A Field Study Evaluating the Delivery and Performance of Injected Activated Carbon for Remediation of PFOA & PFAS

R. McGregor

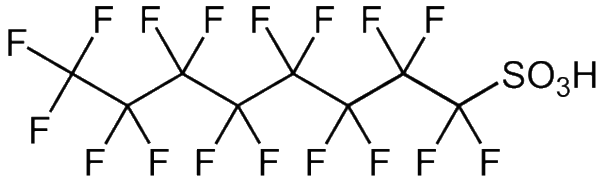
Environmental Technology Company

InSitu Remediation Services

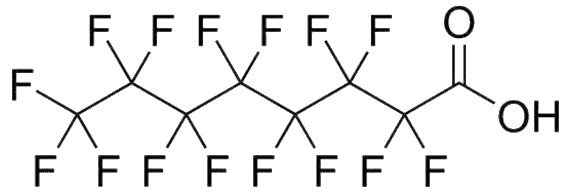
Water Arabia 2017

Background

- Perfluorinated Compounds
  - Perfluorooctane Sulfonate
    - PFOS
  - Perfluorooctanic acid
    - PFOA

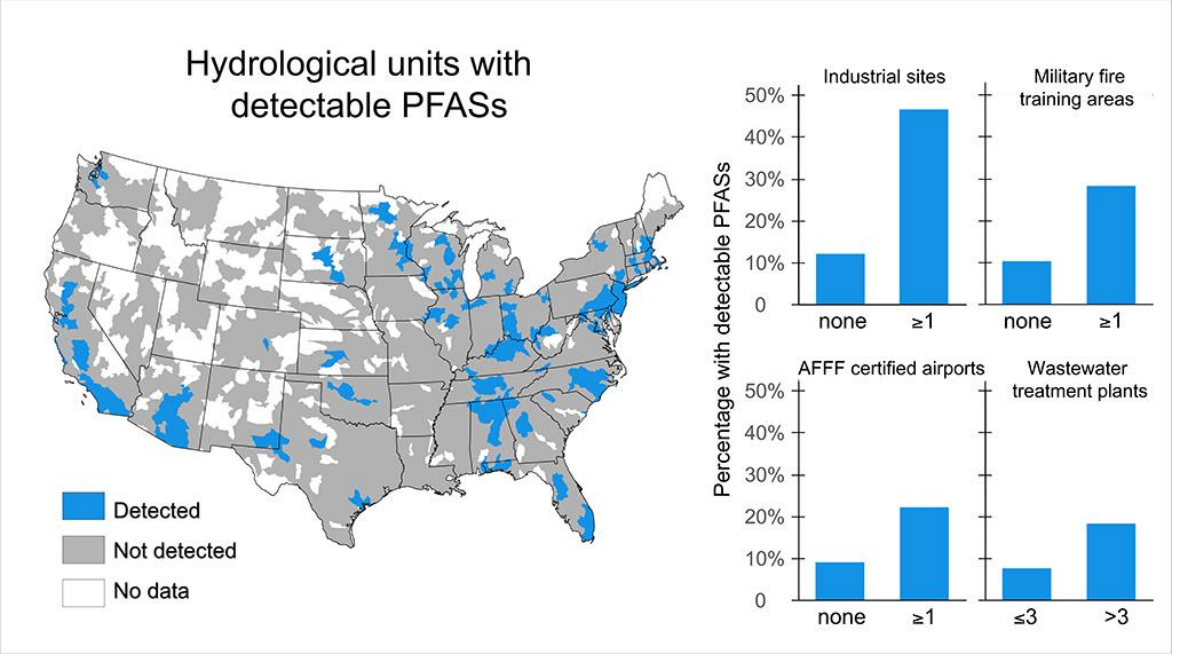


- Emerging Compounds of Concern
  - Especially in USA and Europe
  - Shown to bioaccumulate
  - EU, EPA and EC have issued health advisories
  - Not known to be carcinogens
  - Fate & transport not well understood
    - A. Weber (ES&T, 2017)



Background

- Perfluorinated Compounds
  - 6 million Americans exposed
  - Found in fire fighting foams
  - Reagents for Teflon
  - Repellants for fabrics

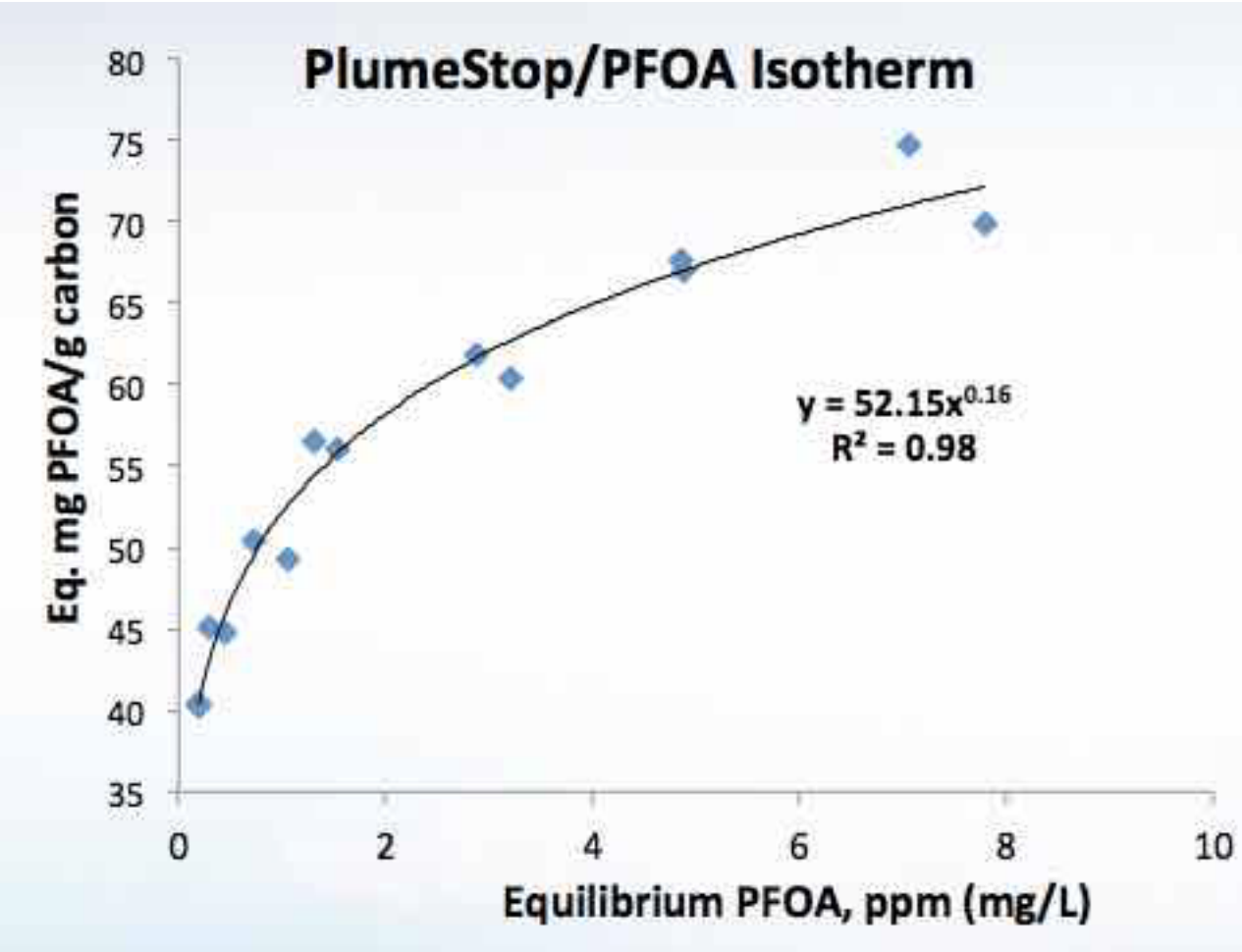


U.S. EPA (https://www.epa.gov/dwucmr/occurrence-da unregulated-contaminant-monitoring-rule)

Background

- Tradition Treatment
  - Above ground (i.e. pump & treat)
  - Treatment trains
    - GAC
      - Common
      - Inexpensive but requires disposal or regeneration
    - Anion exchange resins
      - Expensive
    - Membrane filtration
      - Energy intensive
      - Expensive

Background



	Kf	1/n	PS dose, mg/L: 5 ppm -> .005 ppm
PFOA	52	0.16	**224**
PFOS	135	0.28	**163**
PCE	105	0.42	**445**

Adsorbs well but not destroyed

Study Site

- Petroleum Hydrocarbon Spill
  - Source excavated
  - Residue PHCs in soil and groundwater
    - BTEX <300 ug/L
    - F1 < 2,000 ug/L
    - F2 < 3,500 ug/L
  - Mention of site being used as a fire fighting training site and old building used for fabric coating
  - Grabbed groundwater samples for PFOA and PFOS test
  - Detected!
    - PFOS up to 1,500 ppt
    - PFOA up to 3,300 ppt

Study Site

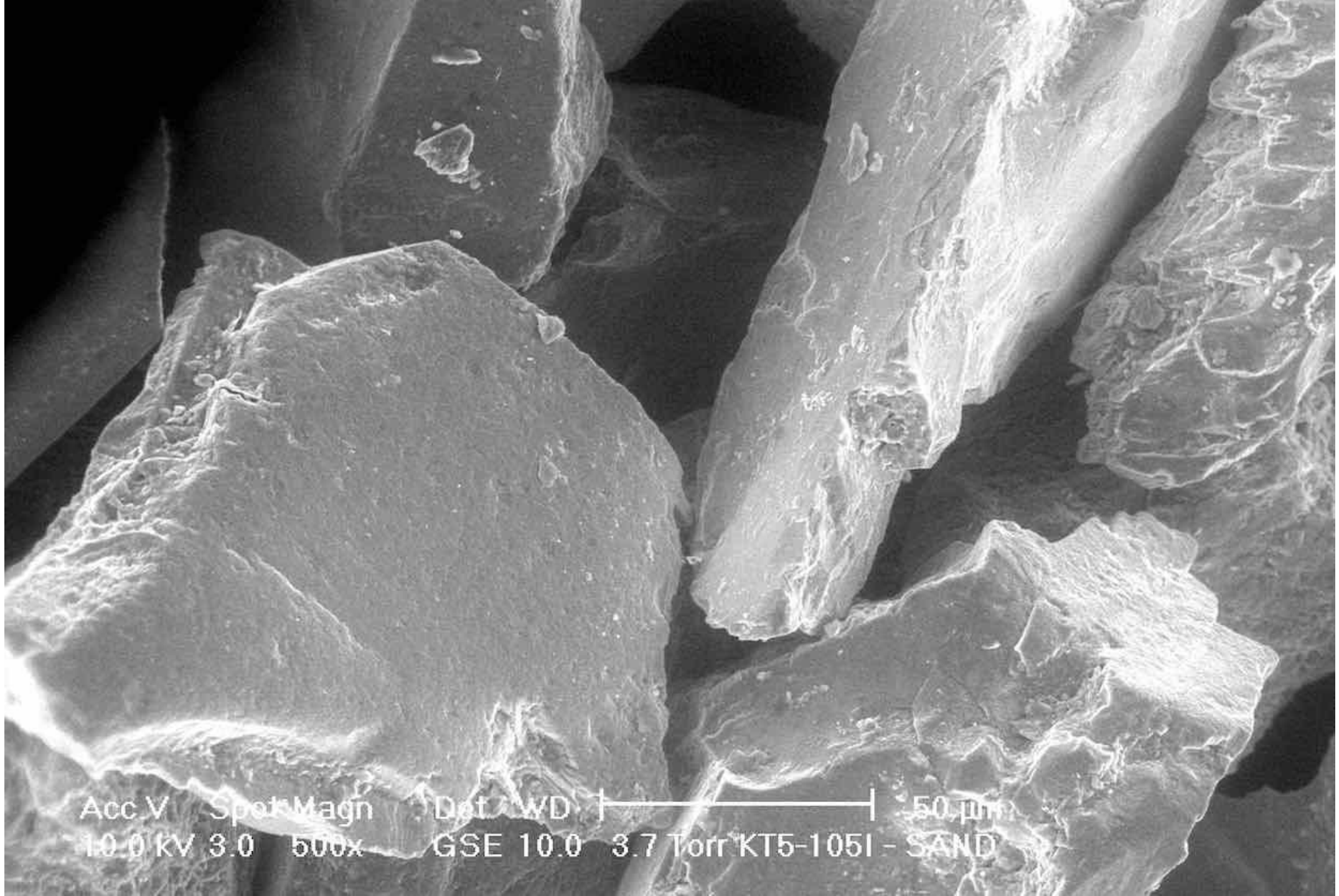
- Petroleum Hydrocarbon Spill
  - Geology
    - Sand to silty sand
    - Sand lens (less than 2 cm thick)
  - Hydrogeology
    - Shallow water table (~1 mbgs)
    - K ~2.6 m/day
    - i ~0.06
    - V ~ 1 m/day
    - Effective porosity ~0.2
  - Geochemistry
    - Reducing
    - Iron-sulphate reducing
    - High chloride concentration

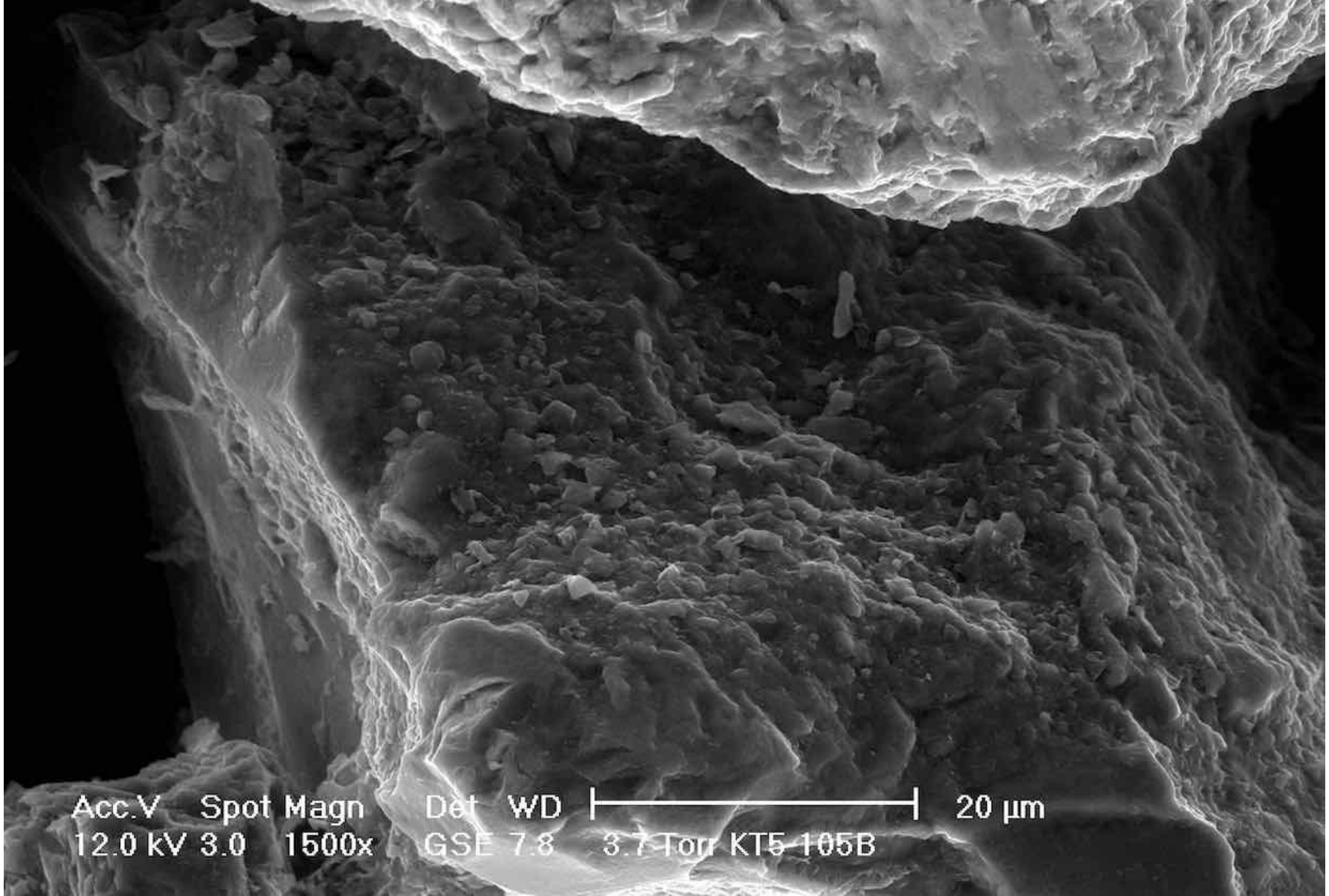
Background

- Remedial Options
  - Pump & Treat
  - Air Sparging & SVE
  - Chemical oxidation
  - Enhanced aerobic bio
  - Sulphate reduction
  - Thermal
  - Adsorption

Background

- Why liquid activated carbon?
  - Not many demonstrated sites
  - ~120 worldwide
  - ~20 in Canada
  - Excellent injection "properties"
    - Viscosity and density of water
    - Colloidal (1-2 microns)
    - Surface area ~5,500 m^2
  - Potentially quick
    - One time application
    - Less disruption
  - Cost
    - ~$75,000

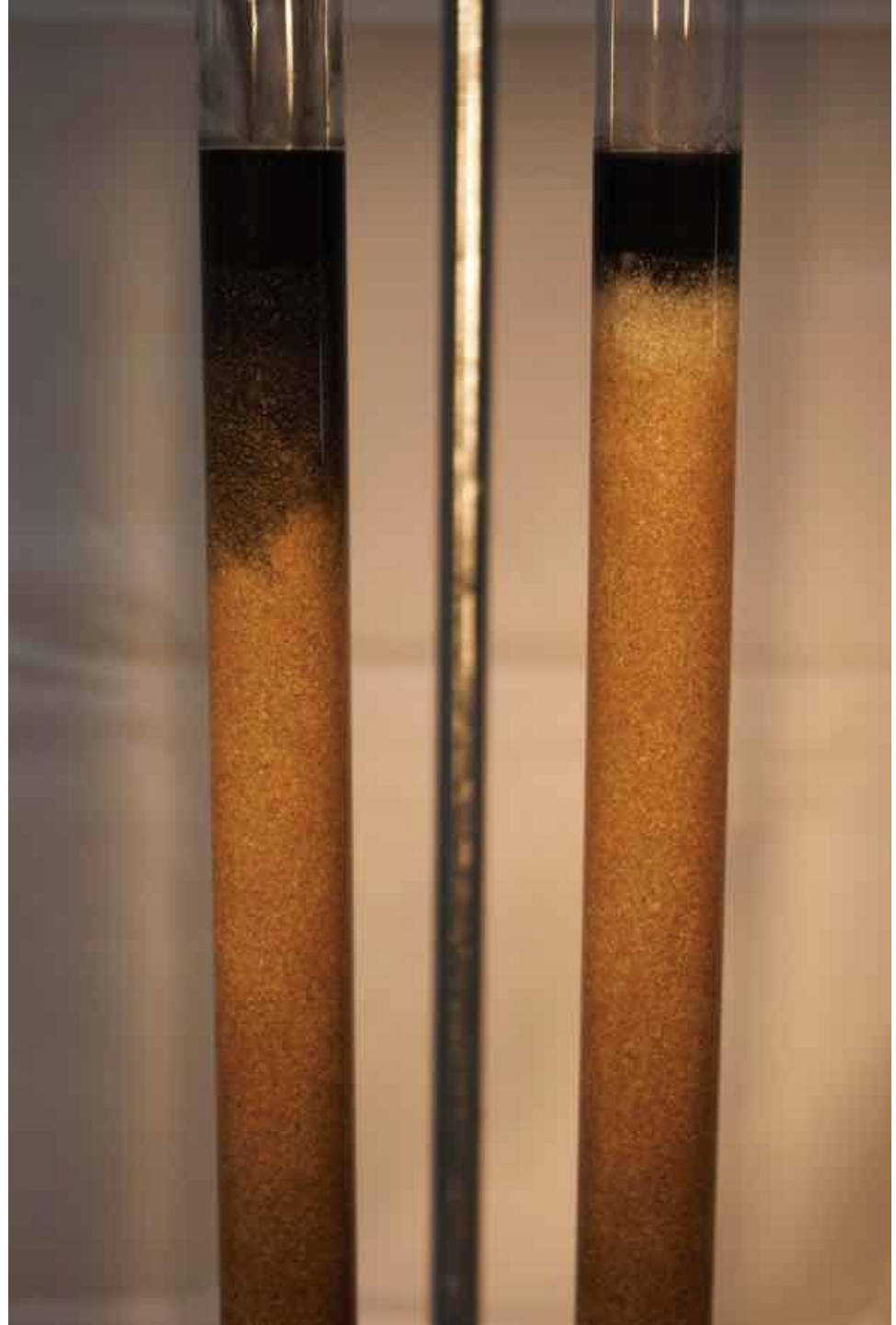

Acc.V Spot Magn Det WD 50 µm
10.0 kV 3.0 500x GSE 10.0 3.7 Torr KT5-105I - SAND


Acc.V Spot Magn Det WD 20 µm
12.0 kV 3.0 1500x GSE 7.8 3.7 Torr KT5-105B

Liquid Activated Carbon

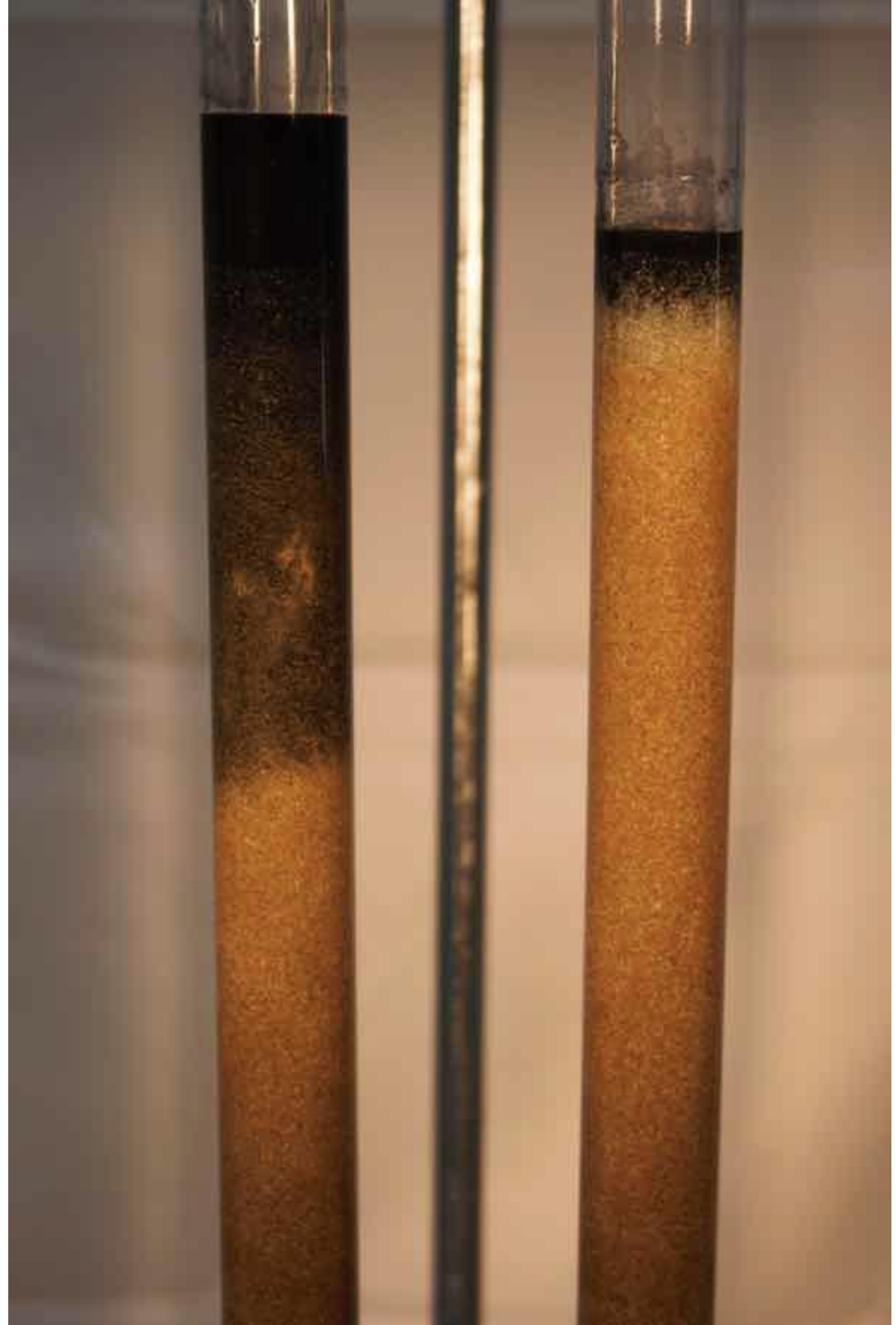
Powdered Activated Carbon

Liquid Activated Carbon



Powdered Activated Carbon

Liquid Activated Carbon



Powdered Activated Carbon

Liquid Activated Carbon

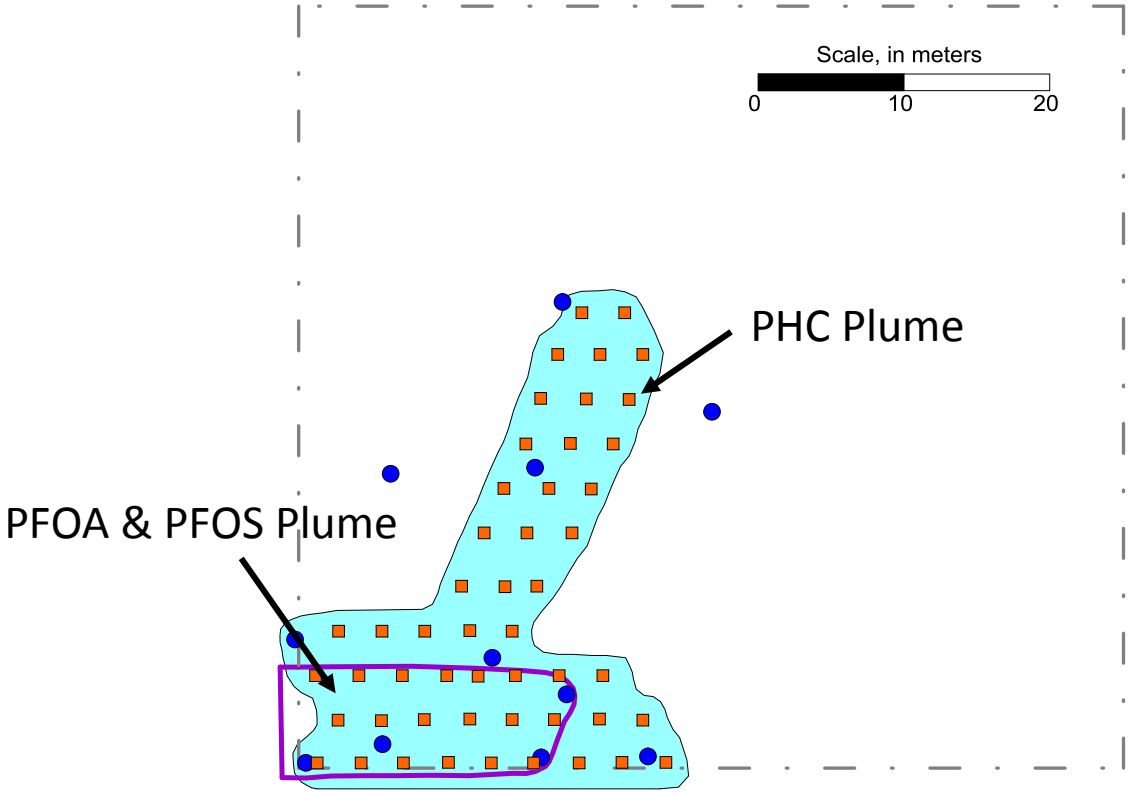
Powdered Activated Carbon

Injection Methodology

- Based on Pore Volume
  - > 0.2 PV
  - One event
- Direct Push
- Geology Specific Tools
- Multiple Locations
- Multiple Intervals
- Low Pressure
  - <25 psi
- Low Volume
  - ~100 to 200 litres/location

Injection Methodology

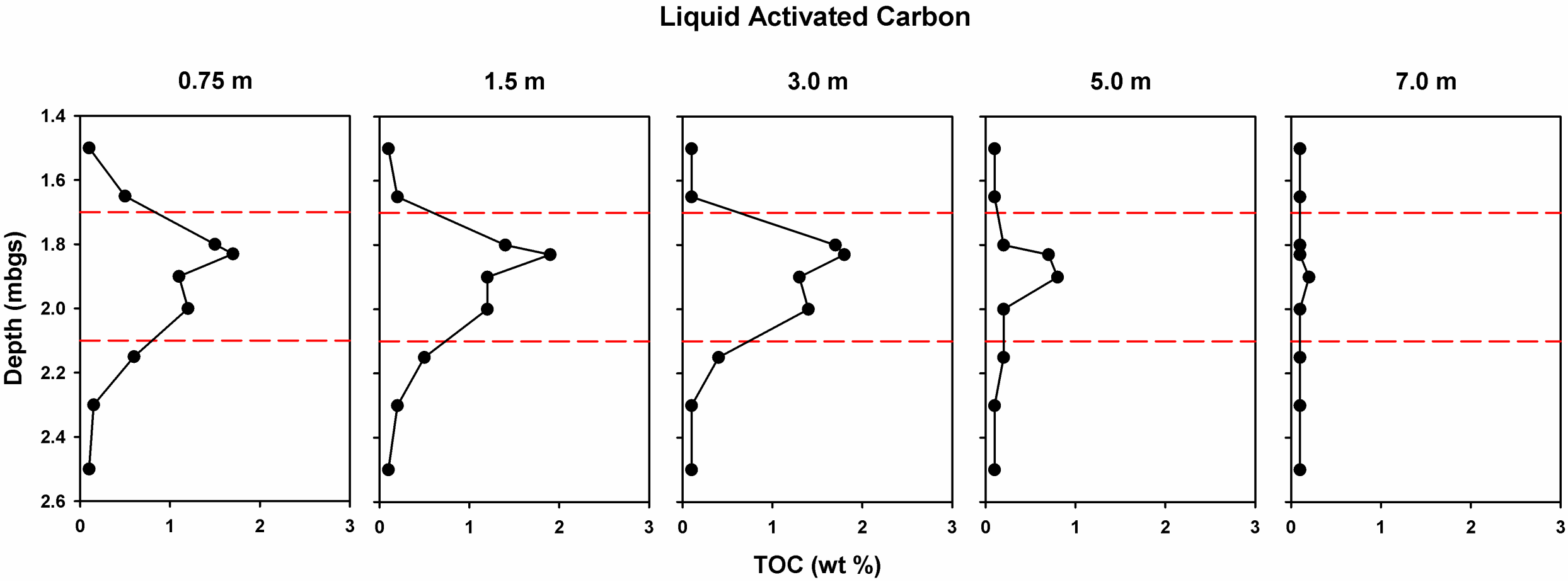
- Combination of adsorption-aerobic bio
  - 725 kg of concentrated liquid activated carbon
  - 440 kg of oxygen-releasing material
  - 7,800 litres of water
  - 50 locations



Injection Methodology

- 50 injection locations
  - 3 days
  - Good distribution
    - ~3 to 4 m radius of influence
    - Target zone showed good coverage
  - BTEX and PHC results
    - Non detect within 8 weeks
  - PFOS and PFOA
    - Non detect within 8 weeks
    - Maintained for over a year

Results


Liquid Activated Carbon
0.75 m
1.5 m
3.0 m
5.0 m
7.0 m
Depth (mbgs)
1.4
1.6
1.8
2.0
2.2
2.4
2.6
0
1
2
3
TOC (wt %)

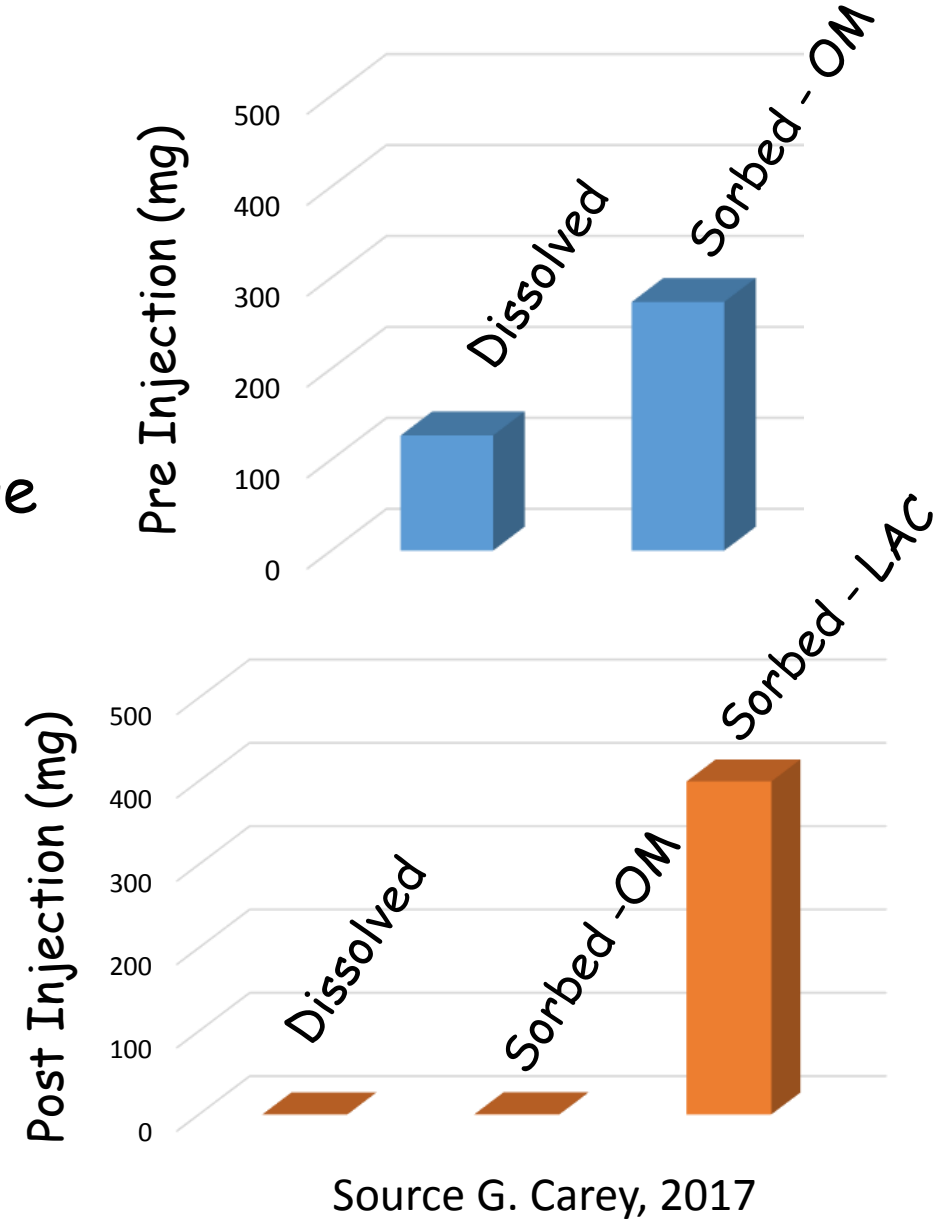
Results

Liquid Activated Carbon

Liquid Activated Carbon

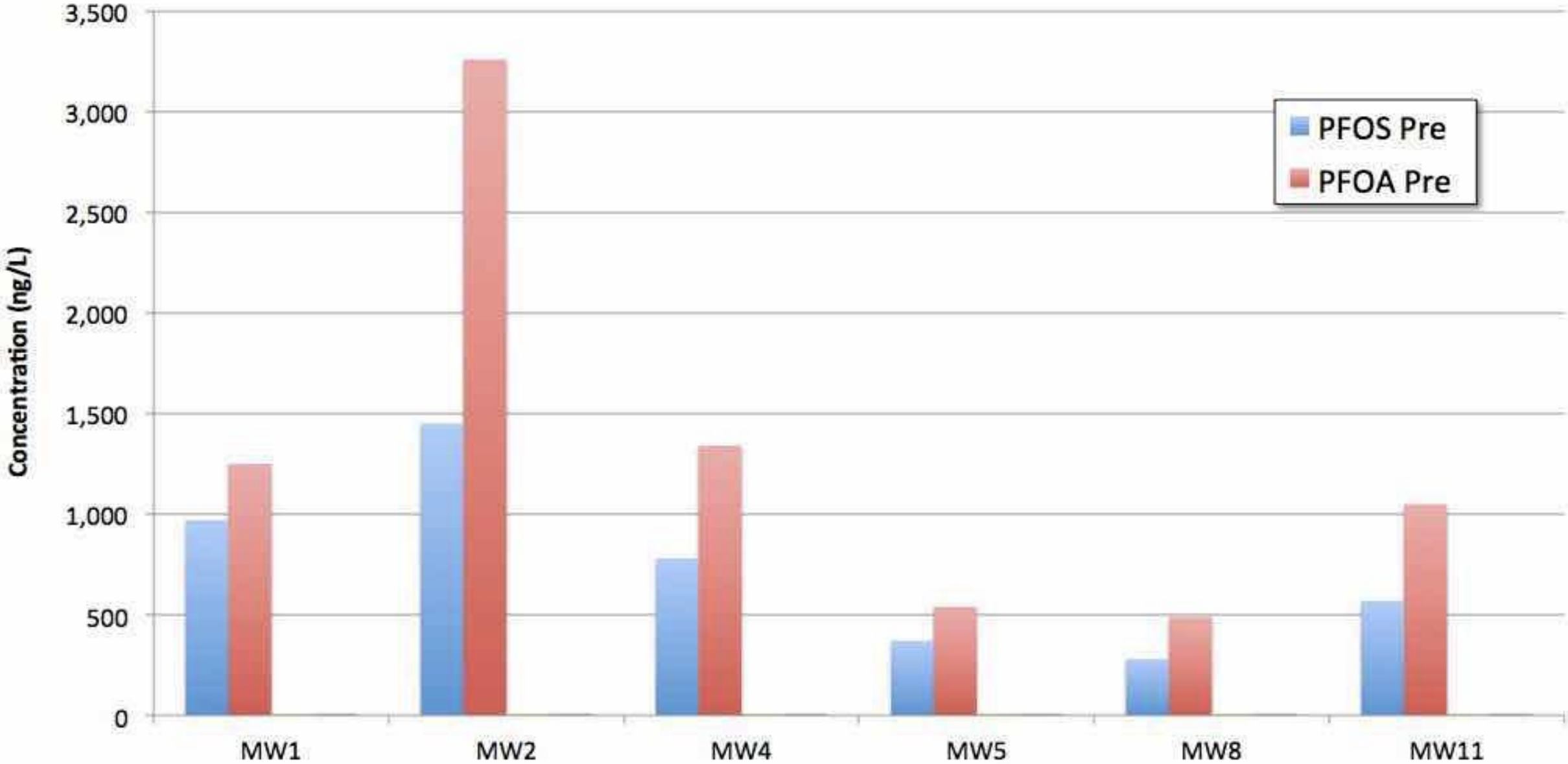
Results

- Injection
  - 3 days
  - Good distribution
    - ~3 to 4 m radius of influence
    - Target zone showed good coverage
  - BTEX and PHC results
    - Non detect within 8 weeks
  - PFOS and PFOA
    - Non detect within 8 weeks
    - Maintained for over a year

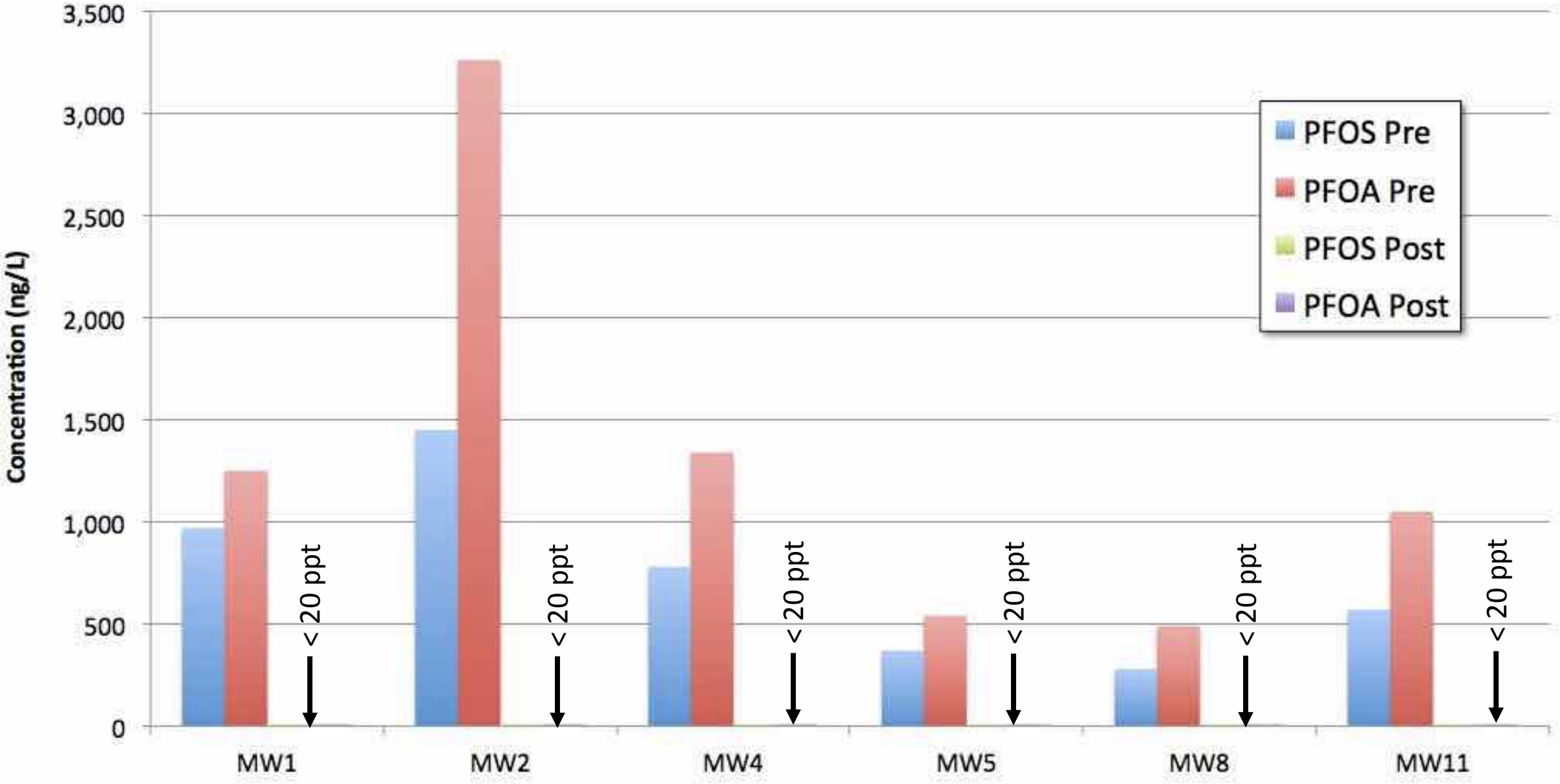


Source G. Carey, 2017

Results


3,500
3,000
2,500
2,000
1,500
1,000
500
0
Concentration (ng/L)
PFOS Pre
PFOA Pre
MW1
MW2
MW4
MW5
MW8
MW11

Results


3,500
3,000
2,500
2,000
1,500
1,000
500
0
Concentration (ng/L)
PFOS Pre
PFOA Pre
PFOS Post
PFOA Post
< 20 ppt
< 20 ppt
< 20 ppt
< 20 ppt
< 20 ppt
< 20 ppt
MW1
MW2
MW4
MW5
MW8
MW11

Preliminary Conclusions

- Liquid activated carbon
  - Effective over the short term for removal of PFOS and PFOA
  - Adsorbed, not destroyed
  - Long term monitoring required for:
    - Partitioning
      - Does it stay on LAC
      - Modelling (Dr Carey)
    - Biodegradation PFOA and PFOS on LAC
      - Does it degrade
      - NGA
      - CSIA

Acknowledgements

Porewater Solutions
Expertise • Experience • Innovation

Grant Carey, President
Porewater Solutions

gcarey@porewater.com

REGENESIS

Jeremy Birnstingl, Vice President
Regenesis

JBirnstingl@Regenesis.com