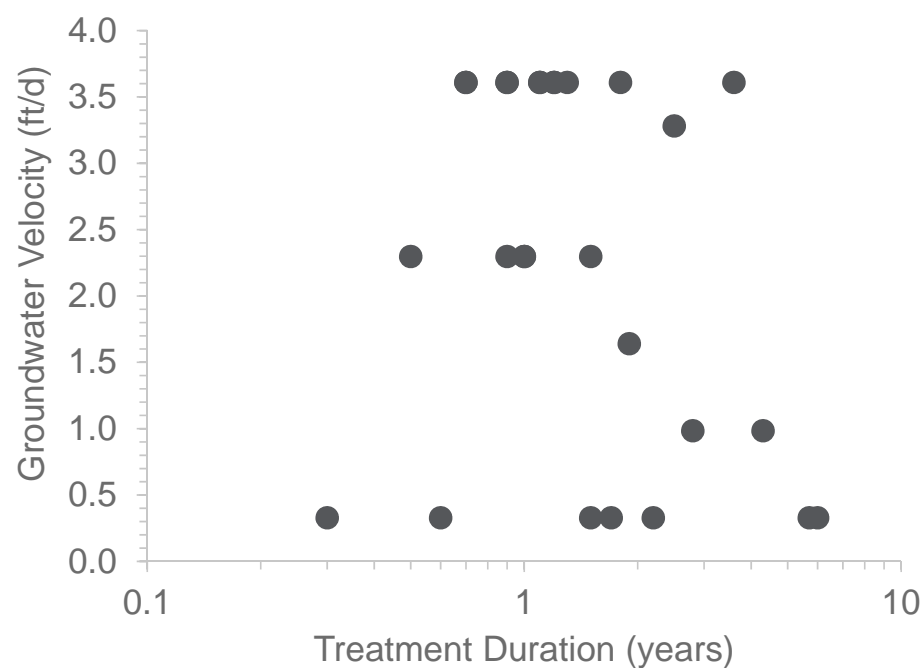
Geology



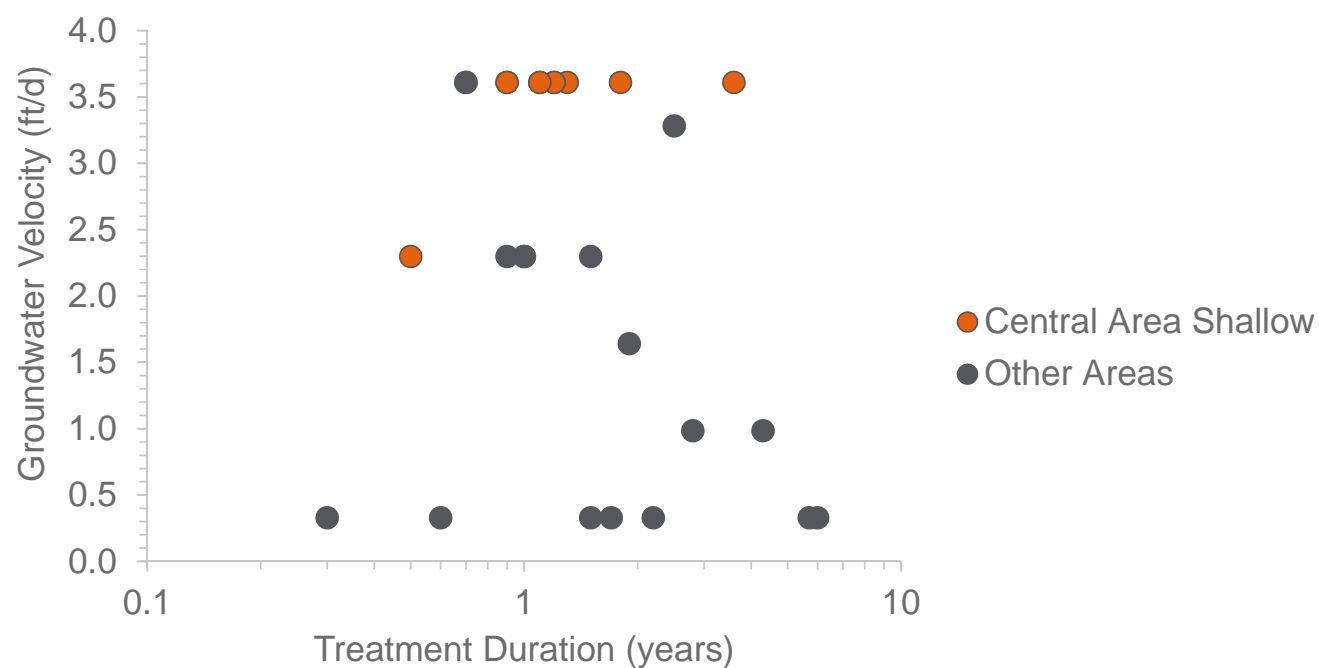
Potential Factors Affecting Longevity



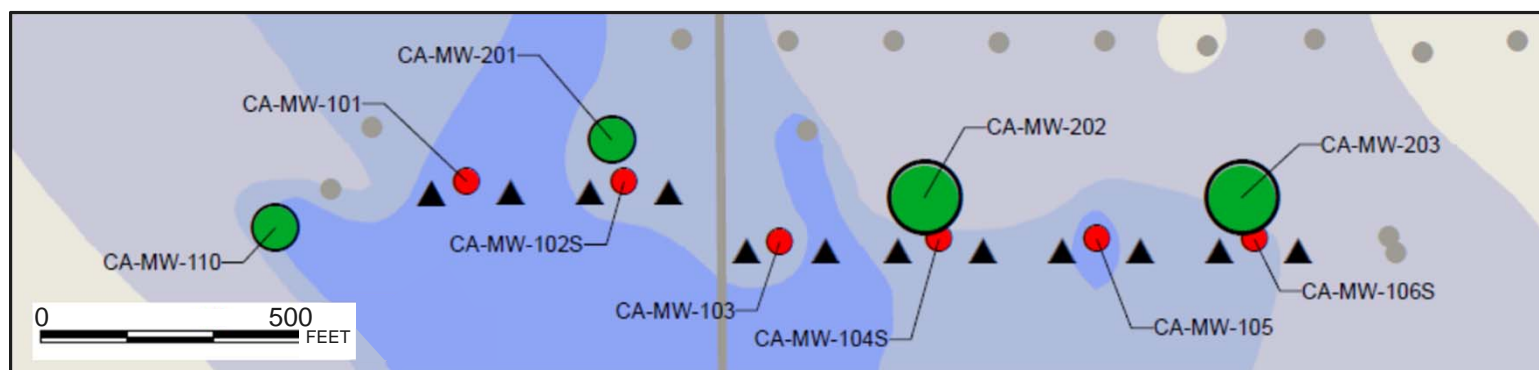
Duration vs Velocity



Duration vs Velocity

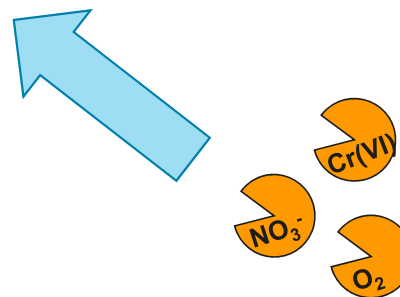


Consumption of Reducing Capacity on Upgradient Side of Reactive zone



Sustained Treatment

- Loss of Treatment 0.3 - 1.4 years
- Sustained 1.4 - 2.7 years
- Sustained > 2.7 years



Conclusions

- Sustained Cr(VI) treatment can be achieved with soluble carbon injections over large spatial scales for periods of years
- The duration of sustained treatment depends on the interplay of many factors for electron storage and consumption
- Operations of injection based remedies can be optimized to utilize stored reducing capacity

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