

The winner takes it all – trialing three parallel remediation options at the same site in order to select one remediation strategy for the entire site

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About us

- Soil and groundwater remediation design
- Pilot test design
- Water treatment design
- Advice to clients, consultants and contractors regarding remediation.

The site

- Mechanical industry
- Two source areas
 - Soil
 - Bedrock
- Contaminant plume in groundwater



Remediation stages

Stage 1:

- Excavation of source area in soil at the former factory area
- 100's of kg CVOC

Stage 2:

- Thermal remediation of bedrock
- 50 mbgl
- 3000 kg CVOC

Stage 3:

- Plume remediation in groundwater
- 100-200 kg VCOC



Image: courtesy of Varbergs kommun

Stage 3

Two part contract

1. Pilot trials (2022)
2. Remediation

Target levels

0.1 mg/l Σ TCE+TCA+DCE+DCA+VC

Within 3 years

Injection technology using degradation and adsorption to activated carbon

But there were also...



Image: courtesy of Varbergs kommun

The train tunnel

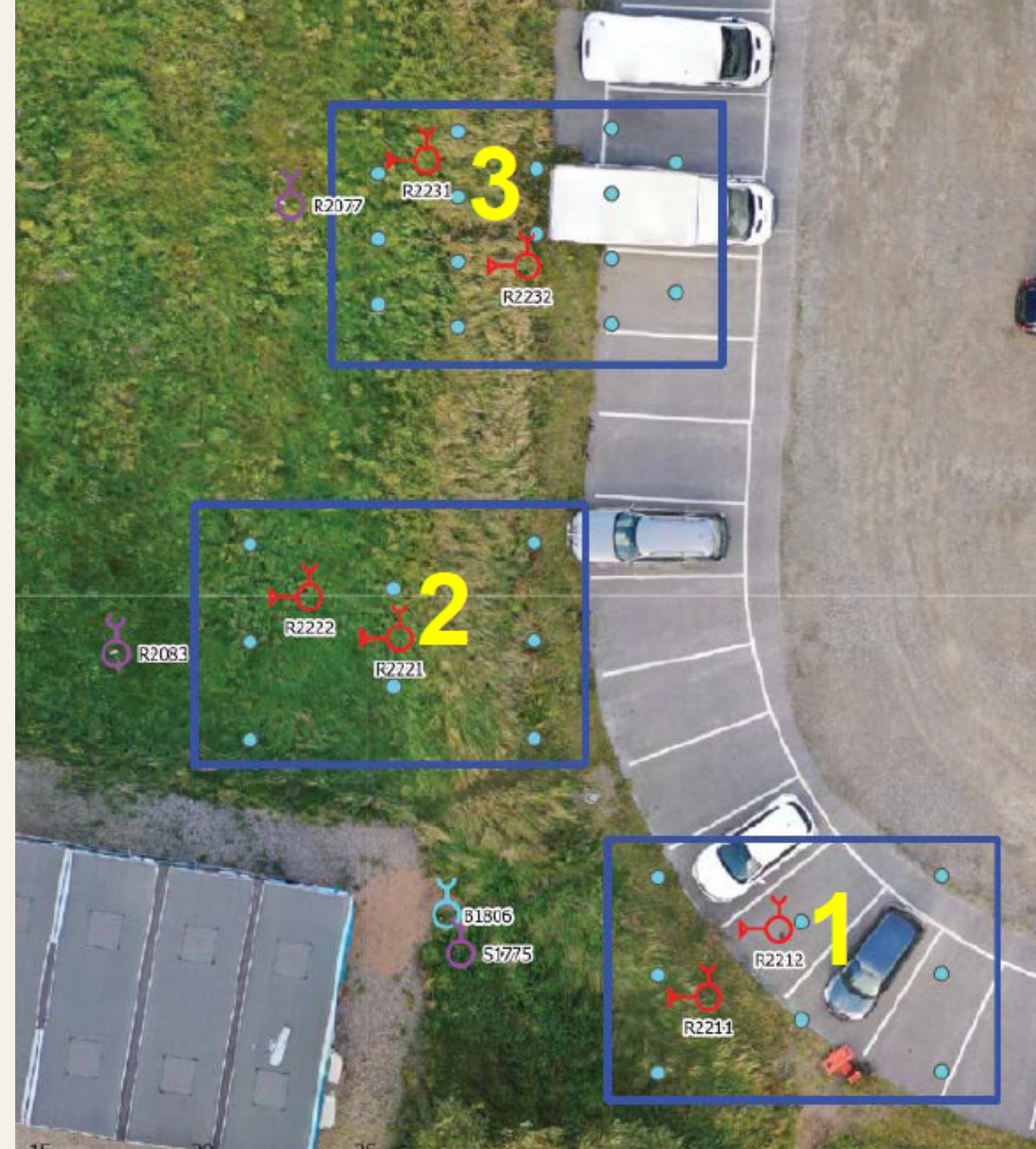
- Downgradient the remediation area
- Almost 20 mbgl
- Pumping groundwater to prevent leakage into the tunnel
 - Water treatment
- Or infiltrating
- High impact on the groundwater in the plume area



Image courtesy of Trafikverket

Pilot trials

- Pilot area
 - Highest concentrations
 - Gw surface app 2 mbgl
 - Bedrock surface app 6 mbgl
- Division into three sub areas
- Pre investigations
 - To verify the conditions
 - Soil samples and groundwater well installation
 - Also downgradient
 - Sonic drilling rig
 - iFlux for contaminant flux and groundwater velocity



Results – pre investigations

- Soil
 - Mostly sand, also silt and gravel
 - Low levels adsorbed to soil (max 5 mg/kg CVOC)
- Groundwater
 - Large variety in groundwater velocity
 - Already reducing conditions (redox less than -100 mV)
 - TCE 310-6,300 µg/l
 - TCA less than 10 µg/l
 - DCE 290-6,800 µg/l
 - DCA less than 100 µg/l
 - VC 5-350 µg/l
 - Ethene and ethane present



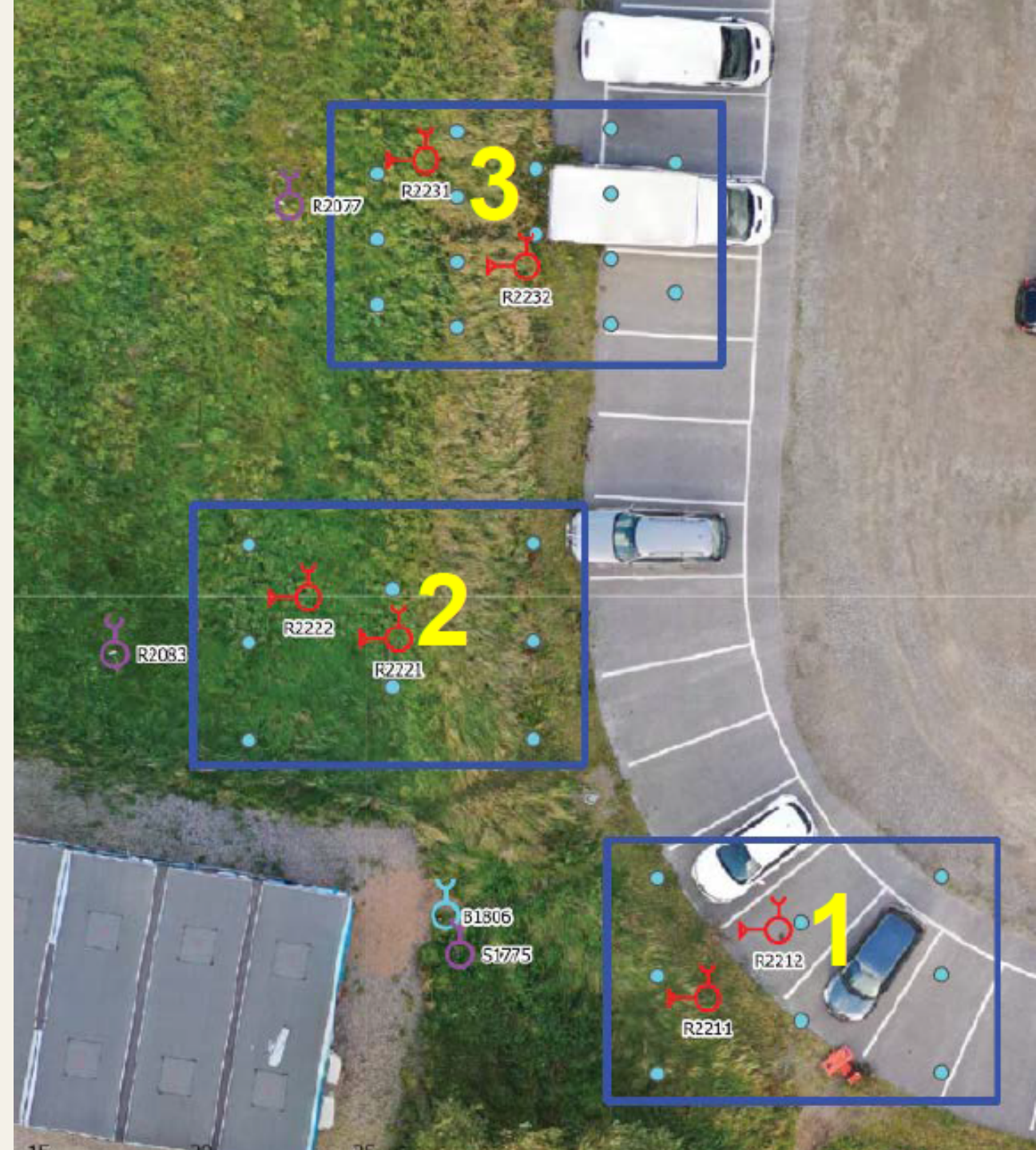
Results – pre investigations

- Conslusions
 - Good correlation between condition on site and those in the procurement documents
 - Complete degradation occurring
 - ERD, active carbon and/or ISCR is the way forward
 - Reductions up to 99,3 % needed

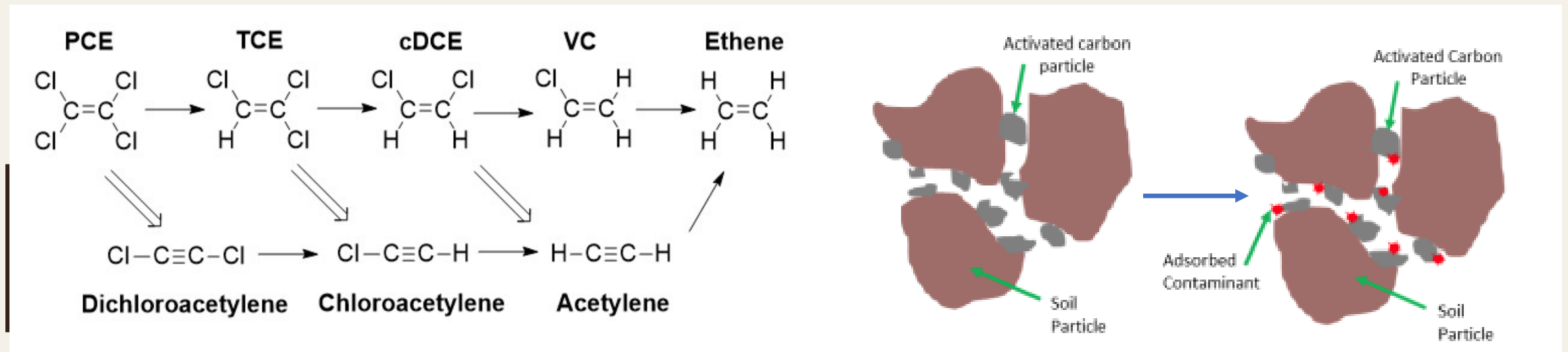


Pilot trials – the winner takes it all

- Division into three sub areas
- Area 1
 - Colloidal active carbon (PlumeStop)
 - Zero valent iron (s-mZVI)
 - Electron donor (HRC)
- Area 2
 - Colloidal active carbon (PlumeStop), higher dose
 - Electron donor (HRC)
- Area 3
 - Powdered active carbon (EHC+)
 - ZVI (EHC+)
 - Electron donor (EHC+)



Degradation mechanisms



Images: courtesy of Regenes and Haupt, 2019

Area 1

µg/l

100000

10000

1000

100

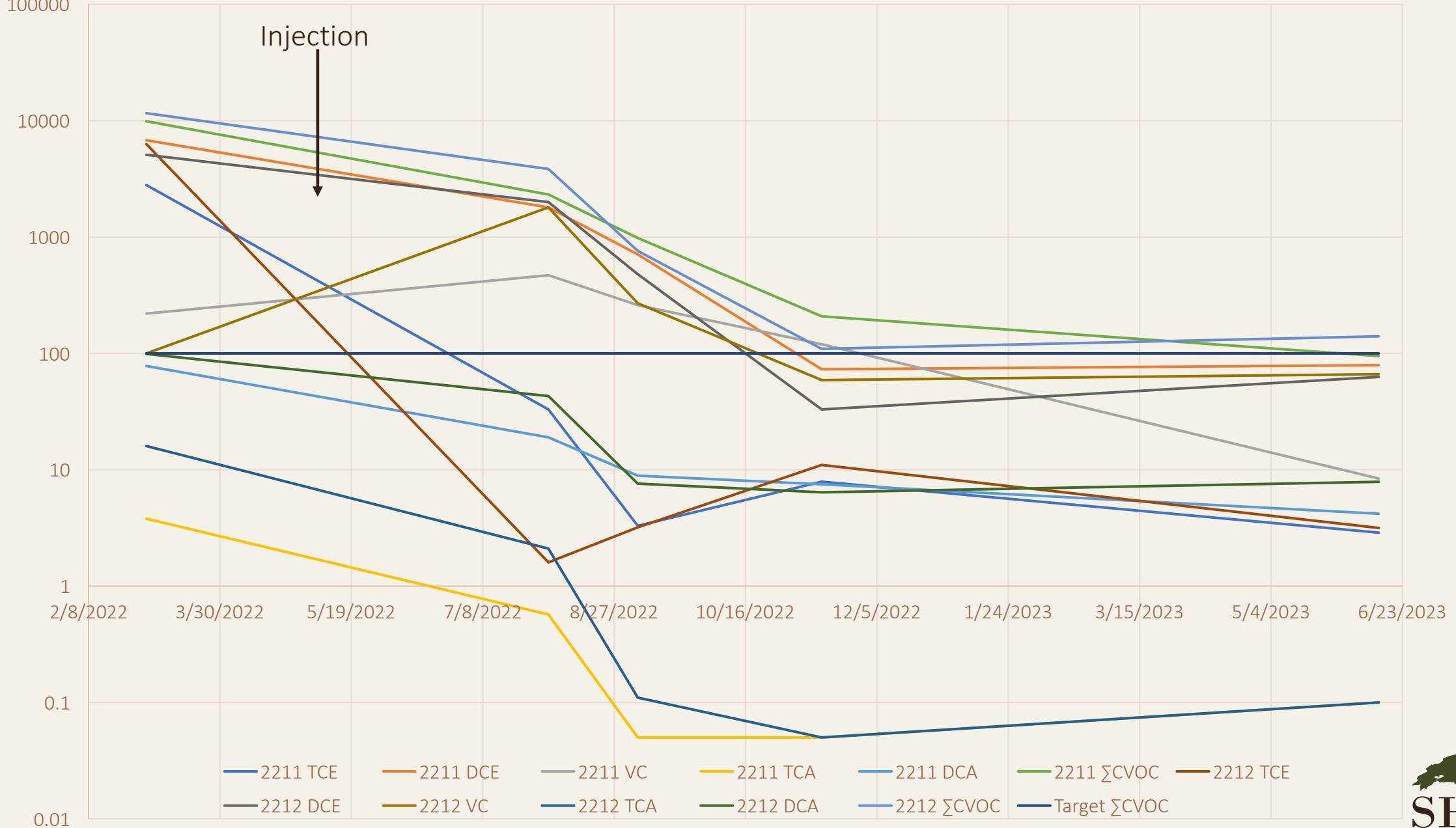
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1

0.1

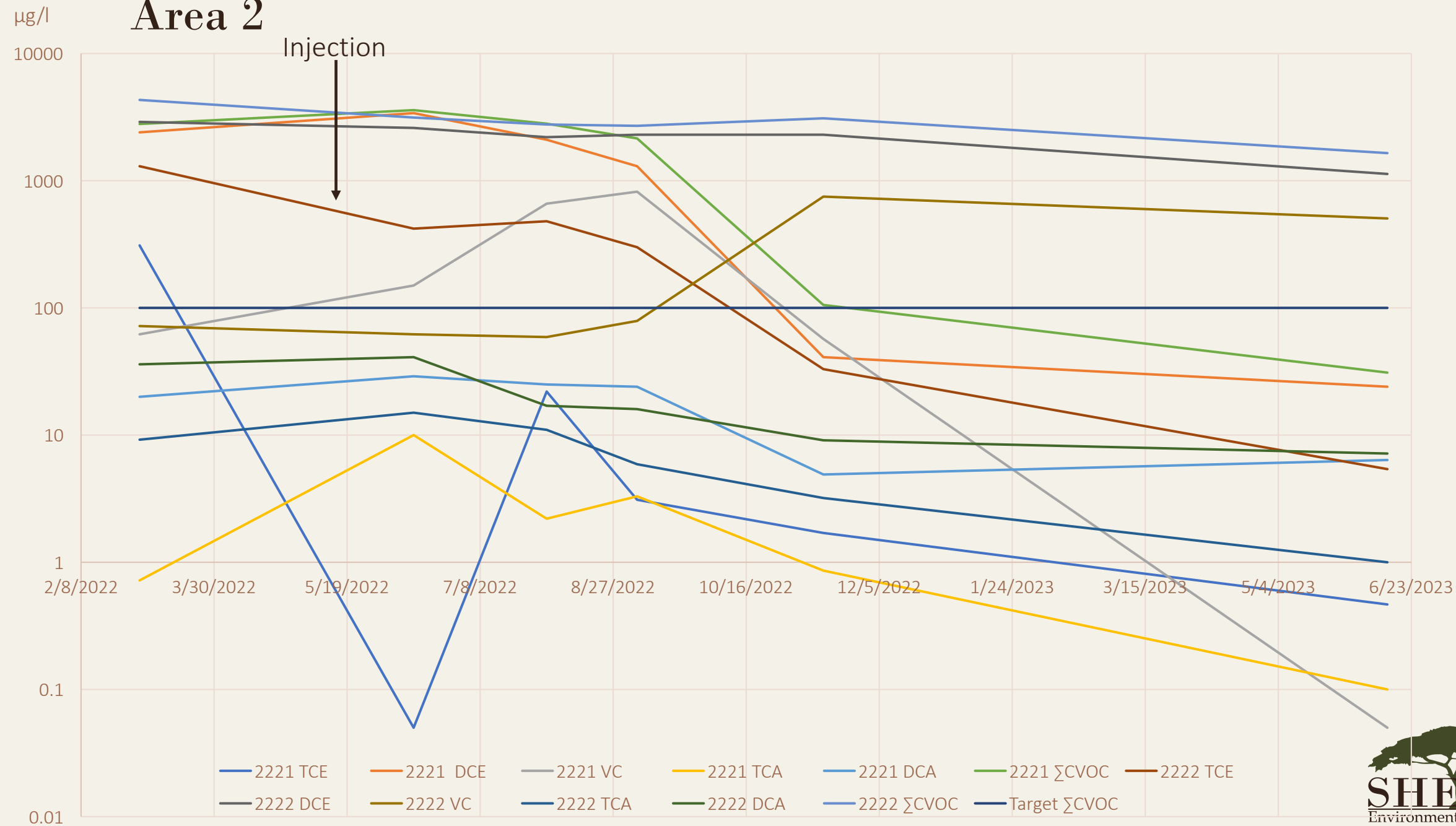
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Injection



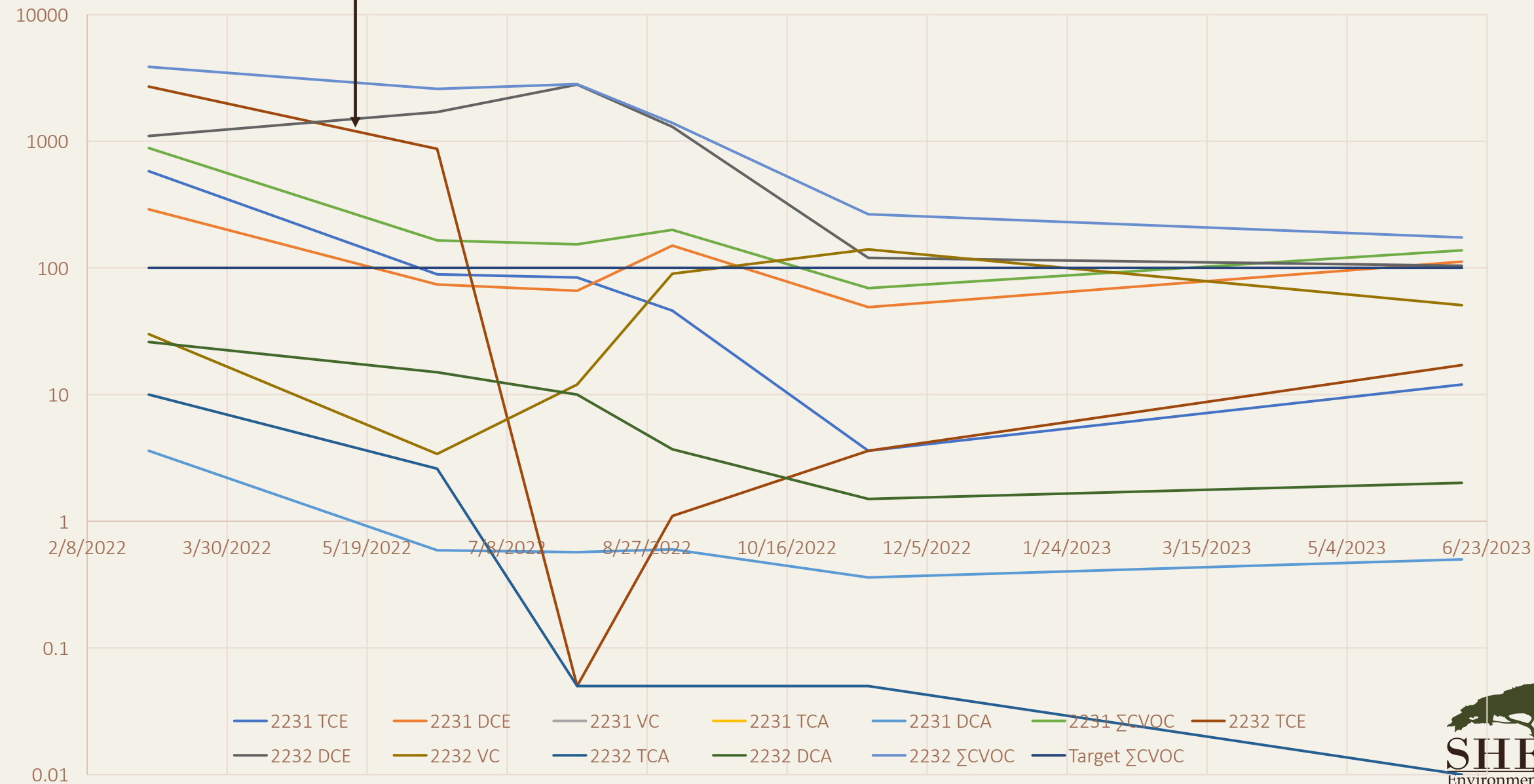
Area 2

Injection



Area 3

Injection



Areas 1-3, 15 months post injection

	Area 1 Colloidal active carbon, ZVI and hydrogen donor		Area 2 Colloidal active carbon (higher dose) and hydrogen donor		Area 3 Powdered active carbon, ZVI and hydrogen donor	
% reduction	2211	2212	2221	2222	2231	2232
TCE	>99	>99	>99	>99	98	92
DCE	98	99	99	61	61	91
VC	96	34	n/d	+700	+245	+170
TCA	n/d	n/d	n/d	89	n/d	n/d
DCA	95	92	68	80	n/d	92
ΣCVOC	>99	99	>99	63	43	98
ΣCVOC (µg/l)	95	140	31	1645	138	174

Evaluation parameters

- Contaminant reduction in groundwater
- Time on site
- Equipment requirements
- Staff and drilling resources
- H&S
- Injectability
- Cost

However...

- Budgetary limitations were not met
- Change
 - Technology (ERD with addition of ZVI)
 - Longer treatment time (app 5 years)
 - Revise the remediation target

Who is the winner?



So far –
no one...

2020



So far –
no one...

2022 - Q4



So far –
no one...

2023 – Q2



What has happened?

- Contaminant levels has dropped to below target in large parts of the treatment area
- Still contaminant left close to the pilot test area

Due to:

- Source removal
 - Soil through excavation
 - Bedrock through thermal treatment
 - Reducing influx of contaminated bedrock groundwater
- Pilot tests
- Train tunnel pumping

What will happen now?

- Continuous monitoring of groundwater
- Soil bound contamination above present groundwater table
- What will the contaminant levels in groundwater be when the groundwater pumping is being cancelled?
- Parallel discussions regarding target and treatment time

Thank you for your attention





Questions?

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