



European Remediation Technologie

*Let us do it
together!*

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www.e-r-t.net



European Remediation Technologies

- **Established in August 2003**
- **100% active since April 2005**
- **Niche player on European level concerning :**
 - **ISCO : Fenton's and permanganate**
 - **CAP18[®] en CAP18-ME[®], vegetable oils for anaerobic bioremediation, whereby ERT exclusive European supplier is**
 - **CAPISCO[™] process : turn key projects**





**Used as anaerobic biobarriers
for VOCs**



European Remediation Technology

Content

- **What are CAP18[®] and CAP18-ME[®]?**
- CAP18[®] biobarrier reference projects

Topics

- How CAP18® Works

- What is CAP18®
- Composition
- Hydrolysis
- Beta oxidation
- Inhibition of methane production

- CAP18® Advantages

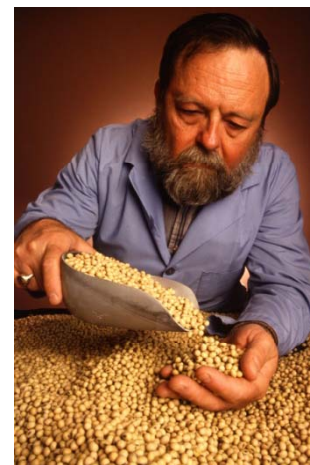
- Lower cost
- Easier application
- Better hydrogen efficiency
- Very long lifetime

- CAP18® Disadvantages

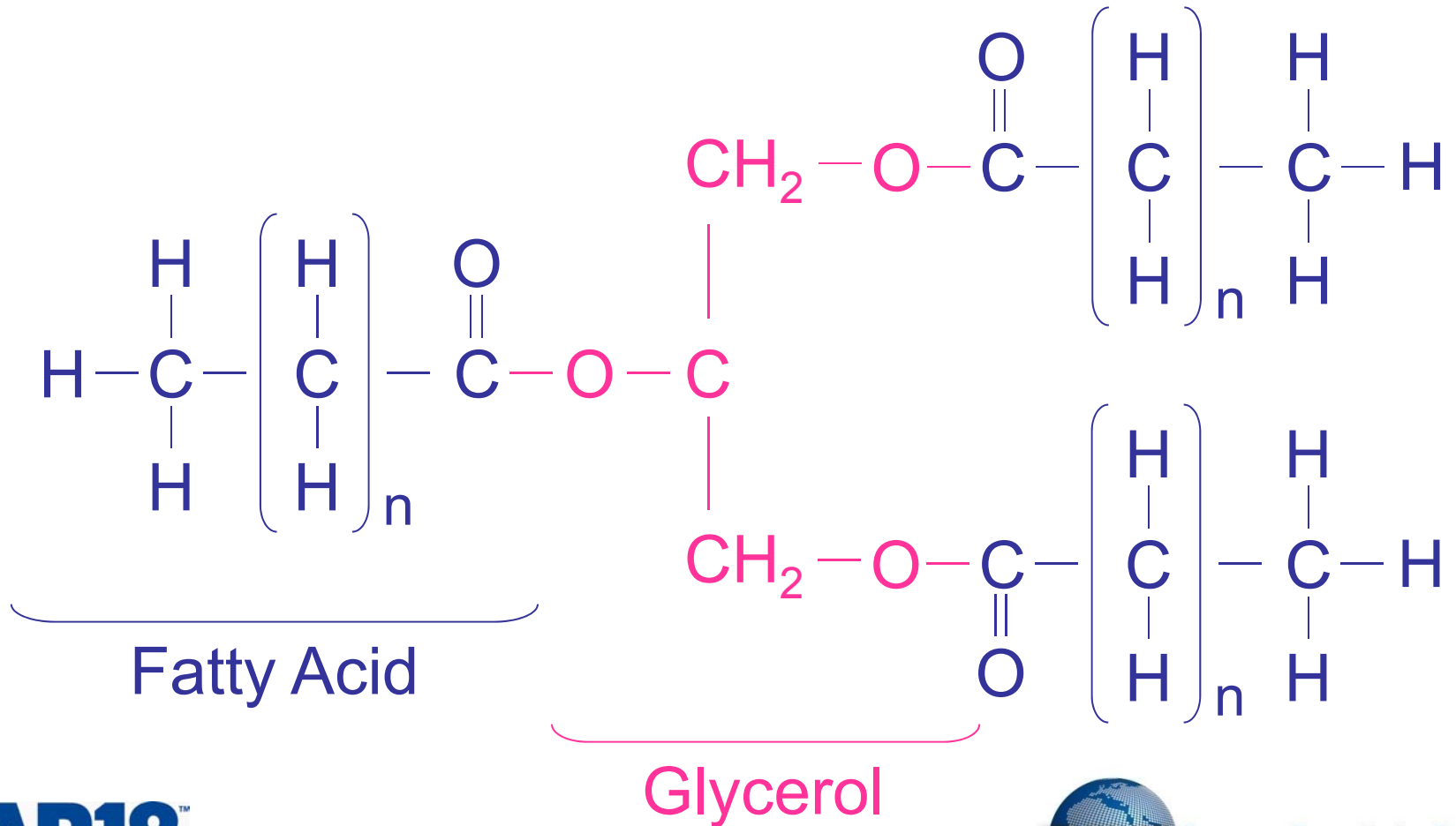
- Hard water

What is CAP18®

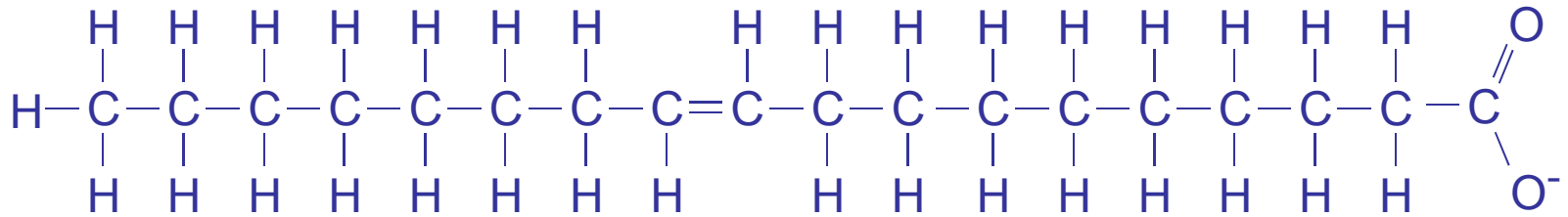
- Food-grade, slightly viscous liquid
- Refined from natural vegetable oil
- Specifically designed for bioremediation
 - Chlorinated solvents (PCE, TCE, TCA)
 - Nitrate, Explosives & Perchlorate
- Concentrates the C18 unsaturated fatty acids



Vegetable Oils are Comprised of Triacylglycerols

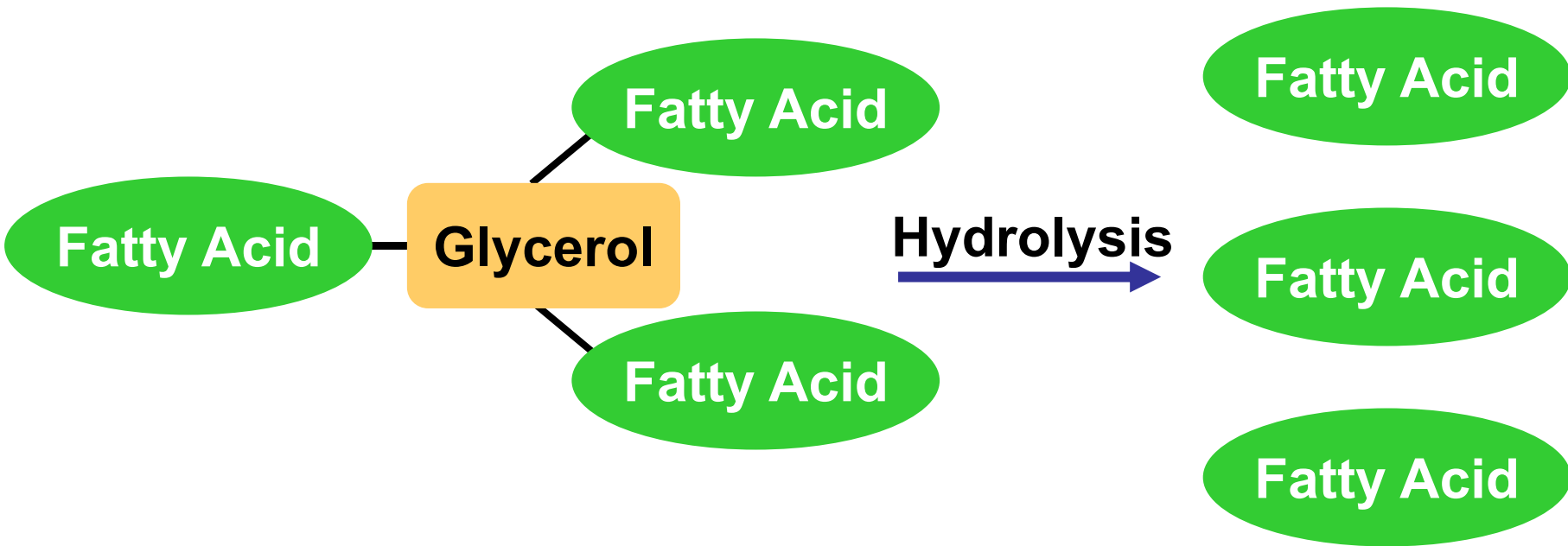


CAP18® Fatty Acids are Primarily C-18 Unsaturated Acids

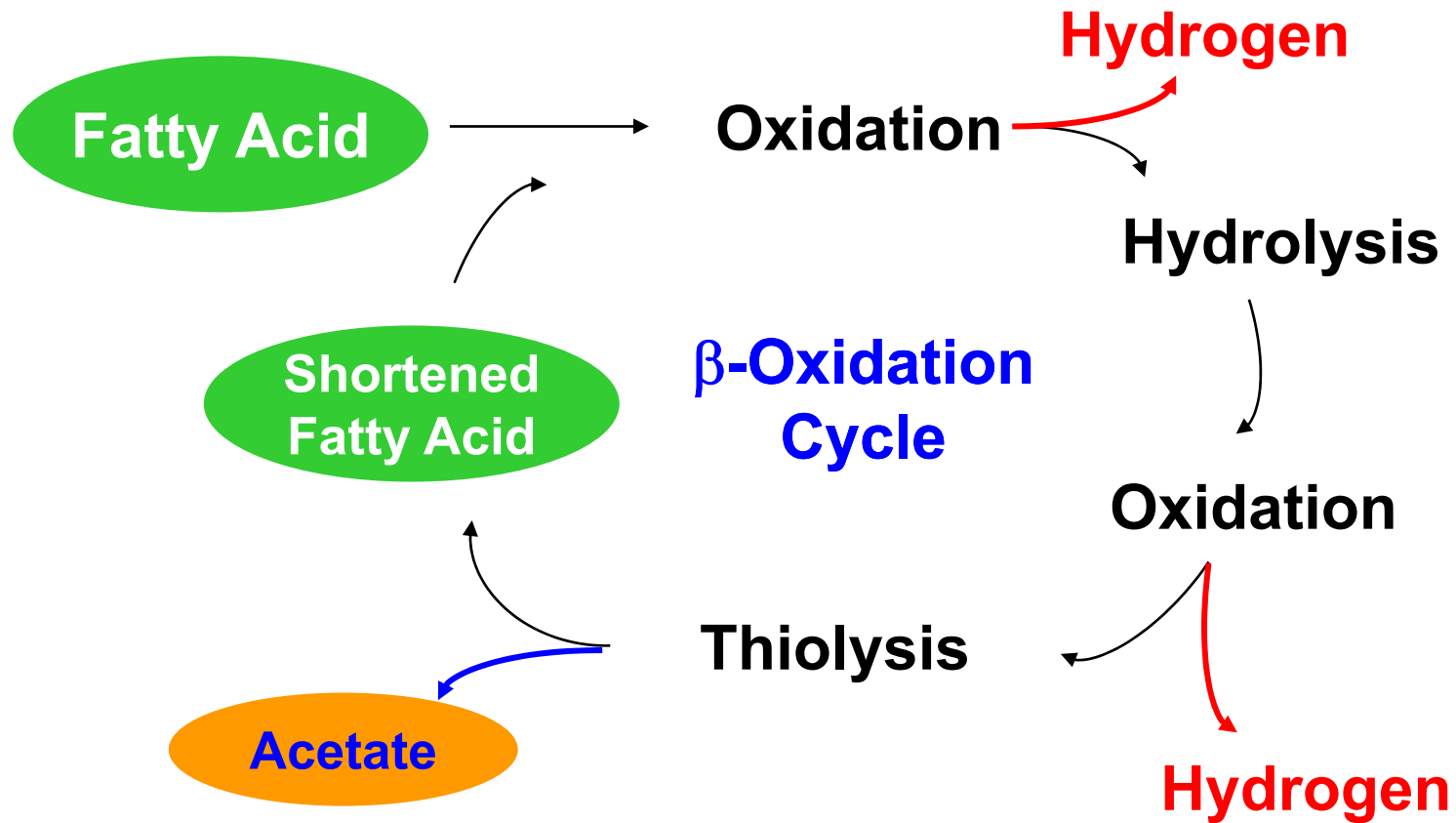


Oleic Acid (C18:1)

In Aquifers, the Triacylglycerols Hydrolyze to Release Free Fatty Acids

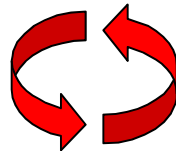
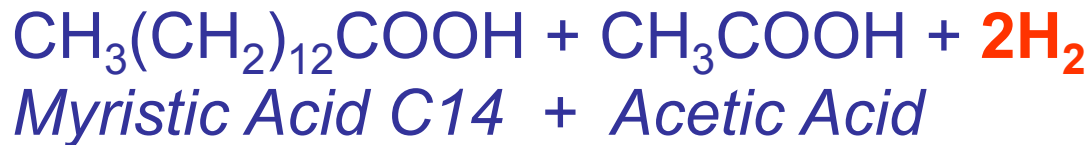
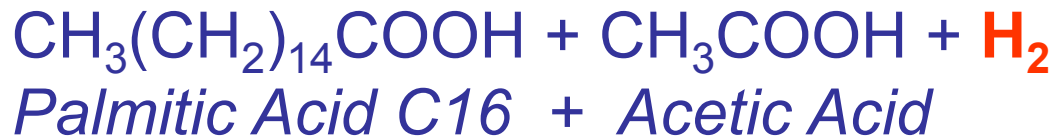
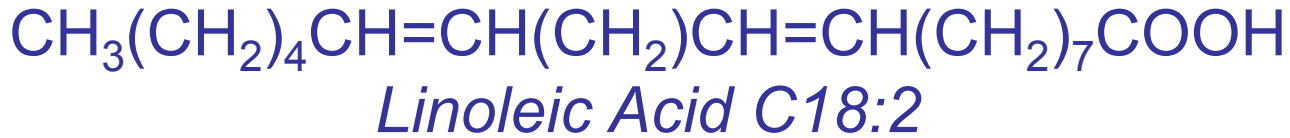


Fatty Acids are Metabolized by Beta (β) Oxidation



Ultimate Production: 13-17 H₂ (26-34 electrons)

β -Oxidation



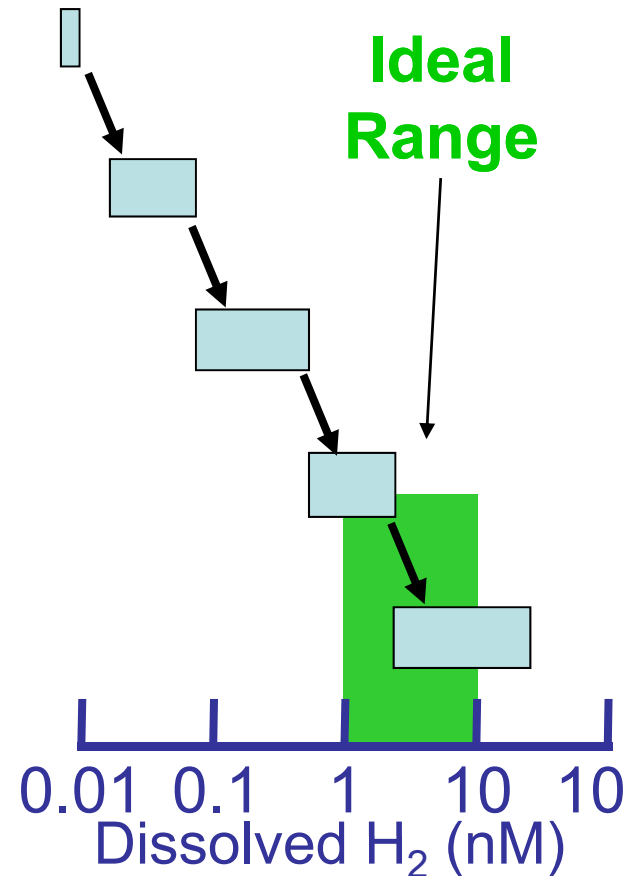
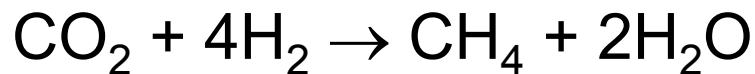
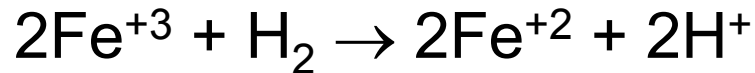
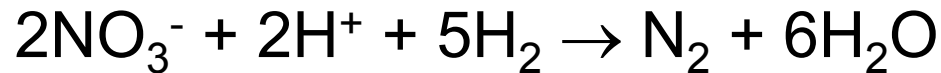
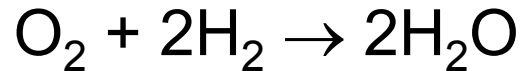
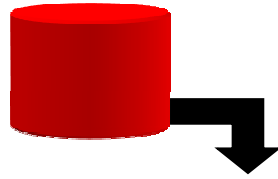
6 Additional Cycles



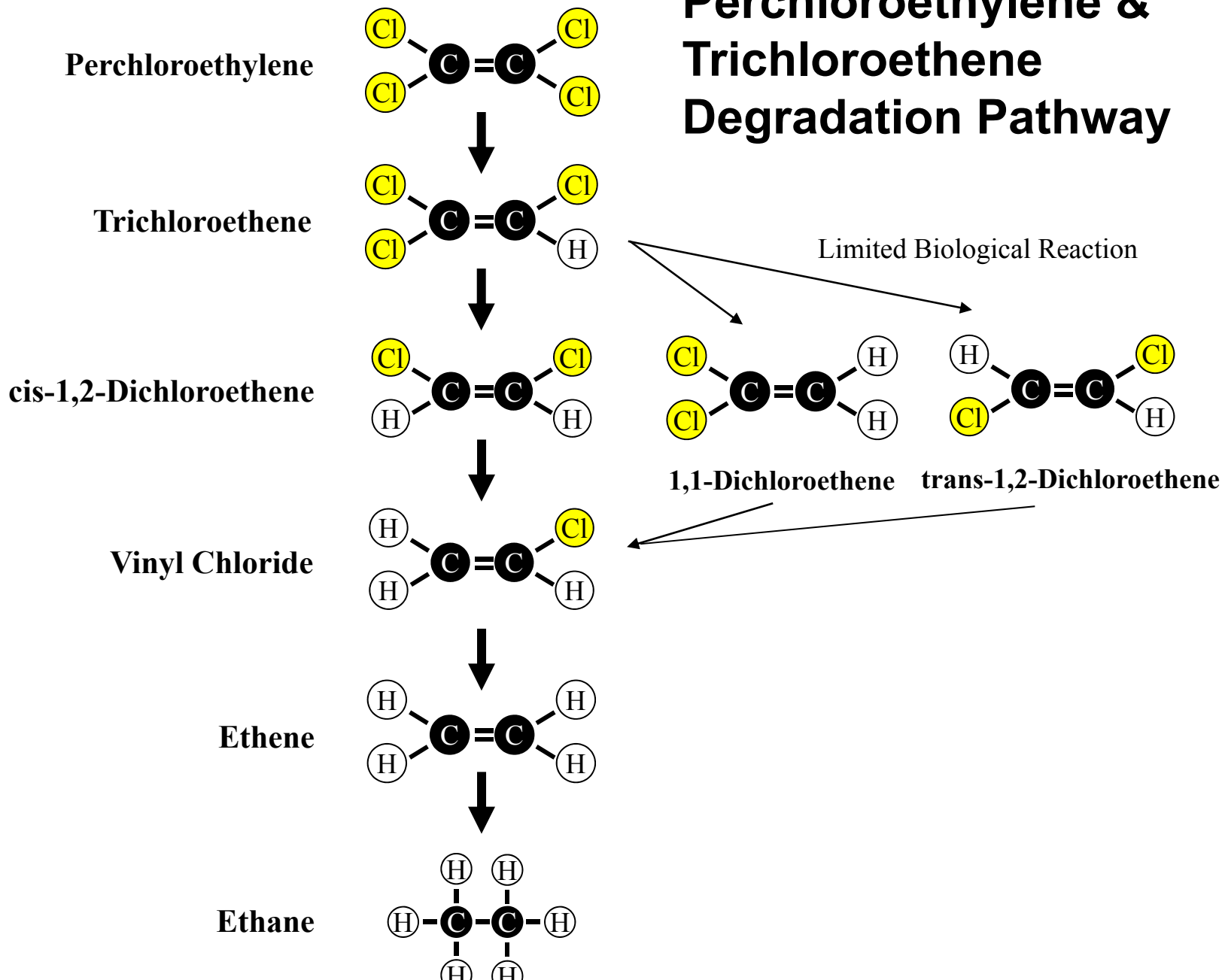
Ultimate Production: 9 molecules of Acetic Acid
15 molecules of H_2

“Footrace for Hydrogen”








Hydrogen
Reservoir



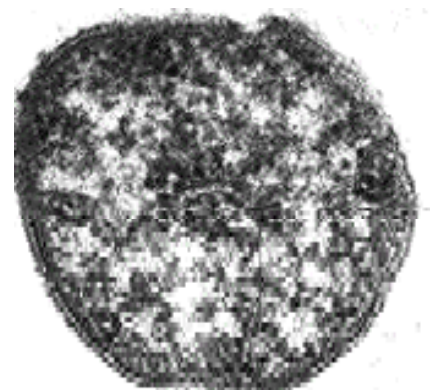
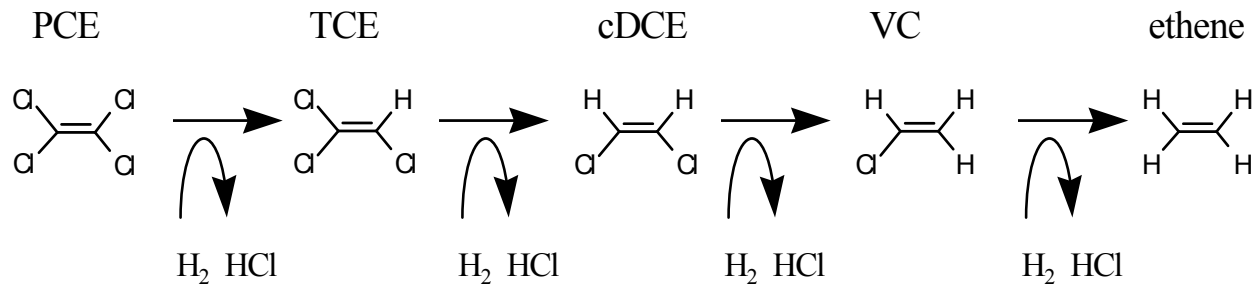
Perchloroethylene & Trichloroethene Degradation Pathway



All Bacteria are Not the Same

<u>Bacterial species</u>	PCE	TCE	DCE	VC	Ethene
<i>Dehalococcoides</i>					
<i>Dehalospirillum</i>					
<i>Desulfuromonas</i>					
<i>Dehalobacter</i>					
<i>Desulfitobacterium</i>	 				
<i>Desulfomonile</i>					

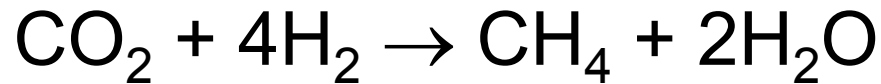
Dehalococcoides ethenogenes Maymó-Gatell *et al.* 1997 Science 276:1568-1571



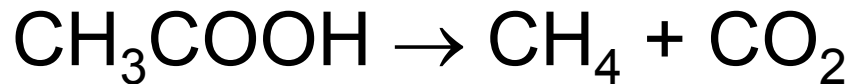
Methanogenesis

Two Pathways

Hydrogenotrophic Methanogenesis



Aceticlastic Methanogenesis



Responsible for 65-80% of Methane Production
INHIBITED BY C18:1 AND C18:2 FATTY ACIDS

Topics

- How CAP18® Works
 - Composition
 - Hydrolysis
 - Beta oxidation
 - Inhibition of methane production
- CAP18® Advantages
 - Easier application
 - Lower cost
 - Better hydrogen efficiency
 - Very long lifetime
- CAP18® Disadvantages
 - Hard water

CAP18[®] is Easier to Apply

Ease of
Application

CAP18[®]

Lactate

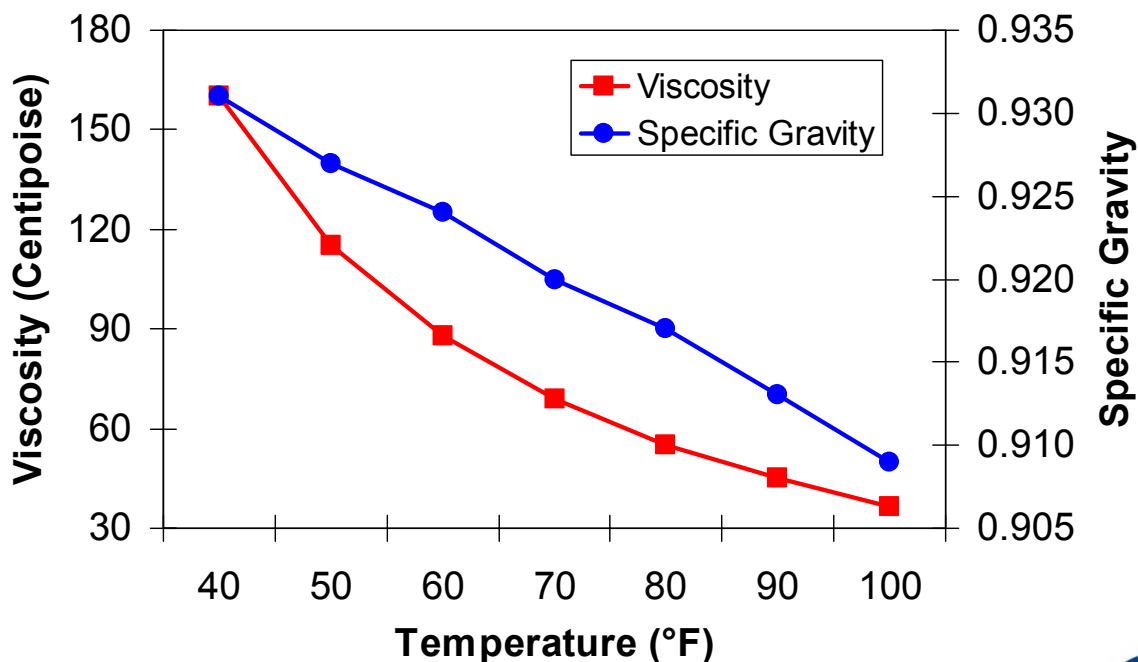
Molasses

Polylactates

No Heating
No Recirculation
No Emulsification

Recirculation
Multiple Injections

High Pressure
Viscous
Needs Heating





EVV215 60

MIL LABO EVV LA2

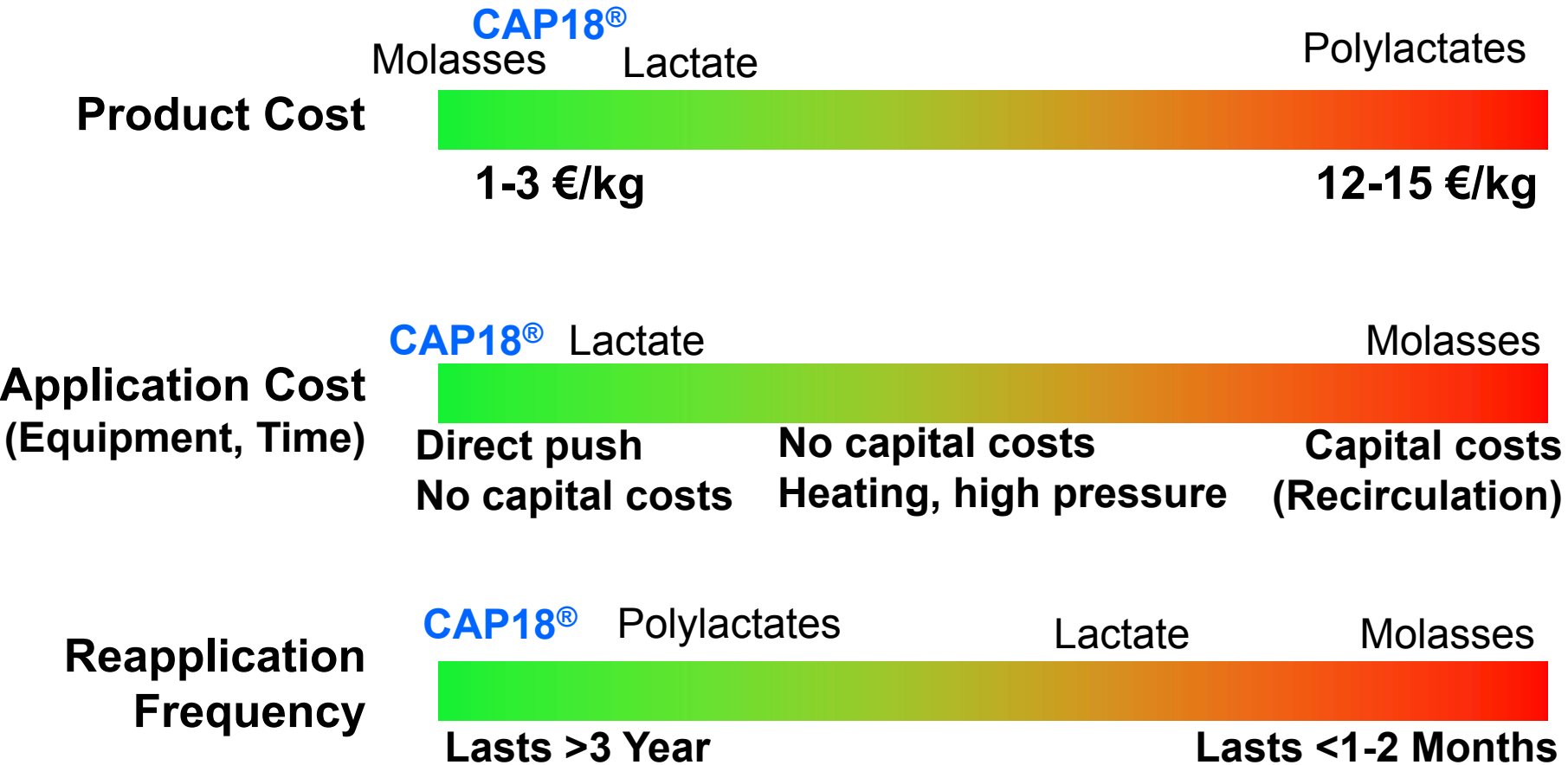
Cap18
Fijne deeg
DB



E.R.T.
Environmental Remediation Technologies
www.e-rt.net



CAP18[®] is More Cost Effective

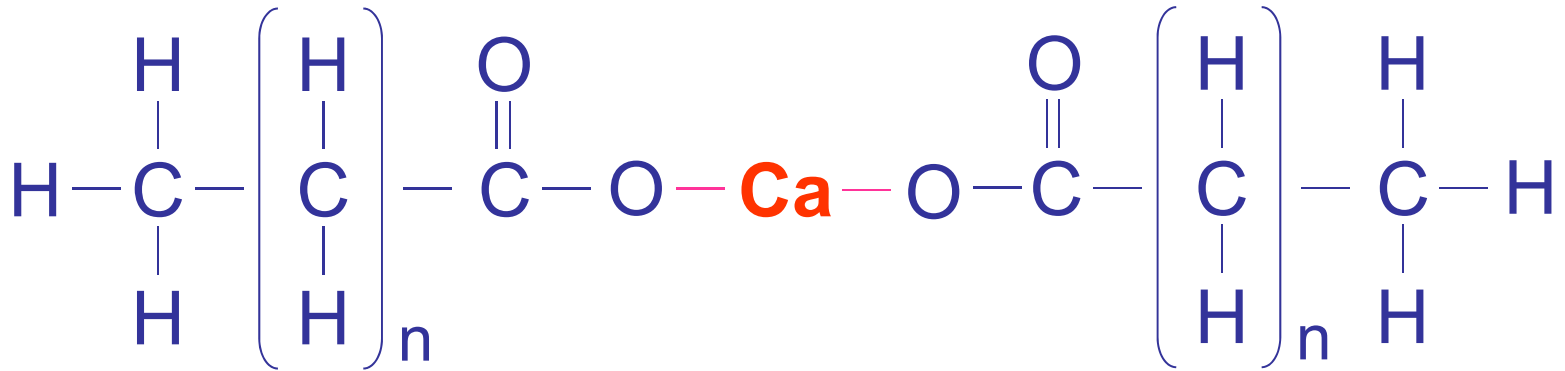


Topics

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 - Hard water

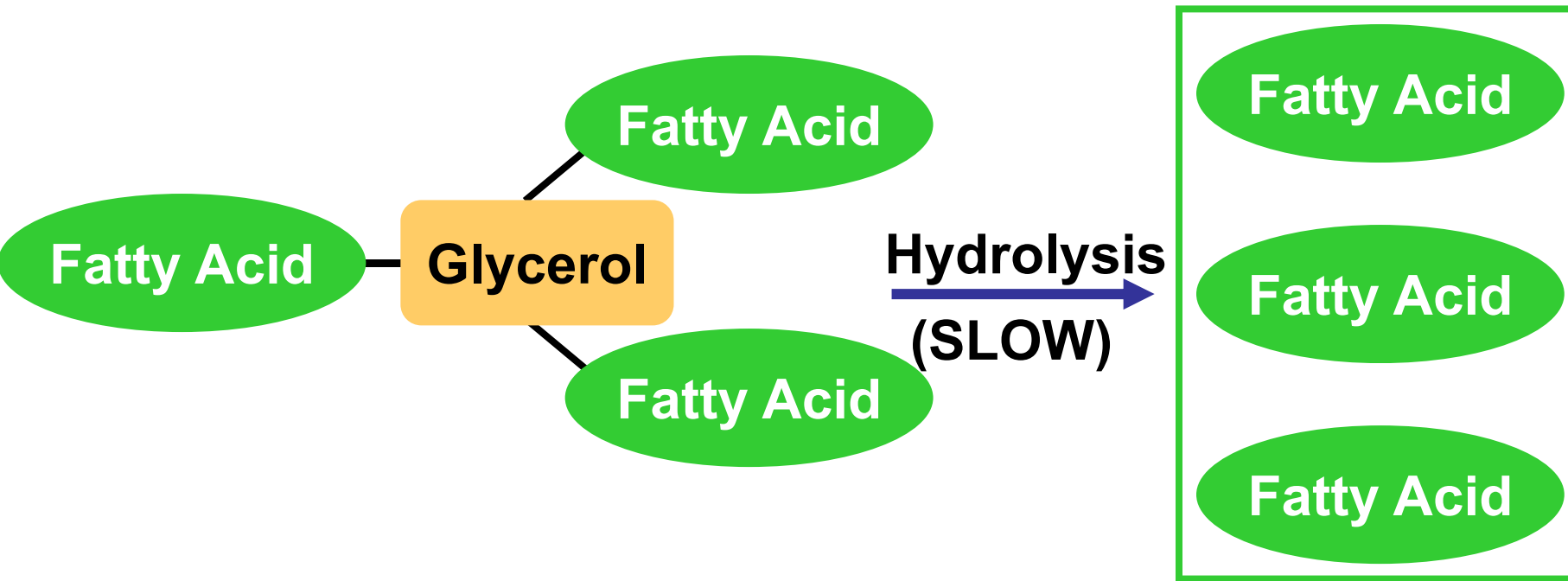
Calcium Precipitation

*Same effect that hard water has on soap & detergent
soap scum formation – insoluble precipitate*



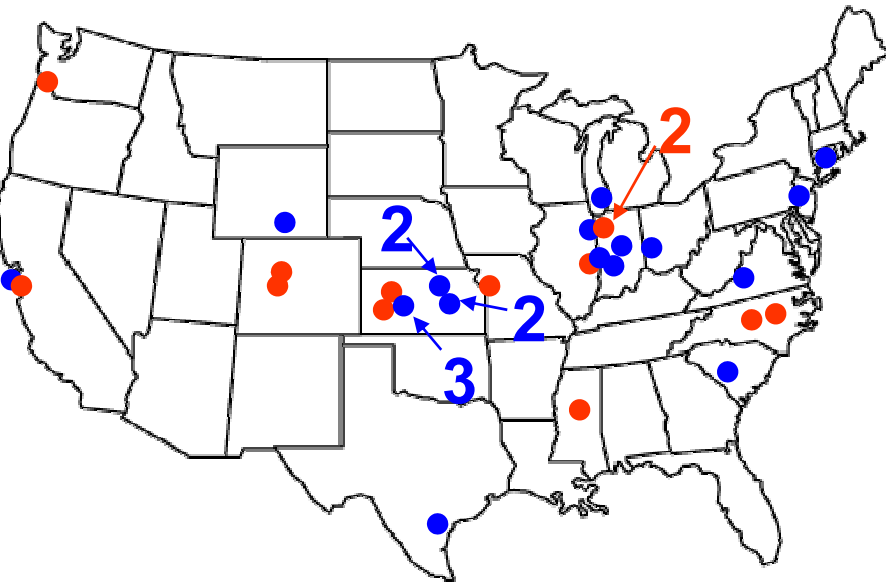
CALCIUM OLEATE

What is CAP18-ME®?



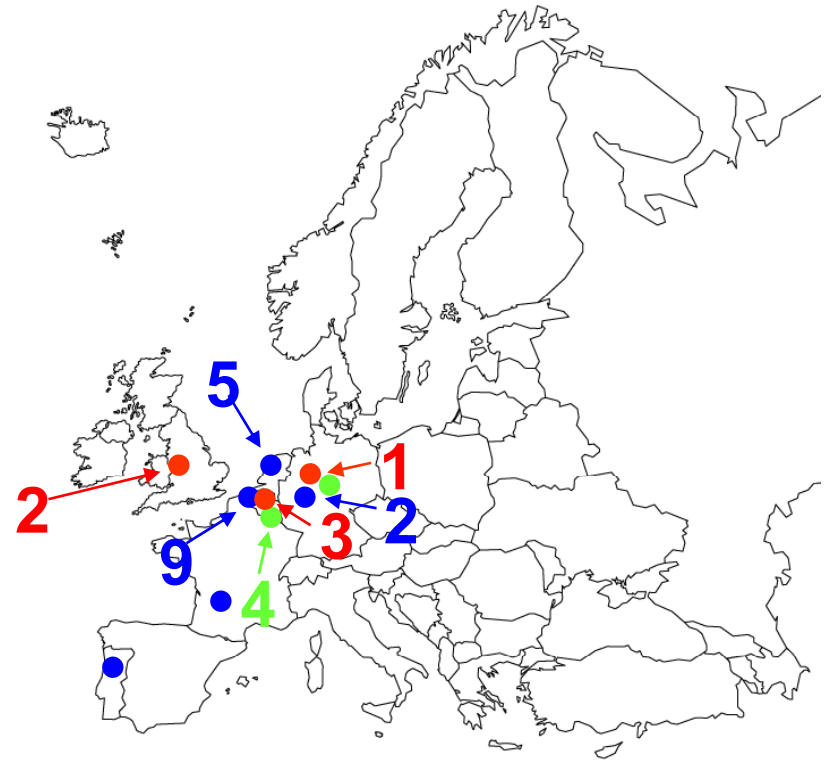
- Limitation of CAP18® is slow initial release
- Addition of methyl esters of fatty acids
- Provides fatty acids immediately to microbes
- Preserves long lifetime of CAP18®

Completed Sites



U.S.:
34 completed

- CAP18®
- CAP18-ME®
- Planned



Europe:
22 completed

TOPICS

- What are CAP18[®] and CAP18-ME[®]?
- **CAP18[®] biobarrier reference projects**

Reference projects

- **CAP18® biobarrier project in Haute-Garonne(F)**
- **CAP18® biobarrier project in Kansas(USA)**
- **CAP18® biobarrier project in Santa Clara(USA)**
- **CAP18®-biobarrier project in East-Flanders(B)**

CAP18[®] biobarrier project Haute Garonne(F)

Site specific conditions :

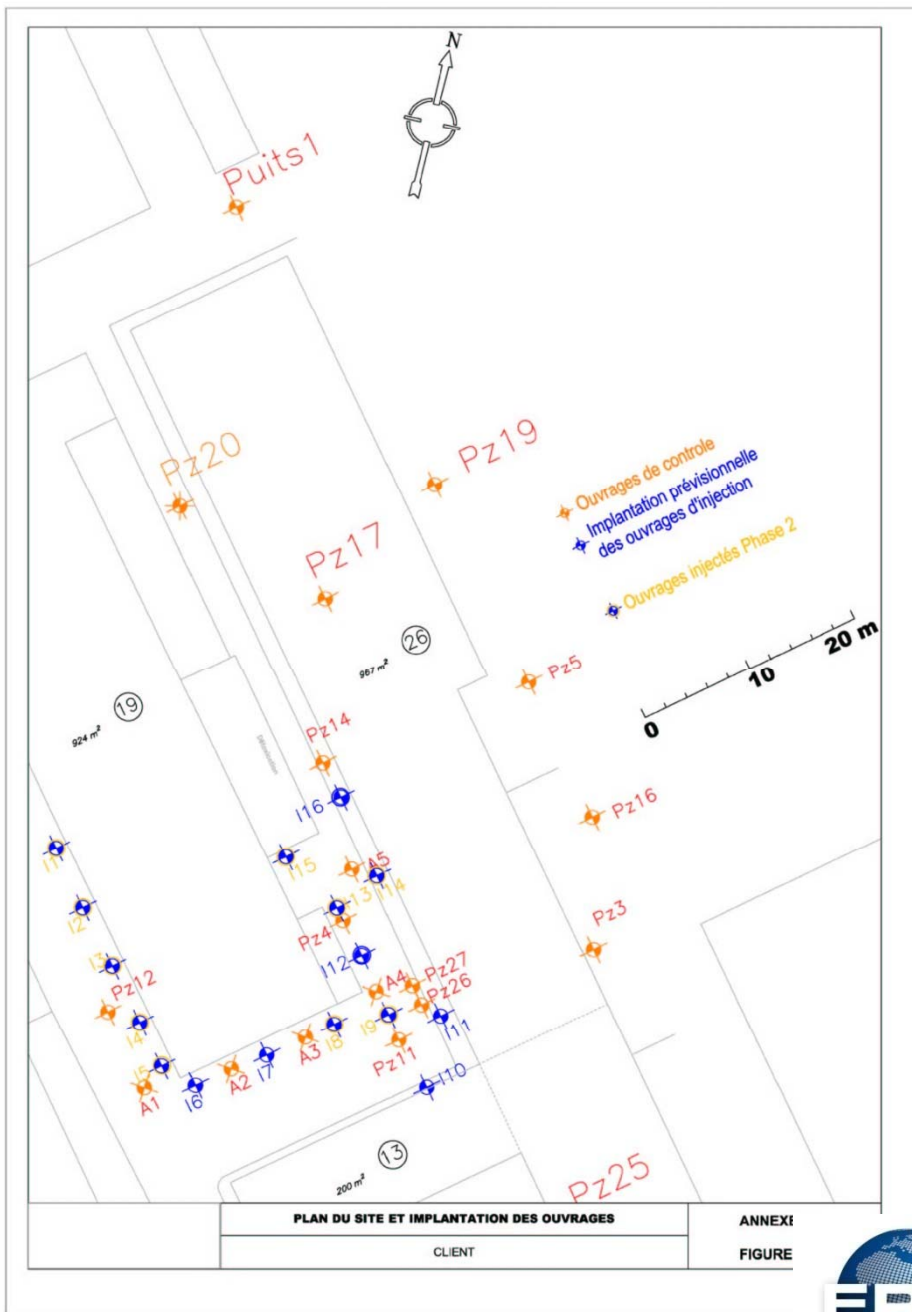
- ***Pollution*** : VOCs, maximum concentrations :
 - PCE = 250 µg/L
 - TCE = 3.600 µg/L
 - Cis = 520 µg/L
 - VC = 10 µg/L
- ***Geology*** : sand with big boulders
- ***Aquitard*** : rock layer at ca.5,5 m-bg
- ***Groundwater*** : ca.3,5 m-bg
- ***Groundwater permeability*** : 10 m/day!!!
- ***Groundwater direction*** : W to NE and SE

CAP18[®] biobarrier project Haute Garonne(F)

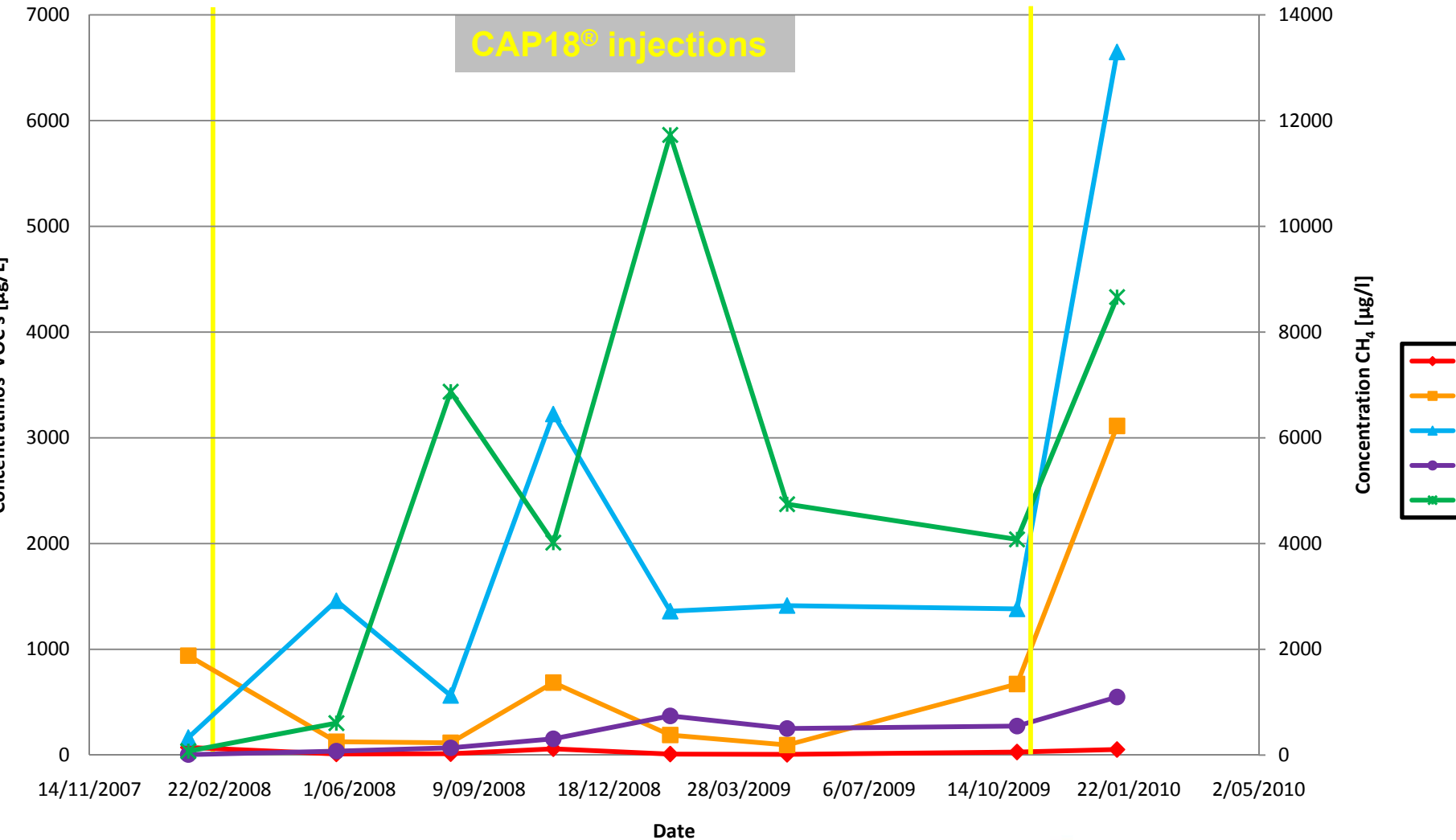
CAP18[®] approach :

CAP18[®] injections via FIXED injectors :

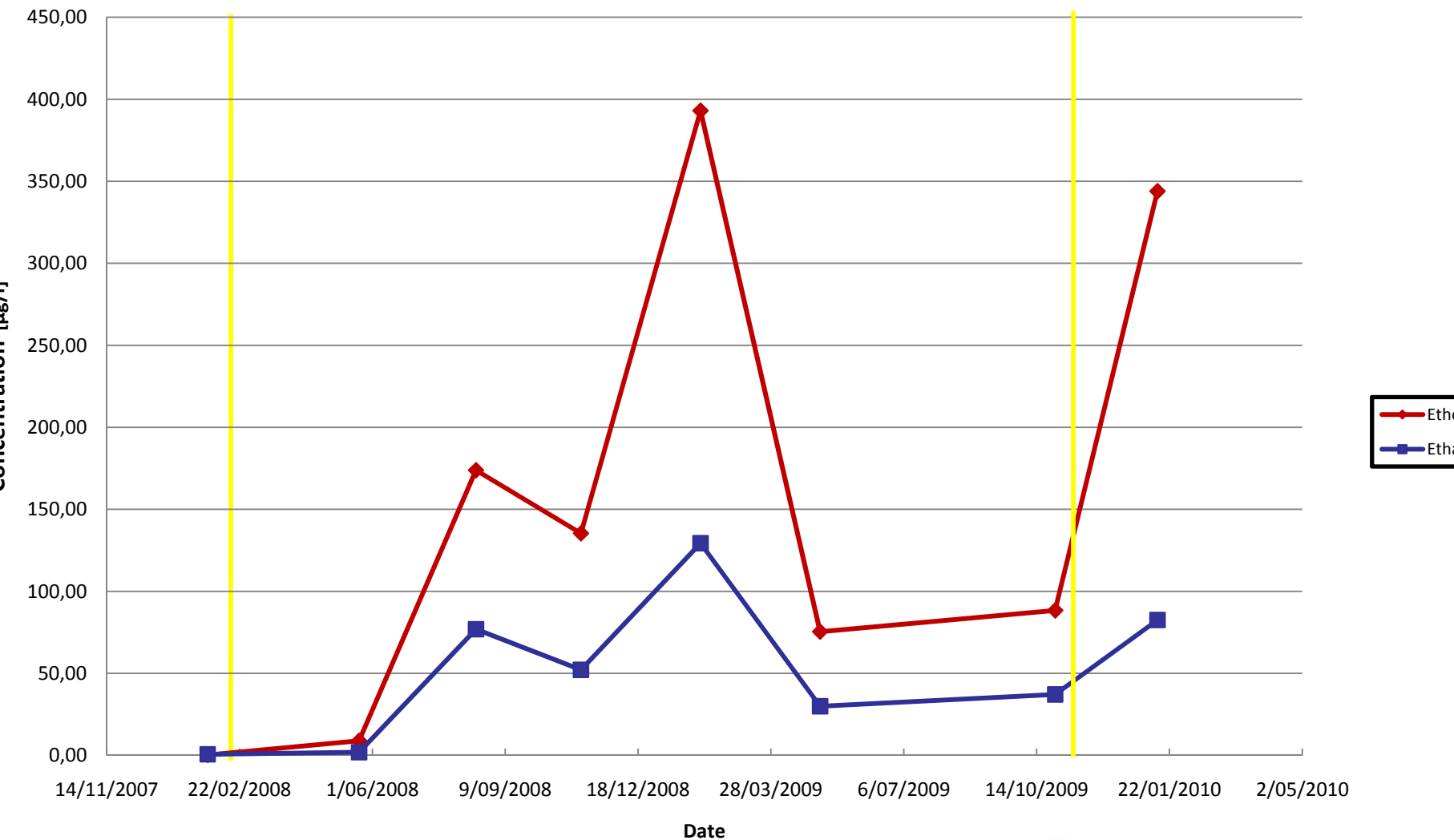
- 1. February 2008 : 8.280 kg CAP18[®] divided into 9 injectors.***
- 2. November 2009 : 4.600 kg CAP18[®] divided into 9 injectors.***



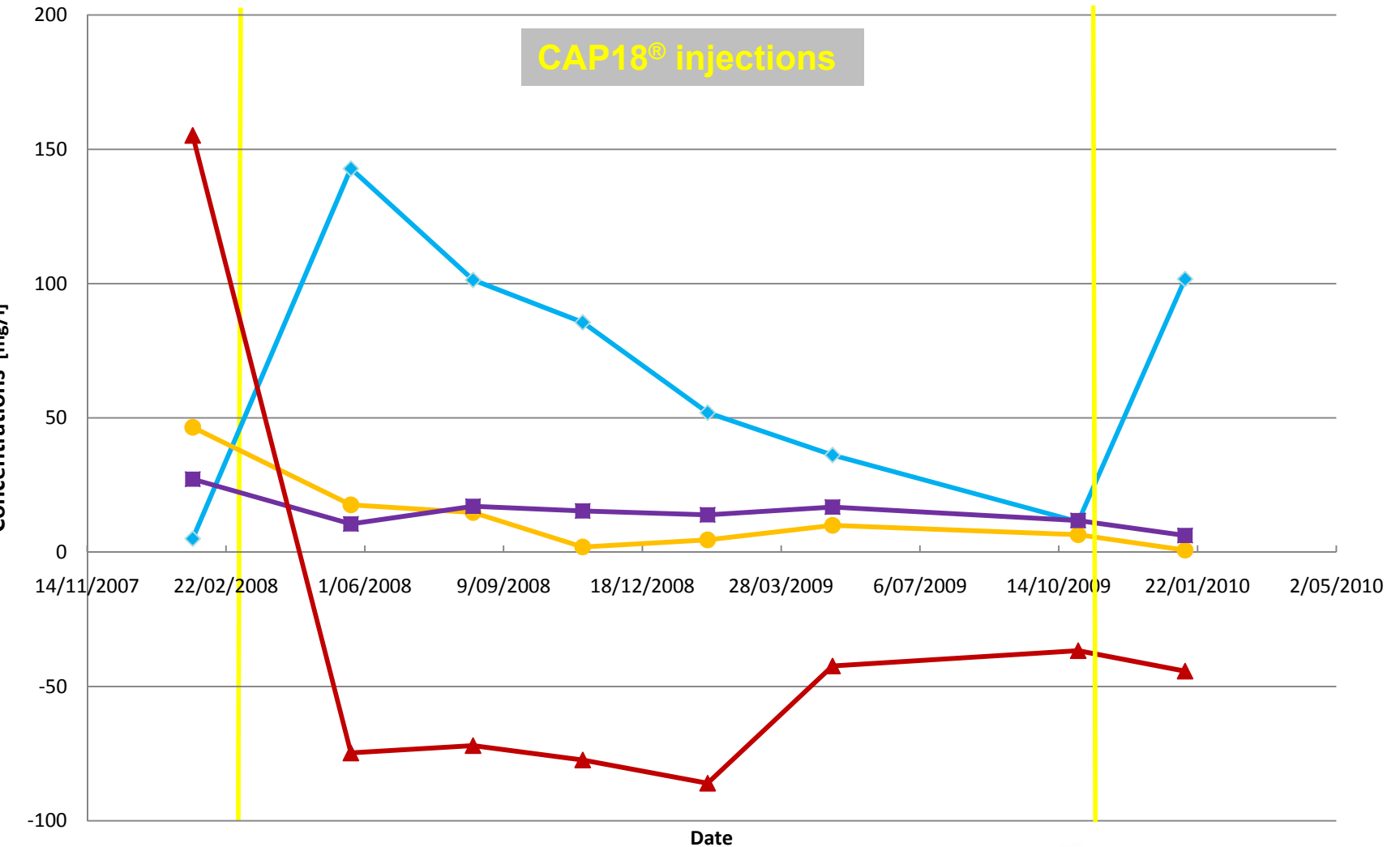
Average VOC- and CH₄-concentrations



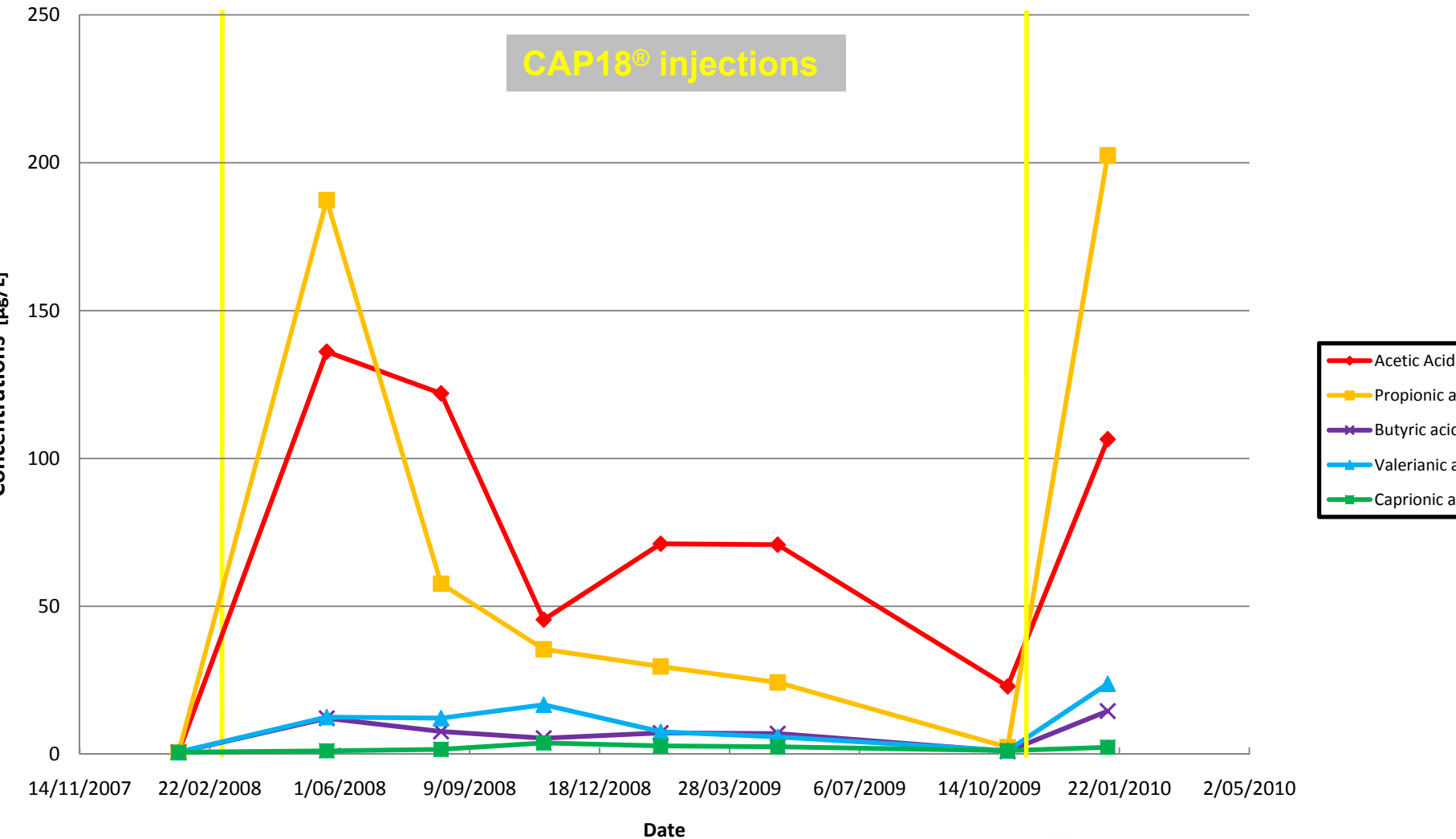
Average ethene and ethane concentrations



Average ORP-, TOC-, NO₃- and SO₄-concentrations



Average fatty acid concentrations



Reference projects

- CAP18[®] biobarrier project in Haute-Garonne(F)
- CAP18[®] biobarrier project in Kansas(USA)
- CAP18[®] biobarrier project in Santa Clara(USA)
- CAP18[®]-biobarrier project in East-Flanders(B)

CAP18[®] biobarrier project Kansas(USA)

Site specific conditions :

- ***Pollution*** : VOCs, max concentration TCE = 300 µg/L.
- ***CAP18[®] pilot (August 2005)*** :
 - *14 injectors;*
 - *Injection of 2.300 kg CAP18[®]*
- ***CAP18[®] full scale*** :
 - *May 2007 : 8.500 kg CAP18[®](pink dots)*
 - *July 2007 : 58.000 kg CAP18[®](blue dots)*

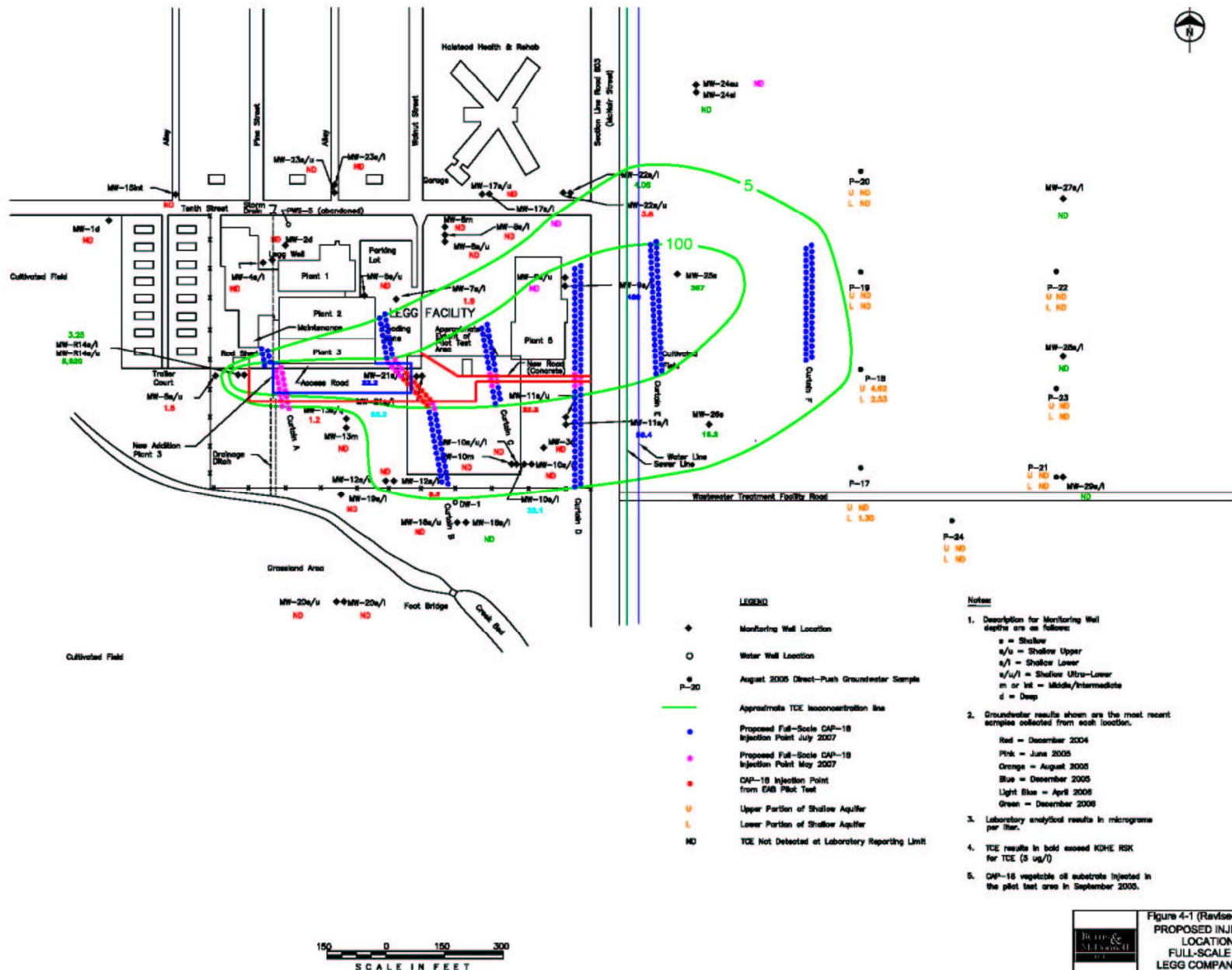


Figure 4-1 (Revised 4/17/07)
 PROPOSED INJECTION
 LOCATIONS
 FULL-SCALE EAB
 LEGG COMPANY, INC.
 HALSTEAD, KANSAS

Reference projects

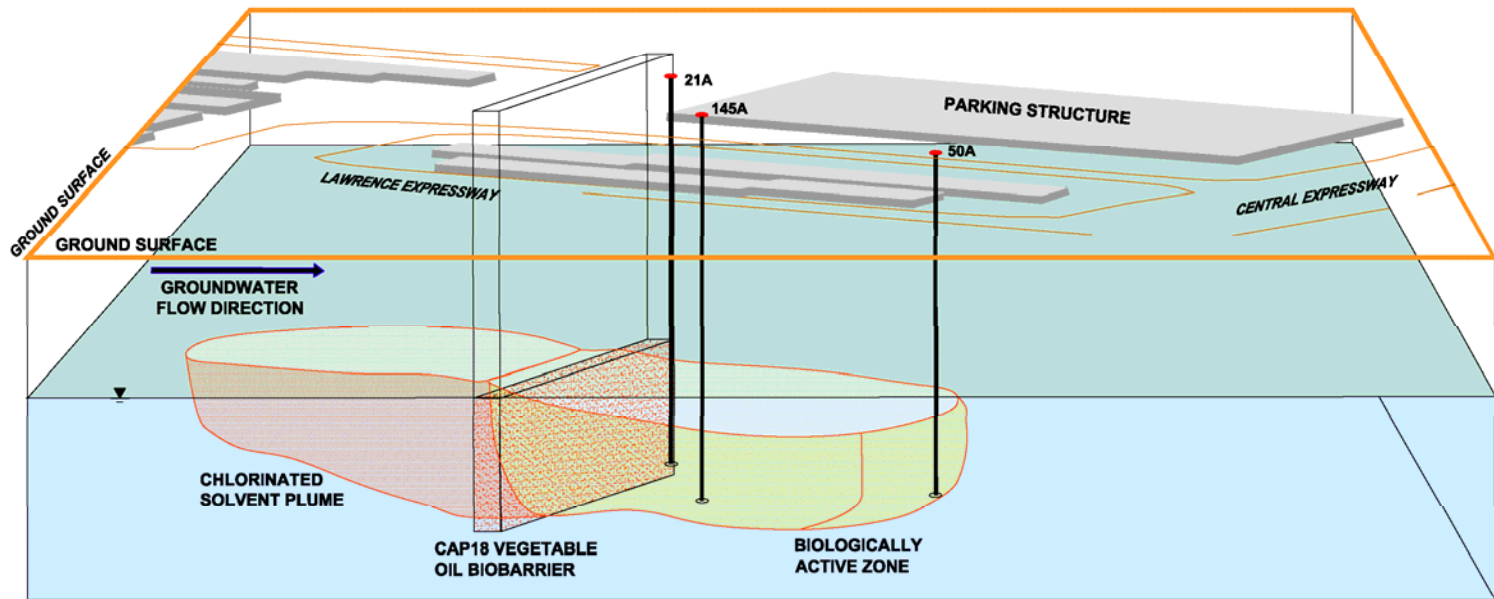
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CAP18[®] biobarrier project Santa Clara(USA)

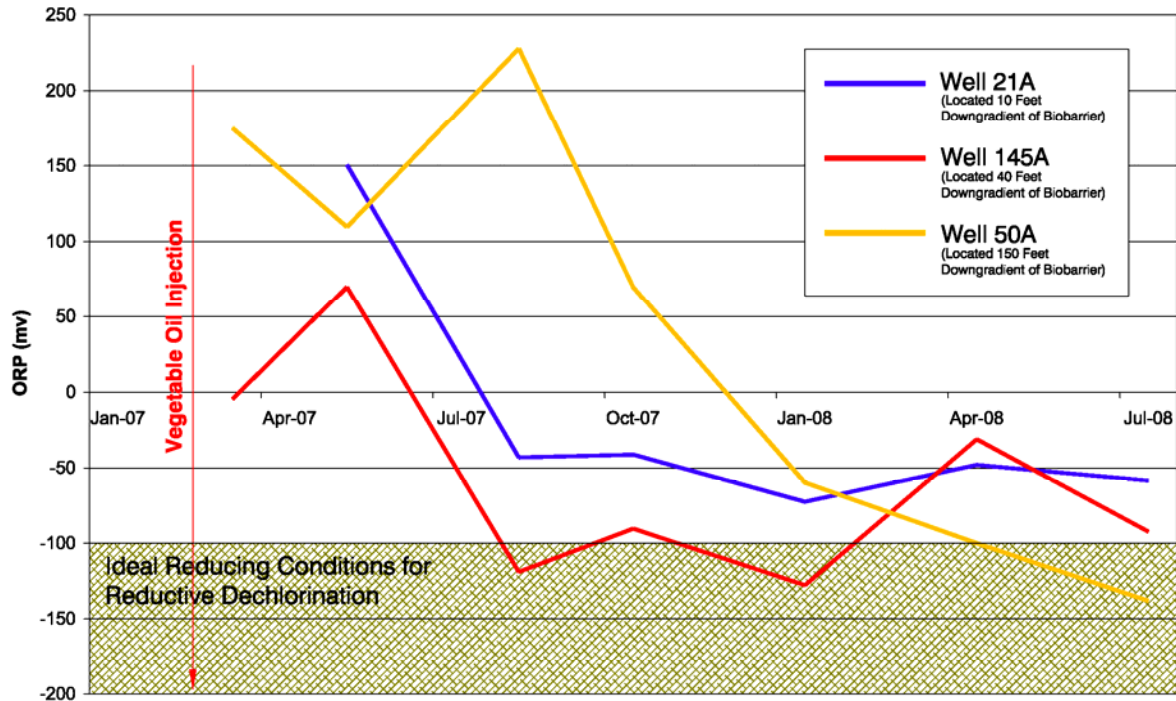
Site specific conditions :

- ***Pollution*** : VOCs, max concentration TCE = 900 µg/L.
- ***CAP18[®] pilot (January 2007)*** :
 - ***Length pilot barrier*** : 140 m;
 - ***Depth to be treated*** : 4,5 and 7,5 m-bg
 - ***Injection of 14.000 kg CAP18[®]***
- ***Geology*** : sandy aquifer
- ***History*** : several years of ‘Pump and treat’ with diminishing returns

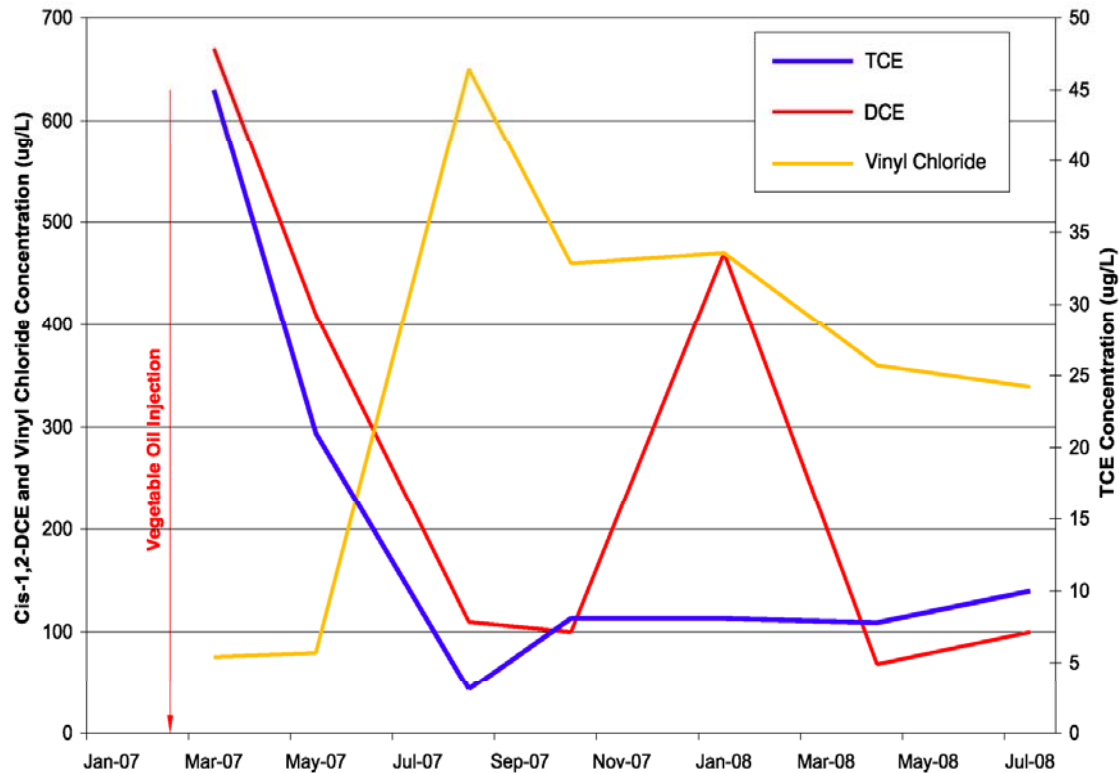
CAP18[®] biobarrier project Santa Clara(USA)



CAP18[®] biobarrier project Santa Clara(USA)



CAP18[®] biobarrier project Santa Clara(USA) – Well 145 A



CAP18[®] biobarrier project Santa Clara(USA)

Conclusions till present :

- **Creation of optimal reducing conditions up to 50 m downgradient**
- **Reductive dechlorination pathway to ethene is active**
- **CAP18[®] remains active at least 20 months after injection**
- **Successful technology demonstration, will lead to a full scale of 8 CAP18[®] barriers and the injection of 450.000 kg of CAP18[®]**

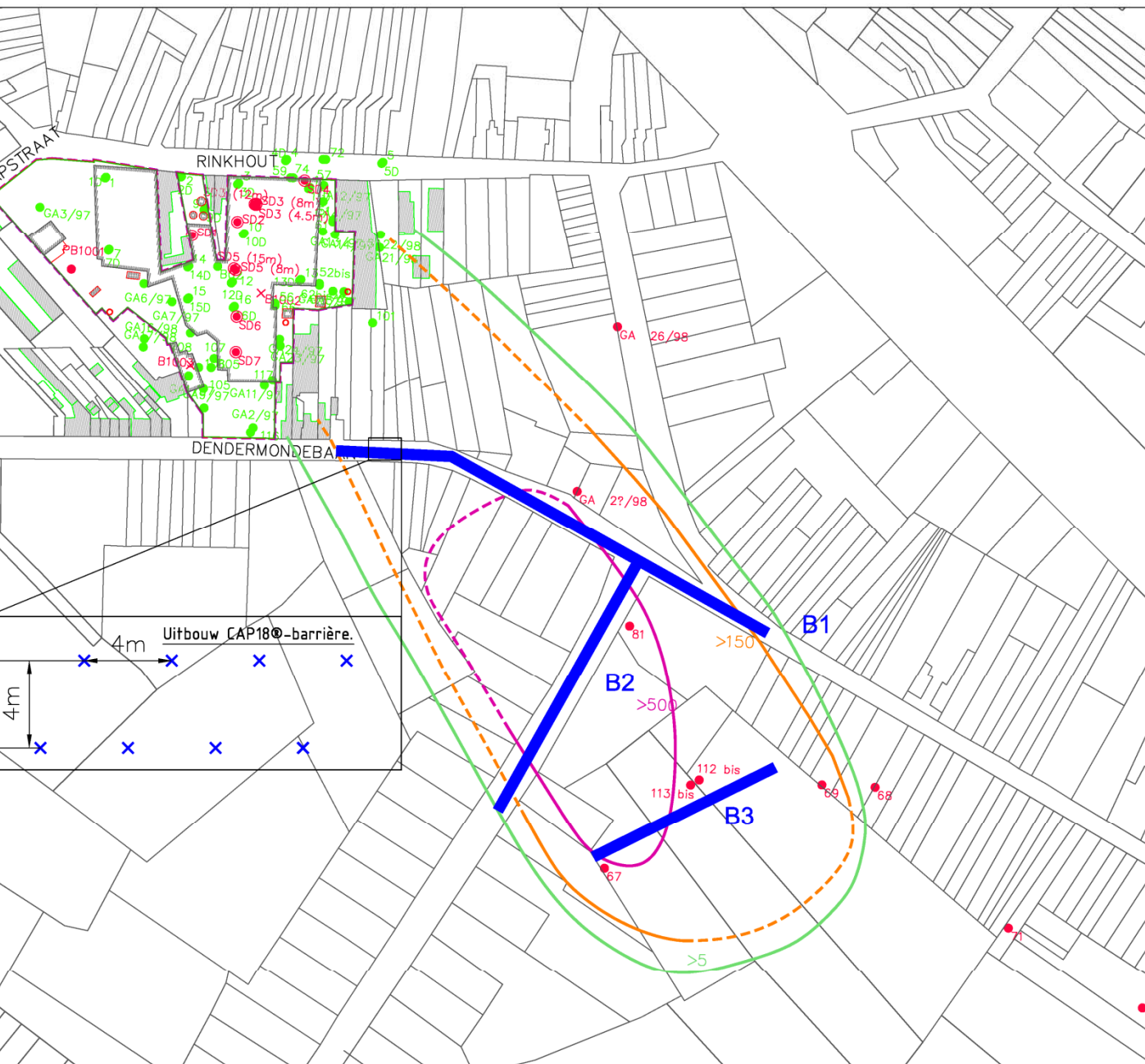
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CAP18[®]-biobarrier project E-FL(B)

Site specific conditions(CAPISCO[™]) :

- ***Pollution(plume)*** : VOCs, max concentration Cis = 21.000 µg/L
en VC = 540 µg/L.
- ***Source approach:***
 - *Fenton's pilot(April 2009) and Fenton's full scale(summer 2010)*
 - *After treatment with CAP18-ME[®](spring 2011) : 85.000 kg*
- ***Plume approach(summer 2010) :***
 - *Multiple CAP18[®]-barrier system : in total 3*
 - *Depth to be treated : 9 m, from 4 till 13 m-bg*
 - *Circa 250 injectors;*
 - *Injection of 90.000 kg CAP18[®]*



LEGENDE

Opdrachtgebied
Uitspraakgebied
Perceelsgrens
Perceelnummer

Bebouwing

Luifel

Beton

Boom

Boorpunt

Peilbuis snijdend

Peilbuis niet-snijdend

Peilbuis voorgaand onderzoek

CAP18® - barrières

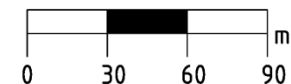
CAP18® - Injector

Boring

B1 = ±235m

B2 = ±125m

B3 = ±90m



8/09/09

Initial Textiles Zele

A3

Situering boringen en peilbuizen - site & pluim

Cis van 6 - 12 m-mv inc. CAP18® - barrières

SCHAAL:

Getekend door:

Dhr. Haghebaert

Tekenaar:

PRD



European Remediation Technologies

Questions?



ERT **European Remediation Technologies**

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Stijn Haghebaert