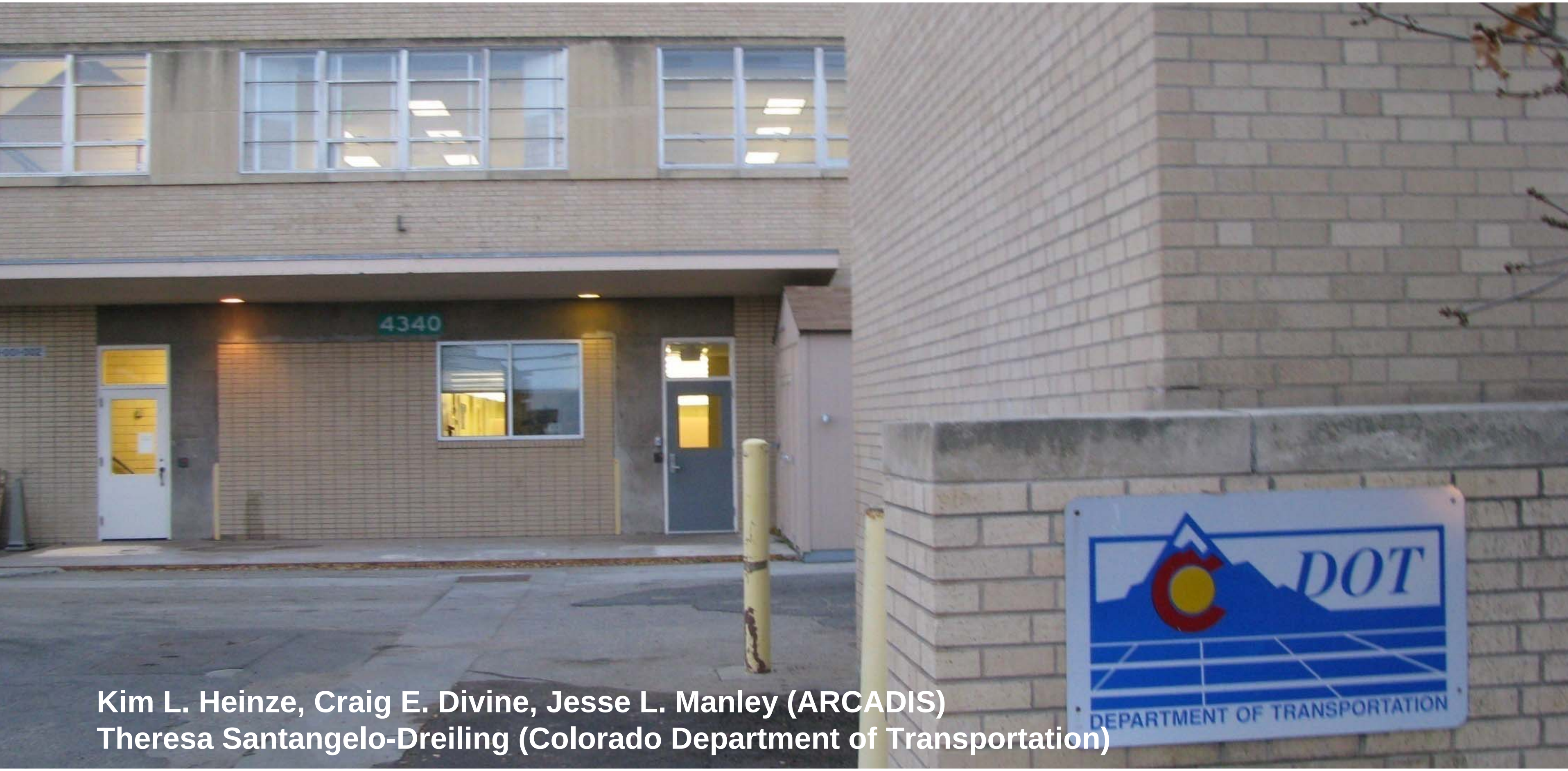
Performance Comparison of Aerobic and Anaerobic In-Situ Treatment Approaches

Former Materials Testing Laboratory (MTL)
Colorado Department of Transportation (CDOT), Denver, CO



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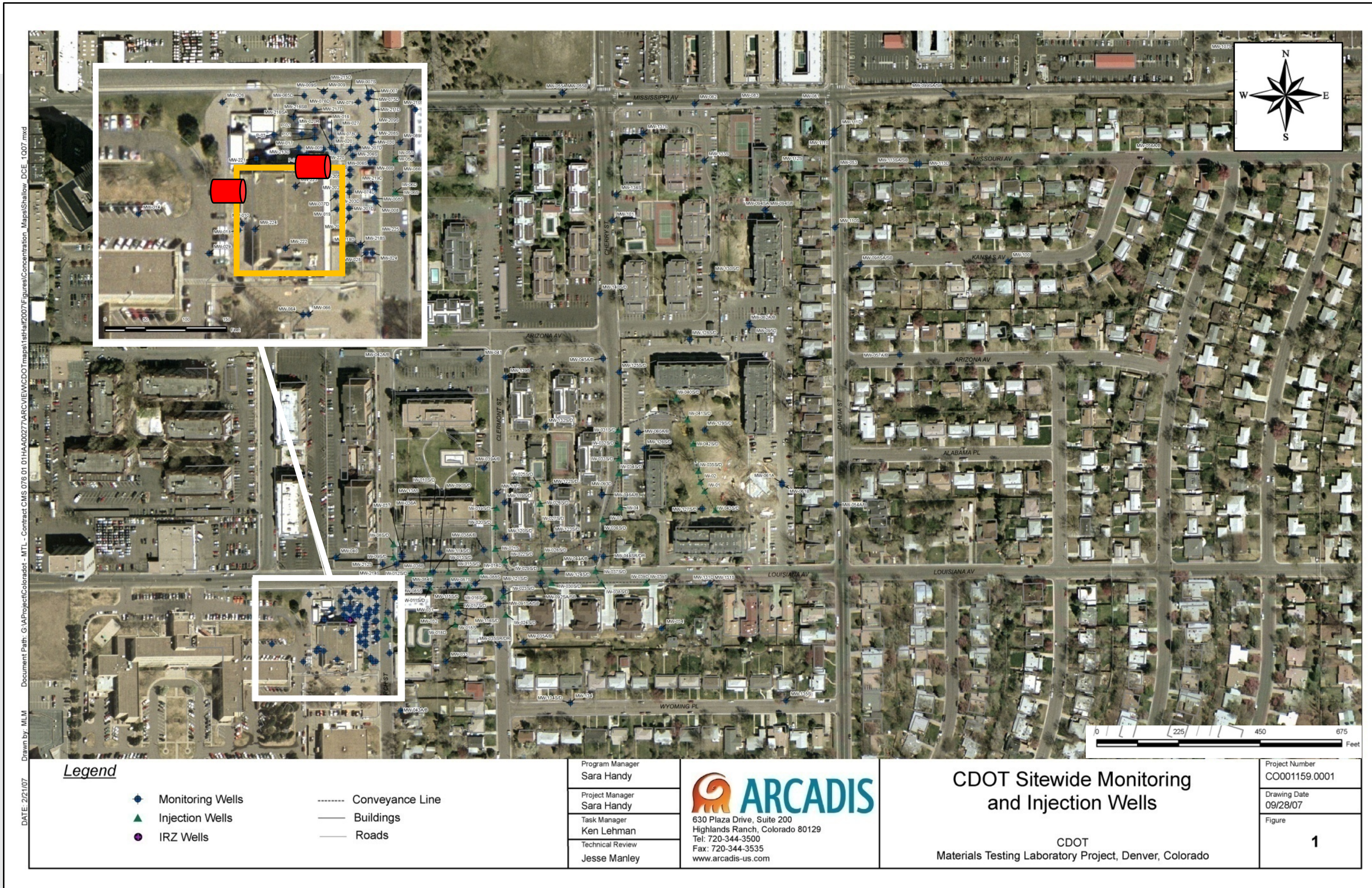
Remediation Technologies Symposium 2008, Banff, Alberta
October 15-17, 2008

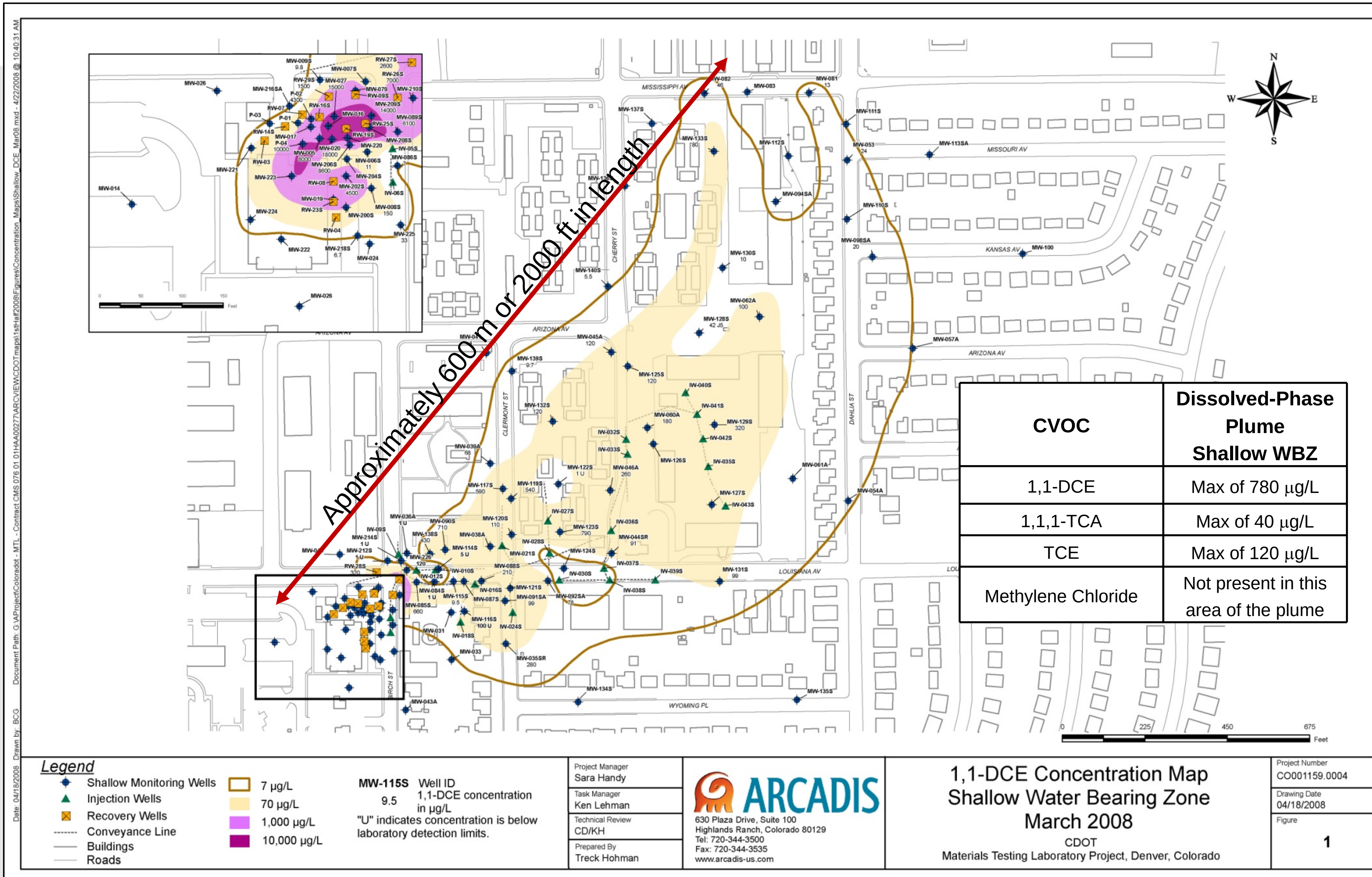
Site History and Conditions

- Materials testing laboratory for the Colorado Department of Transportation (CDOT) from 1957 to 2006
- 2 USTs stored 3 primary solvents (1,1,1-TCA, TCE, and methylene chloride) from 1972 to1987
- CVOCs in groundwater above cleanup goals
- Denver Formation
- WBZs are highly fractured and highly weathered
- Groundwater flow direction is to the north/northeast

Site Plan View



Current Plume Conditions



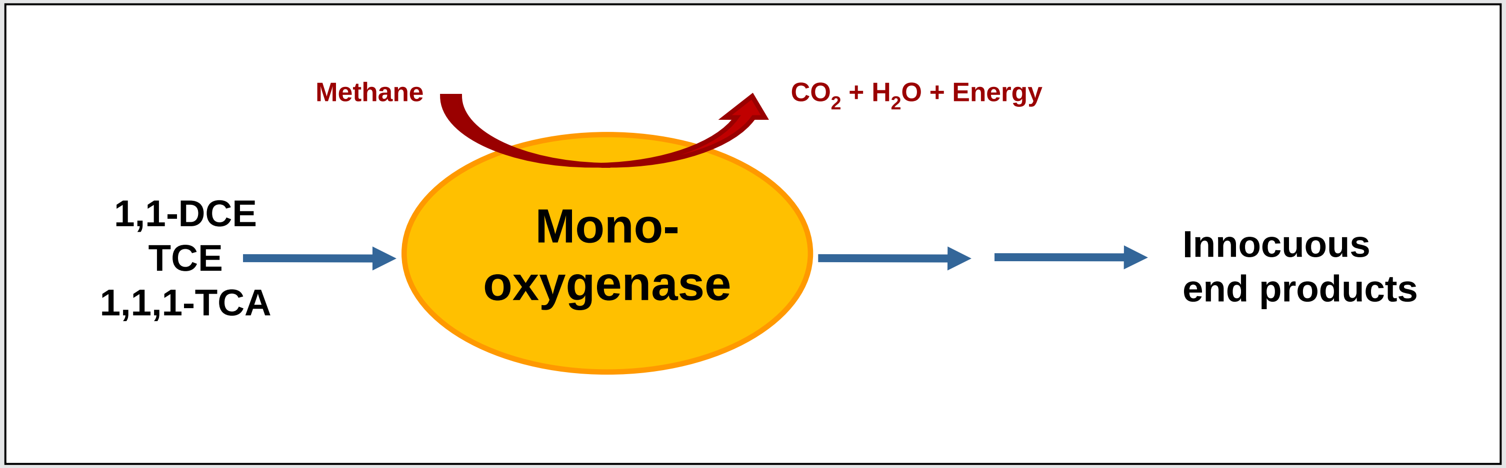
CVOC	Dissolved-Phase Plume Shallow WBZ
1,1-DCE	Max of 780 µg/L
1,1,1-TCA	Max of 40 µg/L
TCE	Max of 120 µg/L
Methylene Chloride	Not present in this area of the plume

Full-Scale Remedy Selection

- Both aerobic and anaerobic enhanced bioremediation strategies were evaluated in the CMS
- Recommendation was to install an aerobic system due to:
  - Concerns about vinyl chloride generation and its potential risk to indoor air; specifically uncertainty of vinyl chloride persistence
  - Indoor air systems were not completely in place at that time

What is Cometabolic Aerobic Biodegradation?

- Occurs when microbial growth is not supported by the target contaminant, but enzymes (i.e. methane monoxygenase [sMMO]) are produced that can destroy the contaminant
- Growth of the methanotrophs must be supported by other electron donors and carbon sources (i.e. methane)

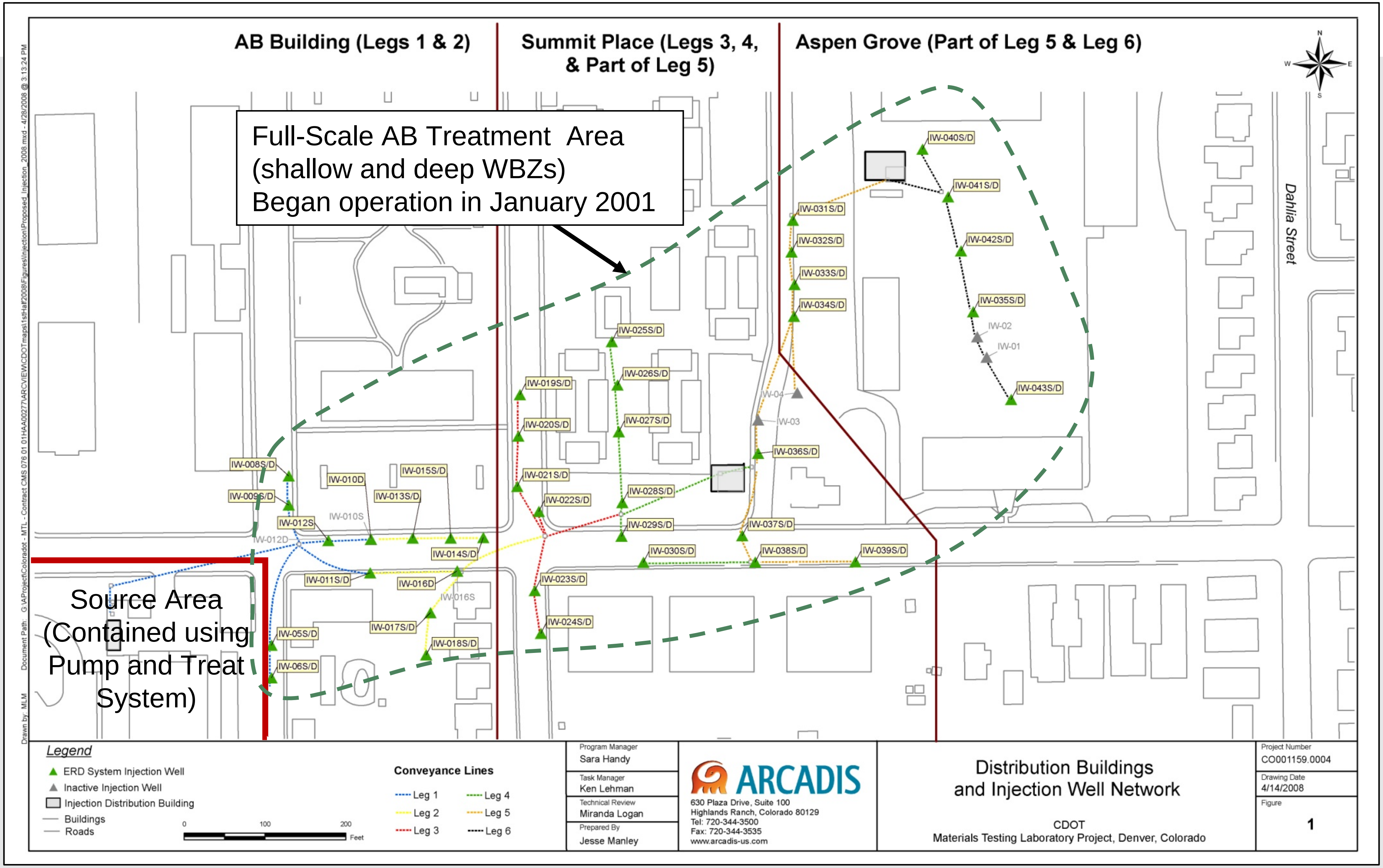


Source: Modified from EPA July 2000 (Modified from McCarty and others 1998)

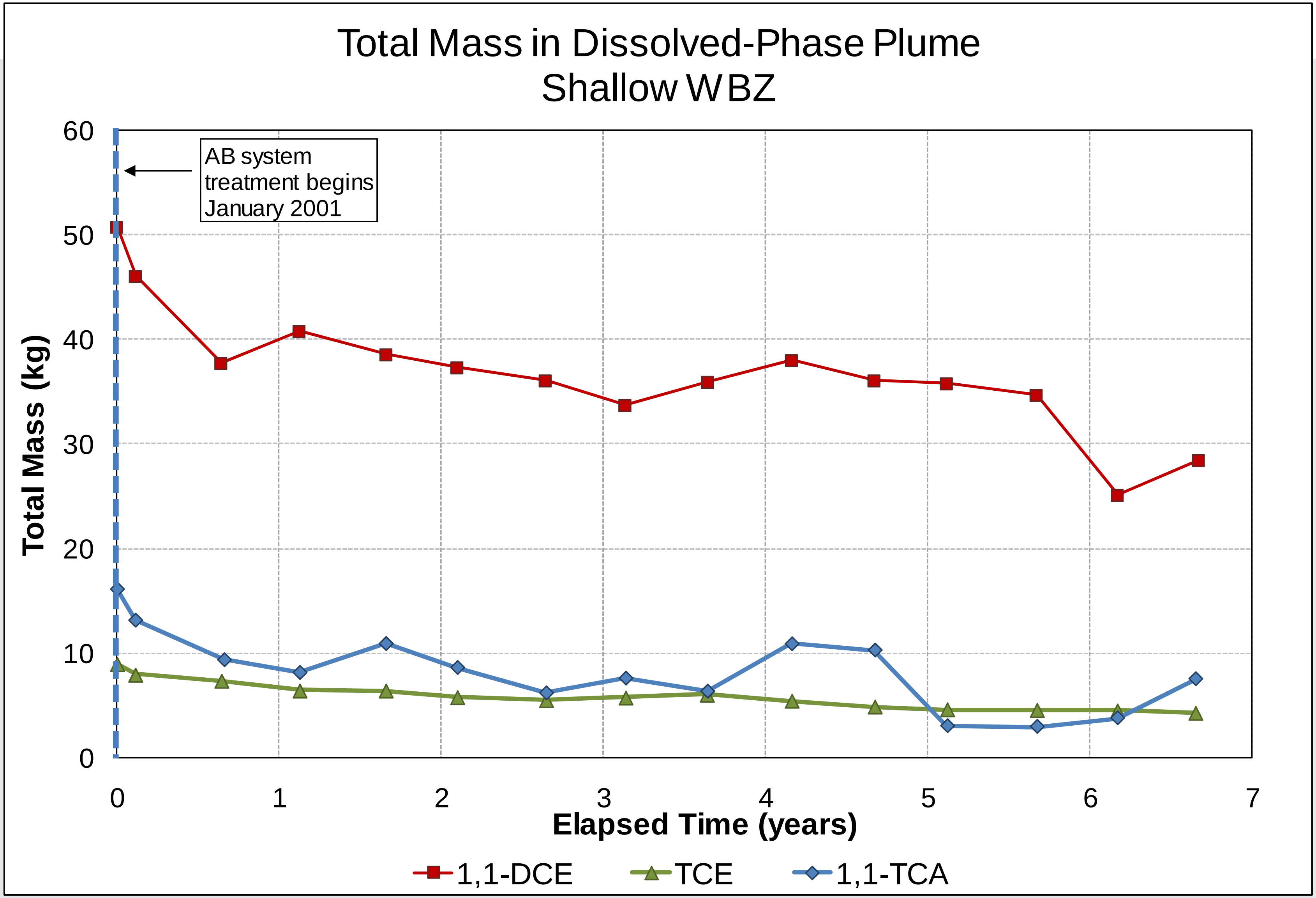
AB System

- Start-up January 2001
- 76 injection wells
- 3 treatment buildings
- Added nutrients
- Methane sparge cabinet with micro-diffusers
- 0.1 - 0.5 gpm per well

AB System Layout



Performance of the AB System



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Results of AB Treatment

- Successful treatment, however, biodegradation rates would not meet site goals despite several efforts to optimize the system
- Contributing challenges:
  - Injectability
  - Short half life of methane limits maximum distribution
  - Solubility of methane
  - Optimal observed performance only had modest treatment rates

Anaerobic Pilot Test: Rationale and Objectives

Rationale

- Potential to meet remedial timeframes
  - Demonstrated performance in same geologic unit
- Reduced concern for vinyl chloride
  - Vinyl chloride is short-lived based on extensive experience since CMS
  - Indoor air systems are in place and proven to be protective

Questions/Objectives

1. Conversion within a reasonable timeframe?
2. Achieve remedial timeframes?
3. Are full-scale lifecycle costs less?

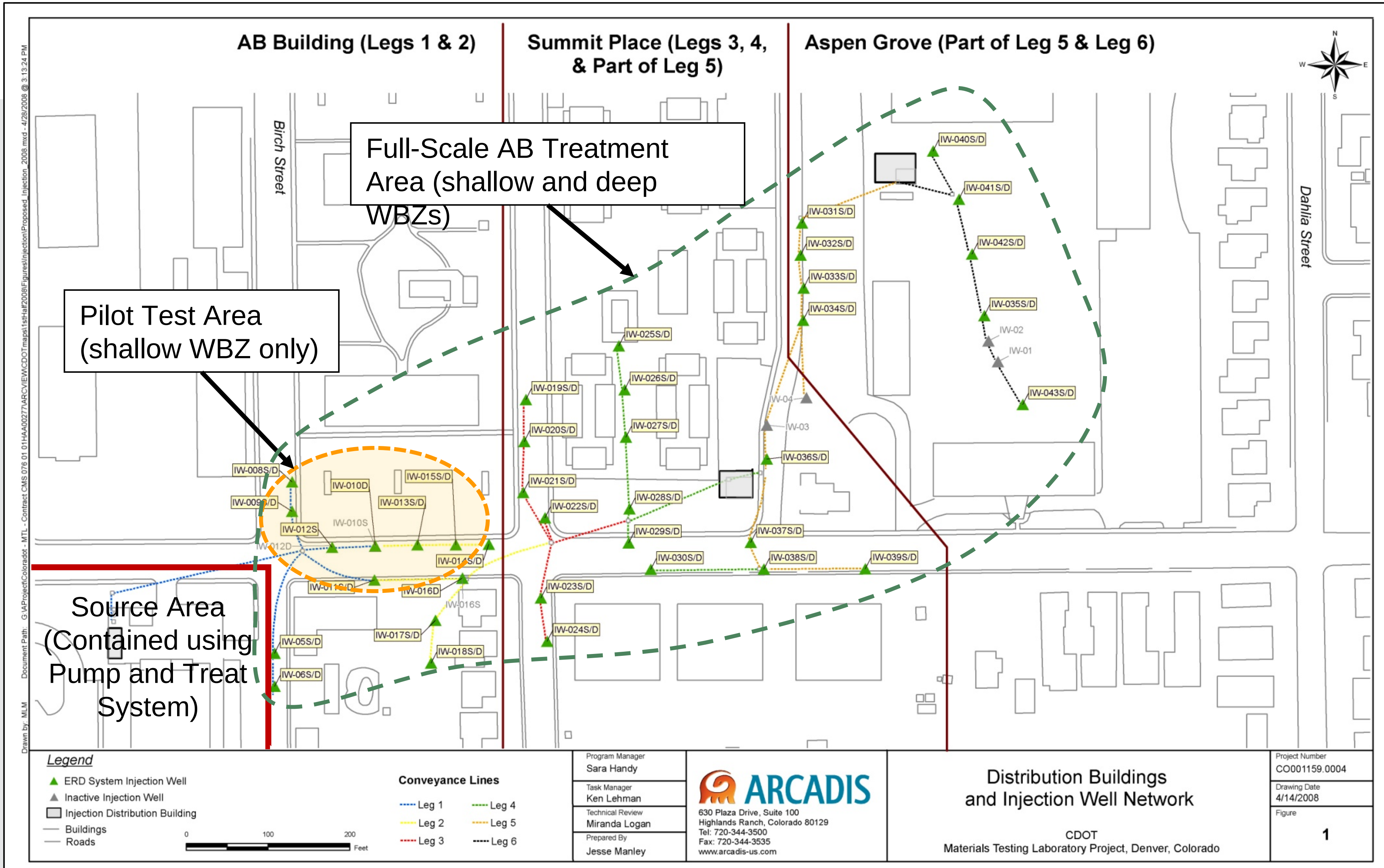
What is Anaerobic Biodegradation?

- Enhanced reductive dechlorination (ERD)
- Occurs under anaerobic conditions
- Chlorine atoms are sequentially replaced with hydrogen atoms
- Hydrogen is supplied through the fermentation of the carbon source (i.e. molasses)

1,1-DCE → Vinyl Chloride → Ethene

TCE → 1,2-DCE → Vinyl Chloride → Ethene

1,1,1-TCA → 1,1-DCA → Chloroethane → Ethane


AB Building (Legs 1 & 2)
Summit Place (Legs 3, 4, & Part of Leg 5)
Aspen Grove (Part of Leg 5 & Leg 6)
Full-Scale AB Treatment Area (shallow and deep WBZs)
Pilot Test Area (shallow WBZ only)
Source Area (Contained using Pump and Treat System)
Birch Street
Dahlia Street
IW-008S/D
IW-009S/D
IW-010D
IW-010S
IW-012S
IW-012D
IW-013S/D
IW-014S/D
IW-015S/D
IW-016D
IW-016S
IW-017S/D
IW-018S/D
IW-05S/D
IW-06S/D
IW-019S/D
IW-020S/D
IW-021S/D
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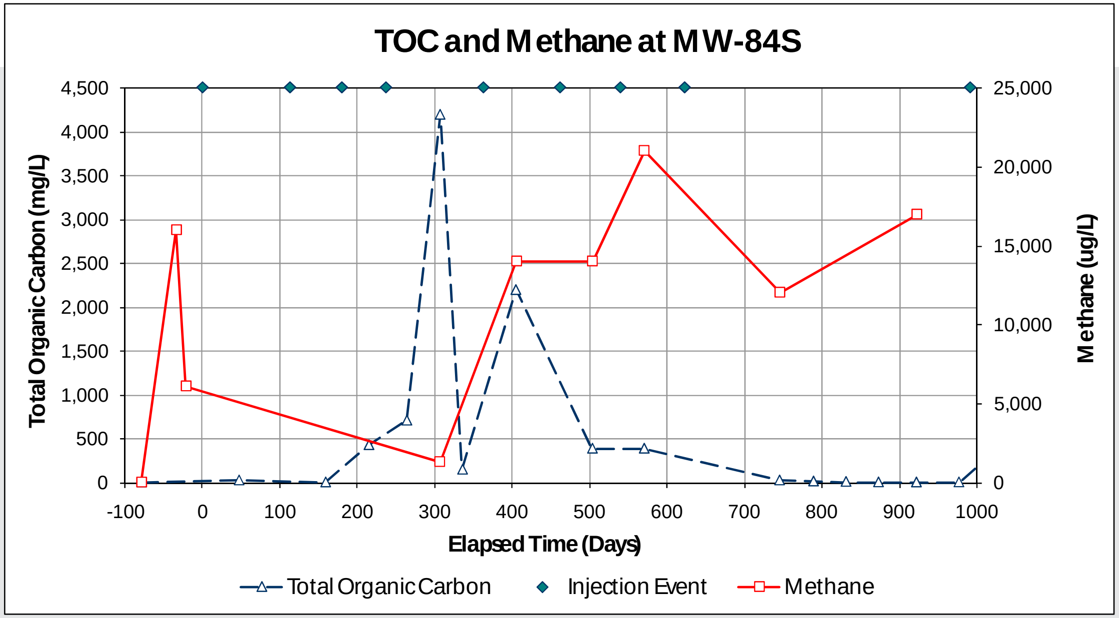
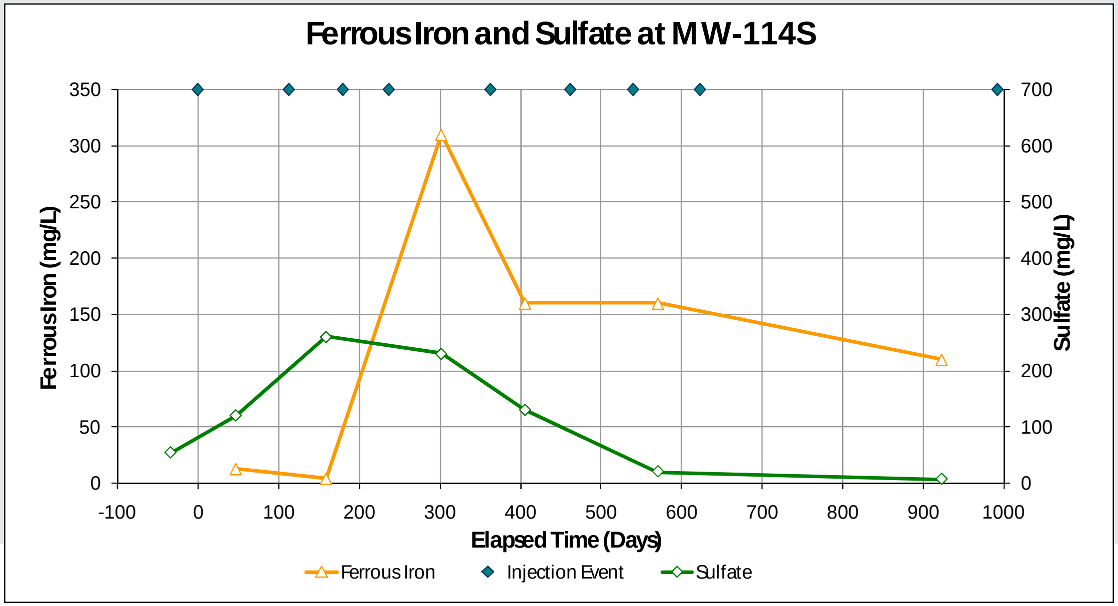
IW-034S/D
IW-036S/D
IW-037S/D
IW-038S/D
IW-039S/D
IW-040S/D
IW-041S/D
IW-042S/D
IW-035S/D
IW-043S/D
IW-01
IW-02
IW-03
IW-04
Legend
ERD System Injection Well
Inactive Injection Well
Injection Distribution Building
Buildings
Roads
0
100
200
Feet
Conveyance Lines
Leg 1
Leg 2
Leg 3
Leg 4
Leg 5
Leg 6
Program Manager
Sara Handy
Task Manager
Ken Lehman
Technical Review
Miranda Logan
Prepared By
Jesse Manley
ARCADIS
630 Plaza Drive, Suite 100
Highlands Ranch, Colorado 80129
Tel: 720-344-3500
Fax: 720-344-3535
www.arcadis-us.com
Distribution Buildings and Injection Well Network
CDOT
Materials Testing Laboratory Project, Denver, Colorado
Project Number
CO001159.0004
Drawing Date
4/14/2008
Figure
1

Geochemical Parameters of Key Pilot Wells





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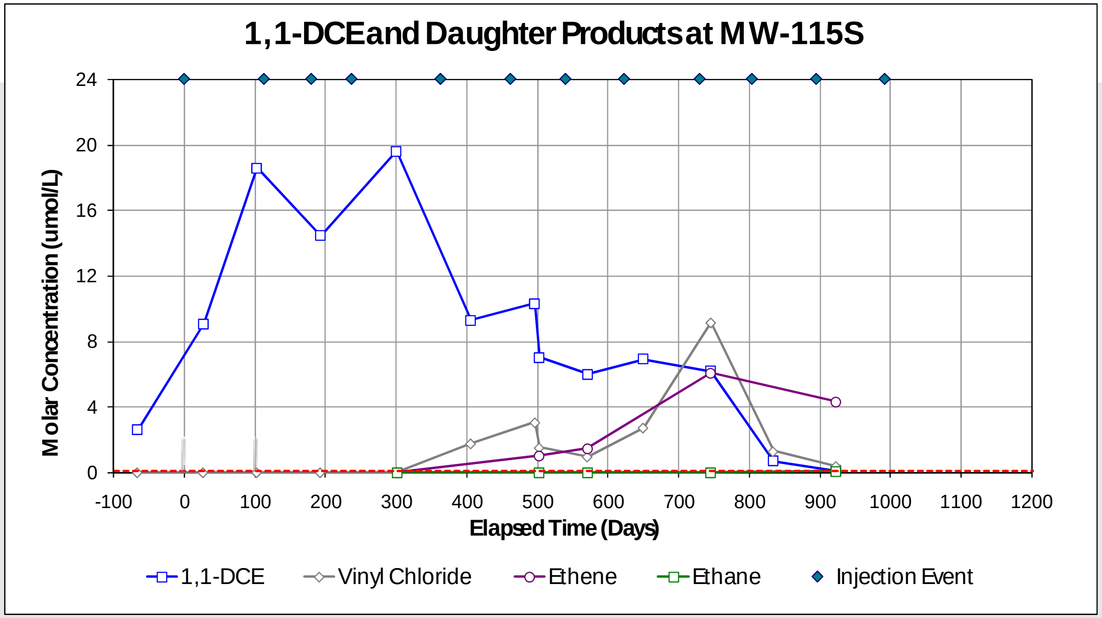
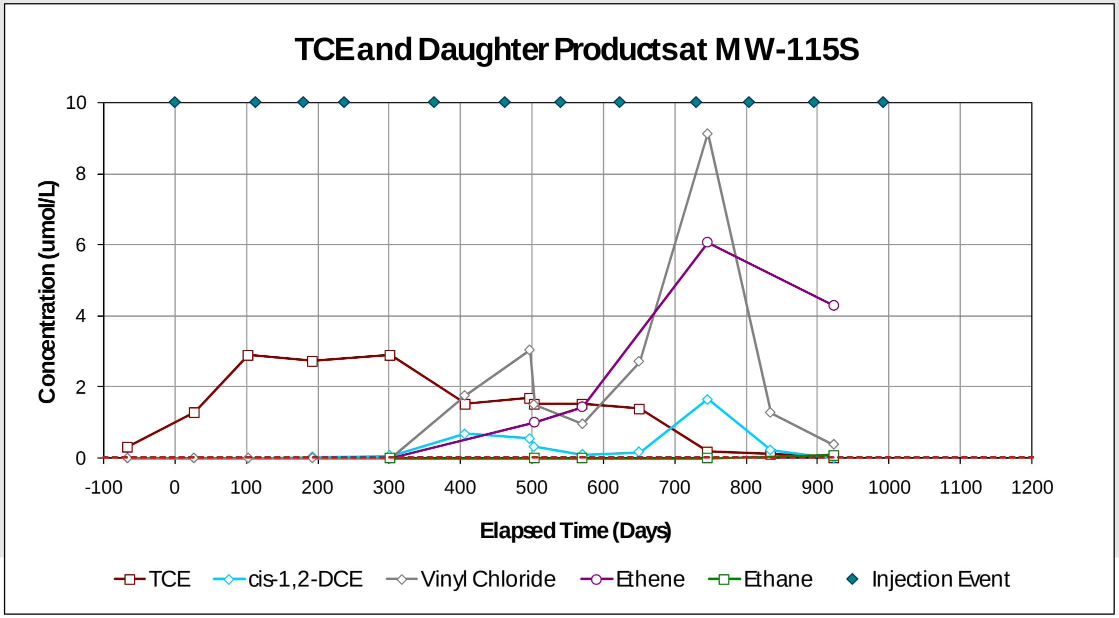
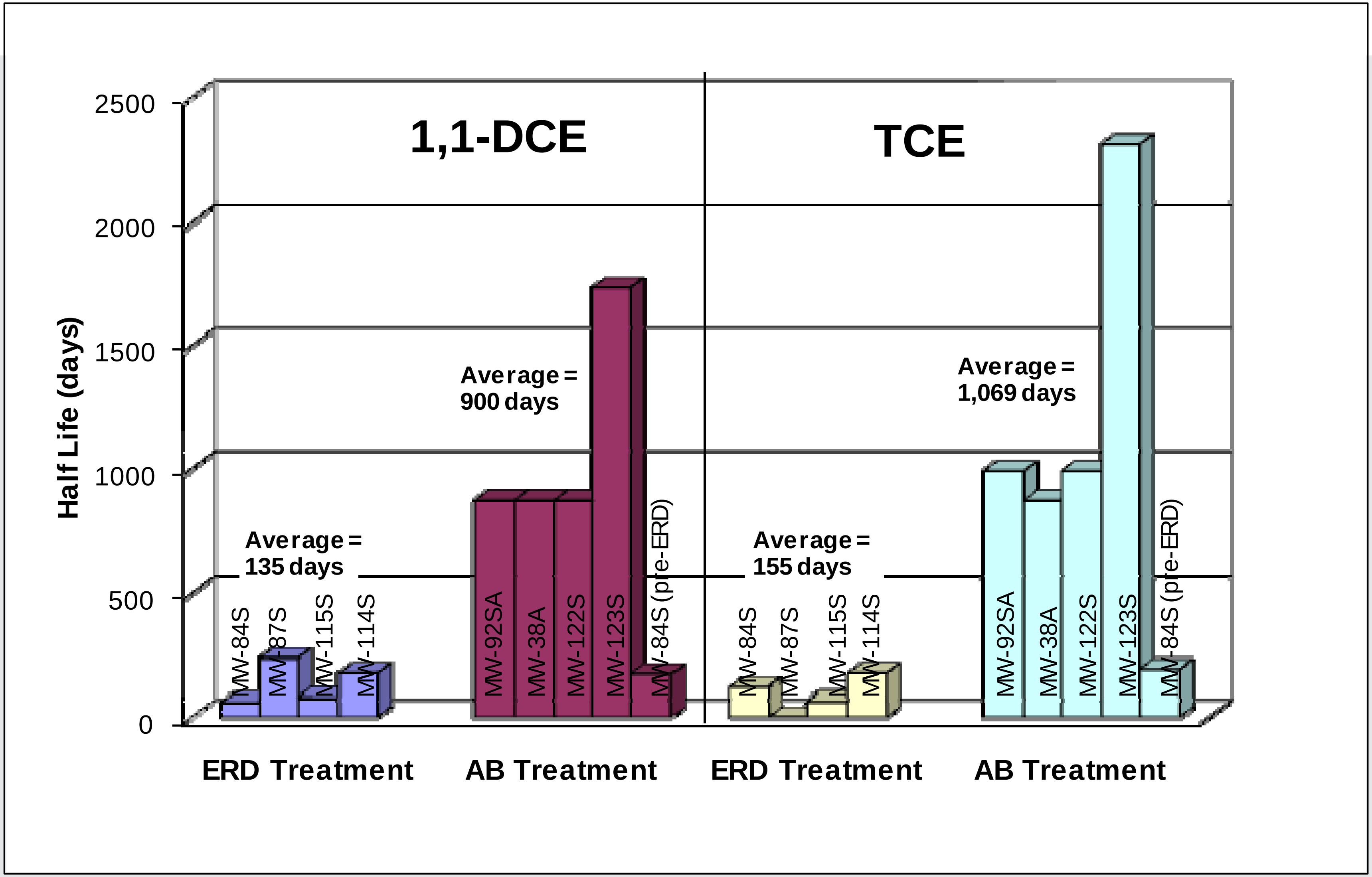
Dechlorination Trends





Half Life Comparison



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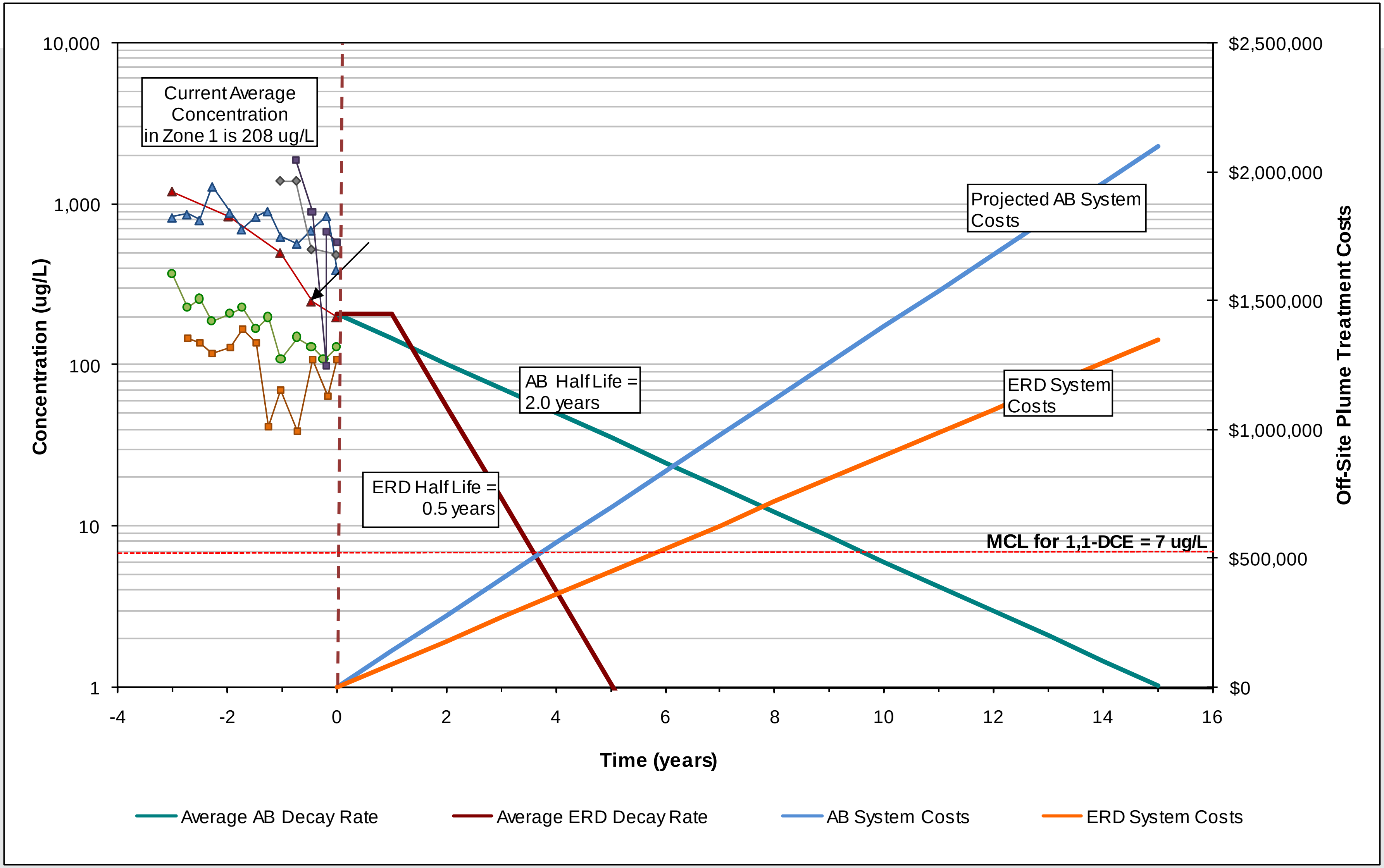
Pilot Test Results

- Achieved anaerobic conditions in 7-10 months in the test area
  - Only 3-4 month lag time compared to other sites in same geologic unit
- Full dechlorination at all wells
- Treatment goals achieved at 5 of 6 wells
- Half-lives are approximately 5 times faster

Projected Treatment Times and Costs



Path Forward

- Full-scale system converted in August 2008
  - Modifications and upgrades made to automate injection
- Anticipated operation is 3 to 5 years

Imagine the result

Questions?