



*Overburden and Bedrock Remediation Using Activated
Carbon Based Injectates*



Mike Mazzaresse
AST Environmental, Inc.

SMART Remediation
Toronto, ON
January 28, 2016

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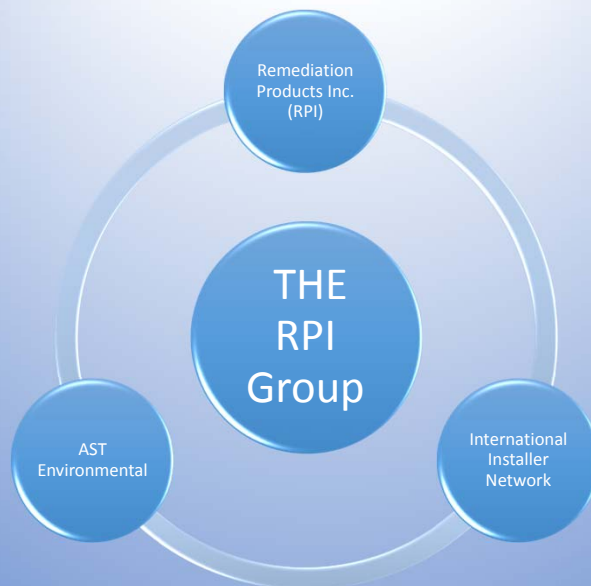


VERTEX
Environmental Inc.

www.vertexenvironmental.ca

Overburden and Bedrock Remediation Using Activated Carbon Based Injectates

Mike Mazzaresse
Senior Engineer
AST Environmental, Inc.



Activated Carbon Based Injectate Technology Overview

- Trap and treat concept
 - Contaminants sorb to activated carbon “trap”
 - Decreases groundwater mass immediately
 - Disrupts groundwater/soil mass equilibrium to help drive desorption
 - Concentrated mass accelerates degradation rates
 - Various degradation mechanisms are used to “treat”
 - Bioremediation (aerobic/anaerobic)
 - Chemical reduction/oxidation

BOS Technologies

- BOS 100
 - Specially manufactured activated carbon impregnated with metallic iron
 - Primarily used to treat chlorinated solvents (ethenes, ethanes, methanes)
- BOS 200
 - Primarily used to treat petroleum hydrocarbons
 - Product consists of:
 - Activated Carbon
 - Terminal electron acceptors
 - Micro and macro nutrients
 - Consortium of facultative bacteria

Proof of Concept or “Treat”

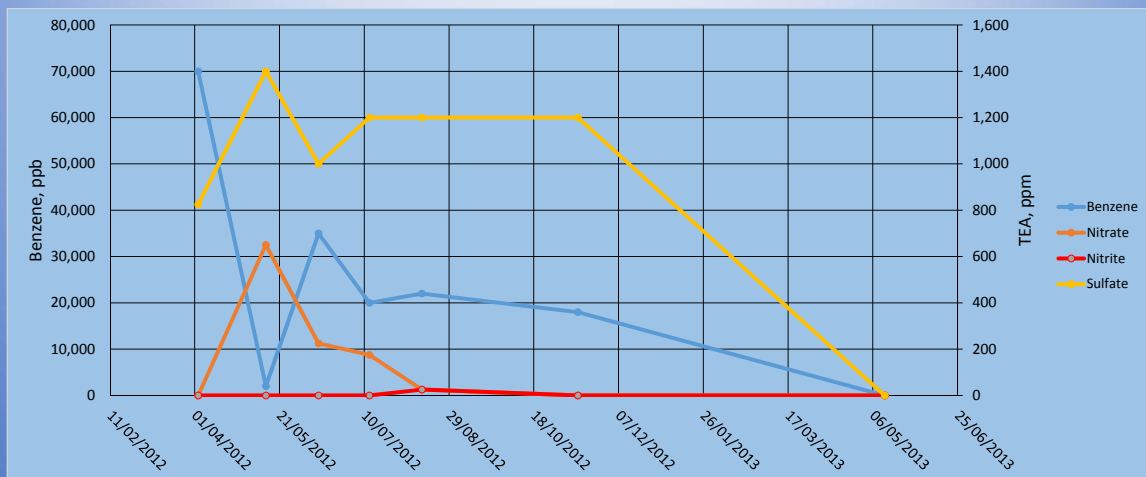
- Terminal electron acceptor depletion (e.g. $\text{NO}_3 \Rightarrow \text{NO}_2$)
- Dissolved Gases (e.g. ethane, ethylene, acetylene)
- Volatile fatty acid generation (e.g. acetate)
- Total mass reduction (groundwater + soil)

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Terminal Electron Acceptor Depletion

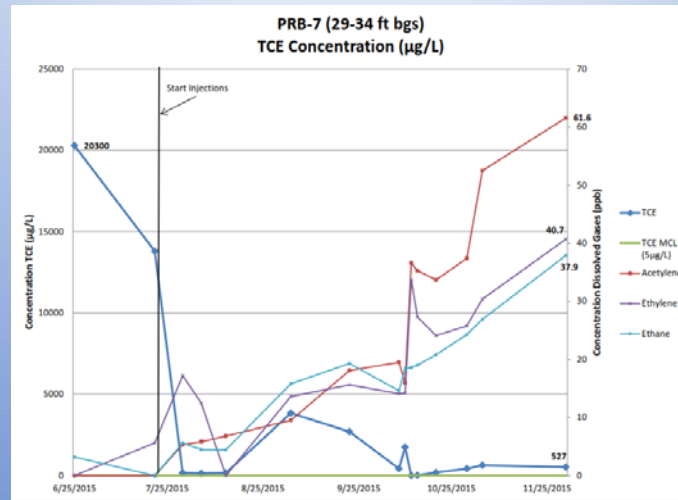


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Dissolved Gas Generation



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A Few Comments Before We Continue.....

- Remediation chemistries work in a beaker/column – so why so many failures?
 - Loading/Dosing
 - Contaminant mass distribution is complex and scales with the heterogeneity of the lithology
 - Soil mass contribution is typically underestimated
 - Contact
 - We all know contact is critical to success
 - Assess distribution to confirm design spacing/injection volumes

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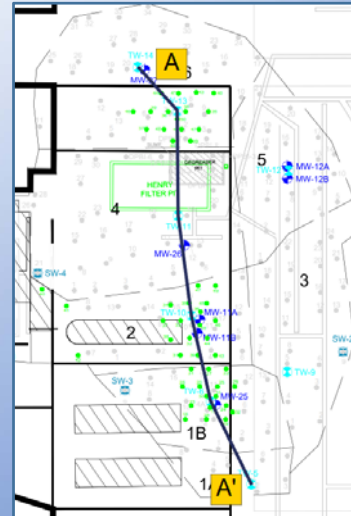
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Remedial Design Characterization (RDC)

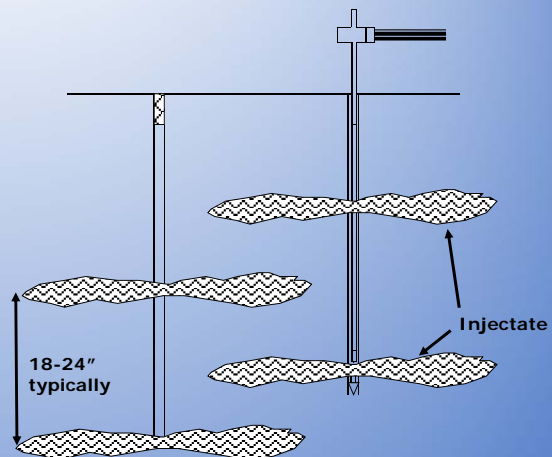
Depth below grade (ft)	A (North)					A' (South)
	TW-14	TW-13	TW-11	TW-10	TW-6	TW-5
0	51	87	63	69	2,862	414
1						
2	106	85	58			841
3						
4	159	2,430	841	612	1,247	3,710
5						
6	1,570	7,195	183	3,068	887	3,277
7						
8	2,220	16	1,560	1,180	1,789	1,973
9						
10	4,191	60	29	18	50	37
11				245		
12	3,160	191	80	Refusal	Refusal	16
13						Refusal
14	2,515	42	116			
15	Refusal	455				
16		Refusal	245			
17			Refusal			

Notes:
 Values are summation of PCE, TCE, cis-1,2 DCE and VC in ug/kg
 Data generated by RPI Laboratory (Golden, CO)



Slurry Application Best Practices

- Proper equipment and field staff
- Develop high resolution (surgical) injection plan
- Assess distribution during pilot test or full scale startup
 - Use implants or nested temp wells and soil coring
- Be prepared to alter spacing, injection volumes, injection tip geometry, etc.
- Top-down critical to success



Bedrock Applications

- Portfolio of bedrock applications growing
- Characterization (geophysics) critical to success
- Proper packer and pumping system selection will help minimize # of injection wells



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Monitoring Well Impacts

- Monitoring wells may be intersected by carbon injectates
- Methodologies in place to minimize injection effects and rehab wells
- Some wells may need to be replaced

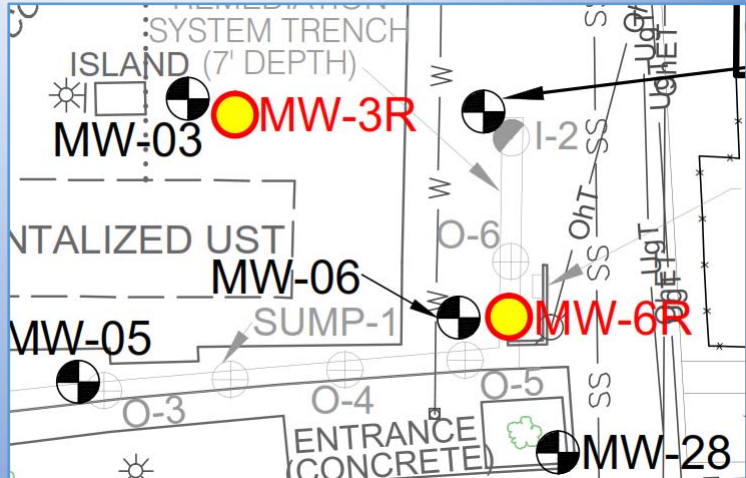
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Replacement Wells

MW Pairs	Benzene		
	Baseline (ppb)	Last Sampling Event (ppb)	% Reduction
MW-3	4,260	ND	100%
MW-3R		96	98%
MW-6	441	ND	100%
MW-6R		41	91%

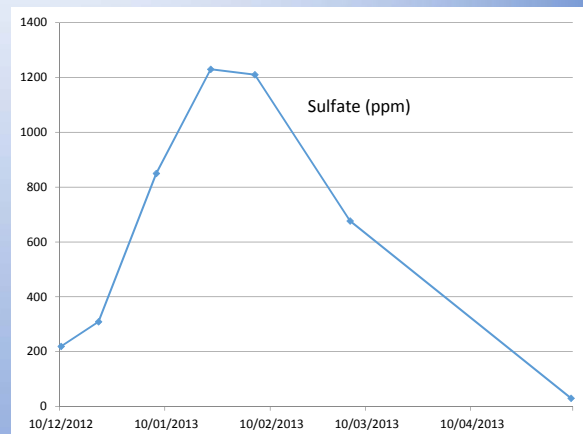
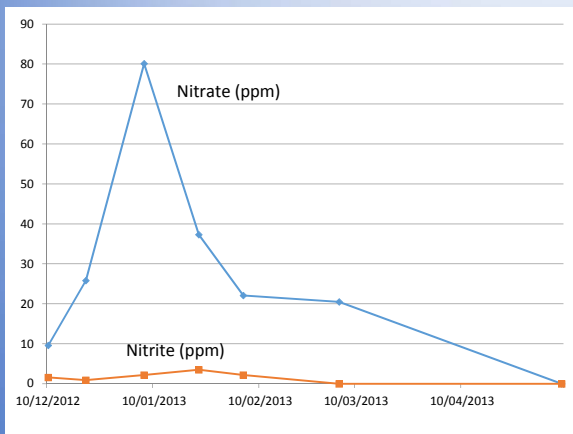


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Post Injection Data – No Carbon Observed During Injection



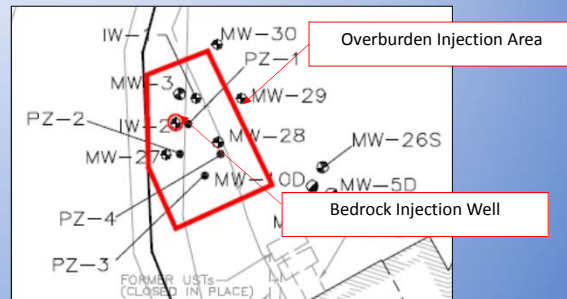
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Project Summary #1

- Former Retail Gas Station
- Impacted groundwater within fractured bedrock (schist) and overburden soil
- Shallow bedrock ~ 3 m bgs
- The initial objective was to evaluate the performance of BOS 200® injections in bedrock
- Overburden injections followed in 2nd mobilization
- Groundwater concentration targets:
 - B = 510 µg/L
 - T = 110 µg/L
 - E = 970 µg/L
 - X = 6,700 µg/L



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Remedial Design Characterization - Bedrock

- Open rock borehole (IW-2) installed for characterization and injection
 - Down hole video logging used to identify fractures (6)
 - Clean water pump tests performed at all fractures
 - Determine ability of features to accept fluid and design volumes
 - Samples collected from transmissive zones (4)
 - Transducers placed in nearby wells to assess connectivity
 - Influence observed at all wells within test area (farthest 8 m) with minimal influence in overburden



B @ 4.1 m = 801 ppb
B @ 4.9 m = 829 ppb
B @ 6.5 m = 577ppb
B @ 6.7 m = 545 ppb

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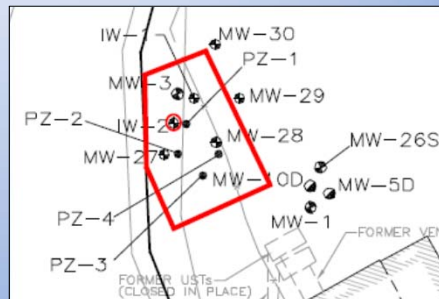
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Remedial Design Characterization - Overburden

- 4 overburden soil sampling locations selected (sampling every 0.6 m vertically, 1.6-3.5 ft bgs)

- Locations converted to temporary piezometers
- Max Benzene in groundwater = 9.89 ppm (PZ-1)



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Implementation

- Bedrock: 1,020 kg BOS 200® (4,320 L)
 - Flow rate = 115-192 lpm
- Overburden: 870 kg BOS 200® injected into 44 pts on 1.6 m spacing (5,900 L)
 - Site divided into two treatment areas based on RDC soil/gw data
 - Injection Zone = 1.6-3.5 m bgs
 - Flow rate = 115-134 lpm

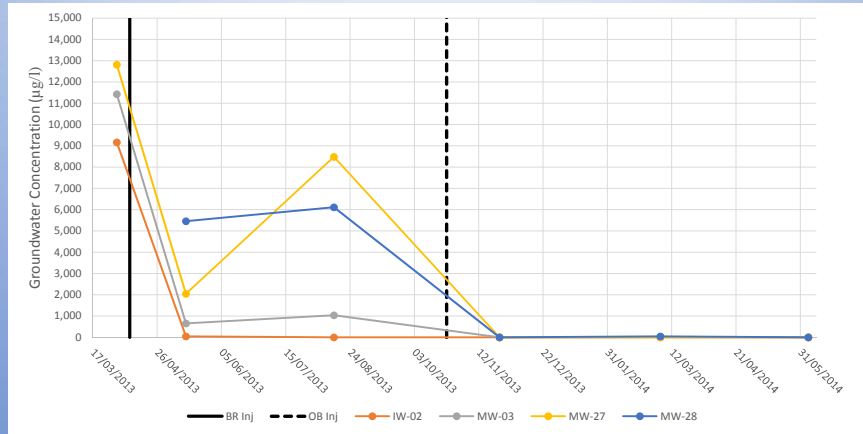


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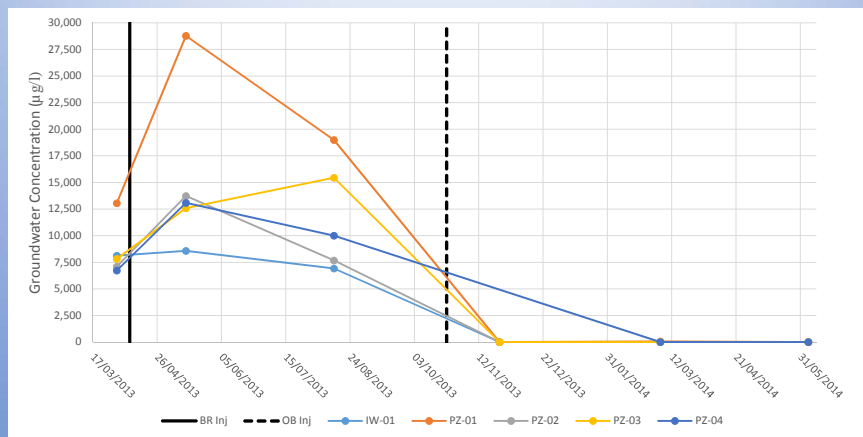
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Bedrock/Transition Well Data



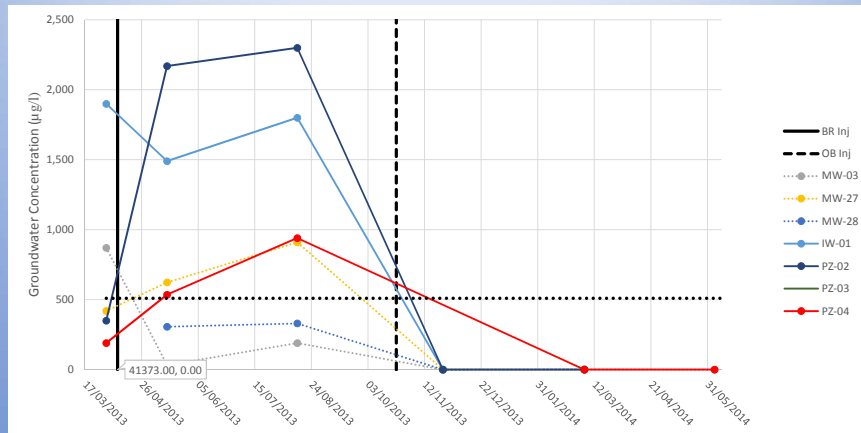
BTEX + MTBE Data

Overburden Well Data



BTEX + MTBE Data

Benzene Only Data



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Project Summary #2

- Former bulk storage facility
- Extensive excavation (performed by others)
- BOS 200® pilot test performed 2008
- Remedial Design Characterization and Full Scale performed 2011/early 2012
- NFA granted after 8 quarters
 - Post injection soil sampling completed to compare against RDC data

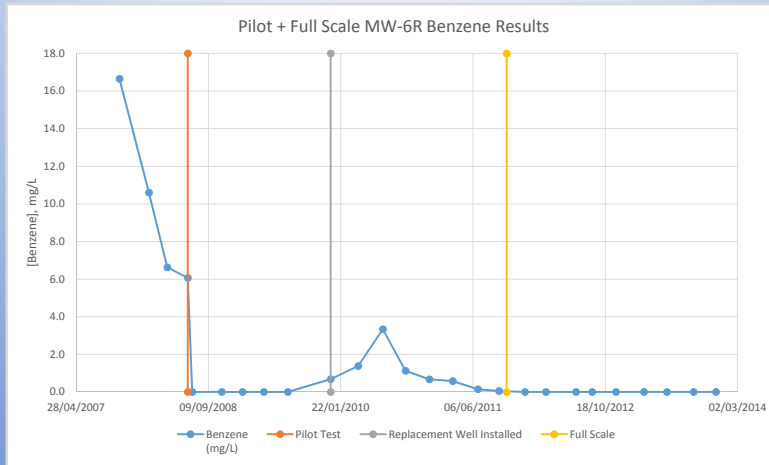


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Pilot Test + Full Scale Data

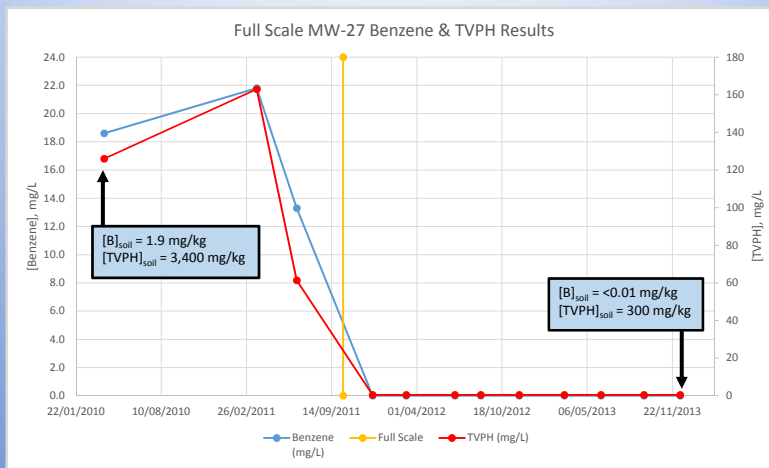


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Pre and Post Injection Soil Sample Data



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Technology Adoption

Consultants

- AECOM/URS
- Kleinfelder
- AMEC FW
- Stantec
- Antea
- CH2M
- Parsons
- Weston
- Arcadis
- ERM
- +Others

Responsible Parties

- Exxon Mobil
- BP
- Shell
- Chevron
- 7-11
- Conoco-Phillips
- CSX
- GE
- Noble Energy
- DOD/DOE
- +Others

Thank you for your time.

Questions?