

Nested Horizontal Wells Selected to Assess, Inject, and Monitor a Multi-Aquifer Chlorinated Solvent Plume



Presenter:
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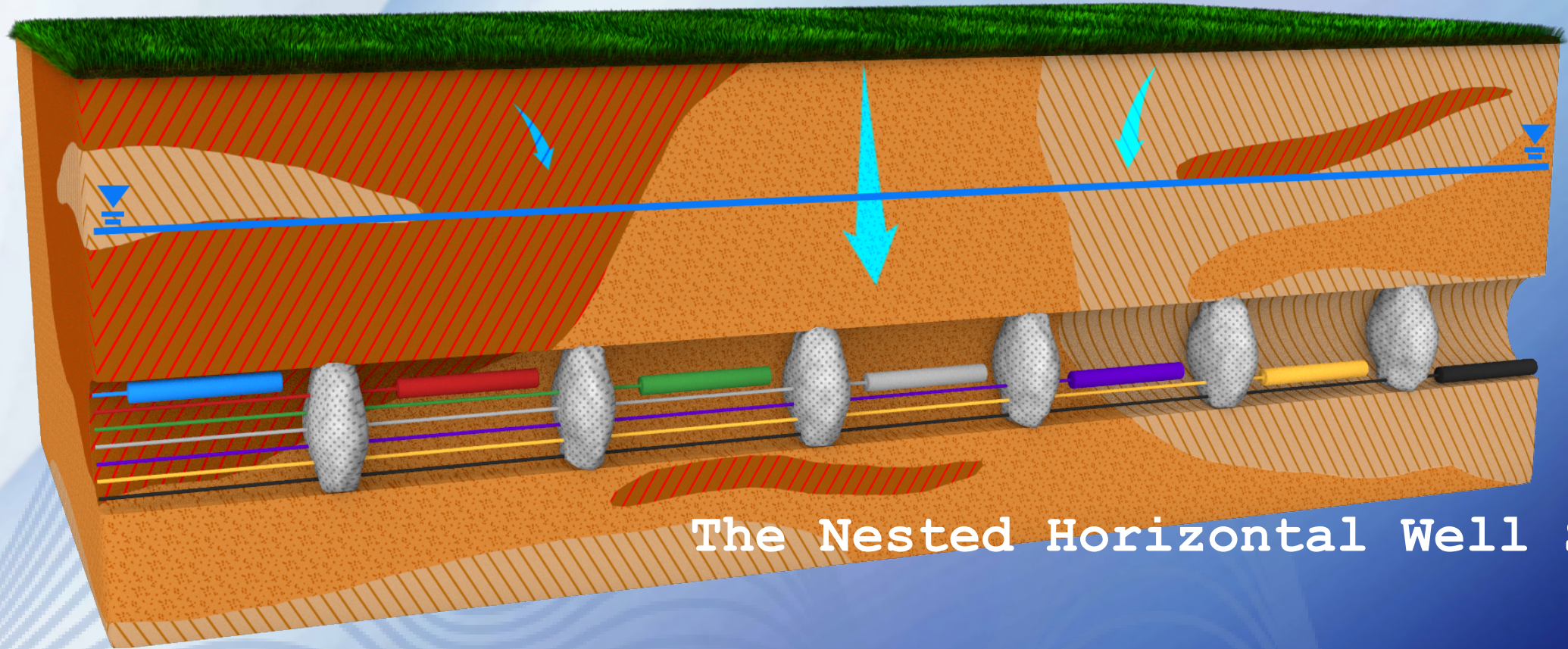
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Presentation Overview

- What is a nested horizontal well? Vertebrae™
 - General Description
- What is it used for?
- Project Summary
- Initial Data
- Performance Data
- Utility of Vertebrae
- Data Gaps and How They Cause Risk





The Nested Horizontal Well System™!



Total Halogenated Volatile Organic Compounds
HVOCs in ppb

98

Groundwater Sample Location

6820

BDL

41

BDL

BDL

Dry Cleaner Site
Shallow Zone – Vertical Data



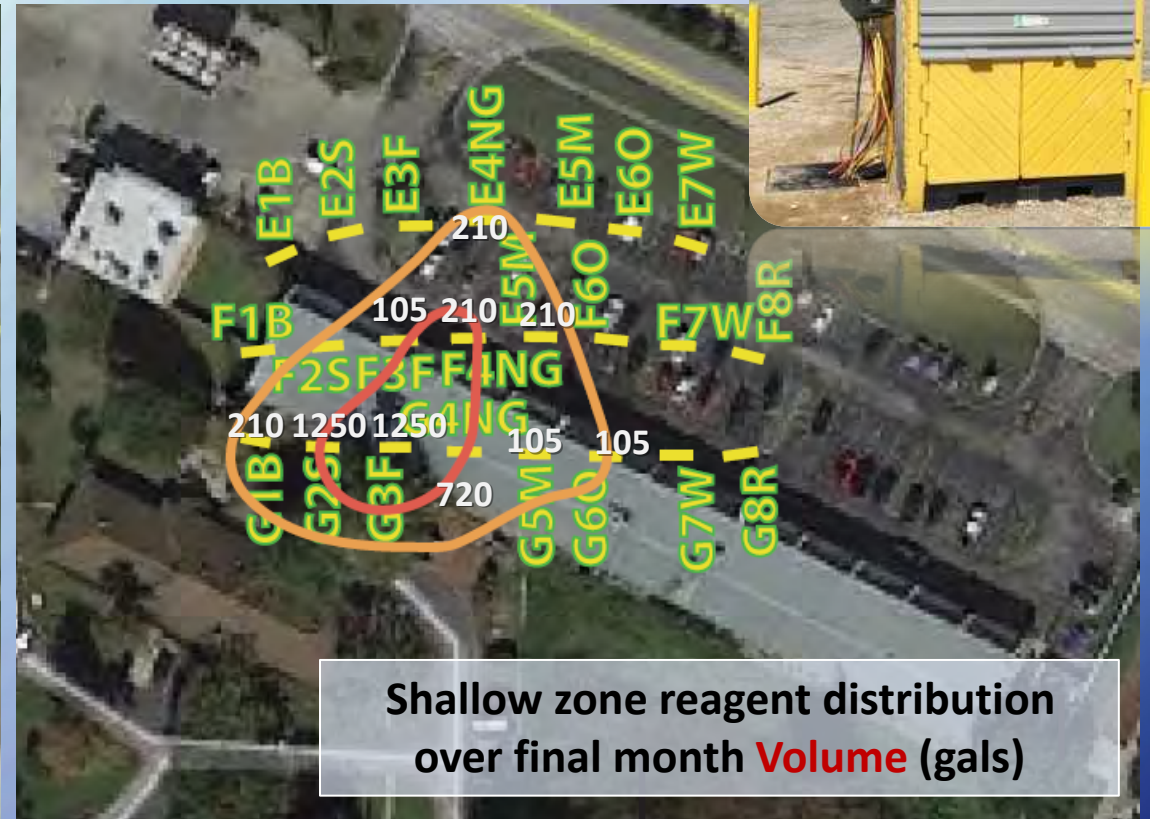
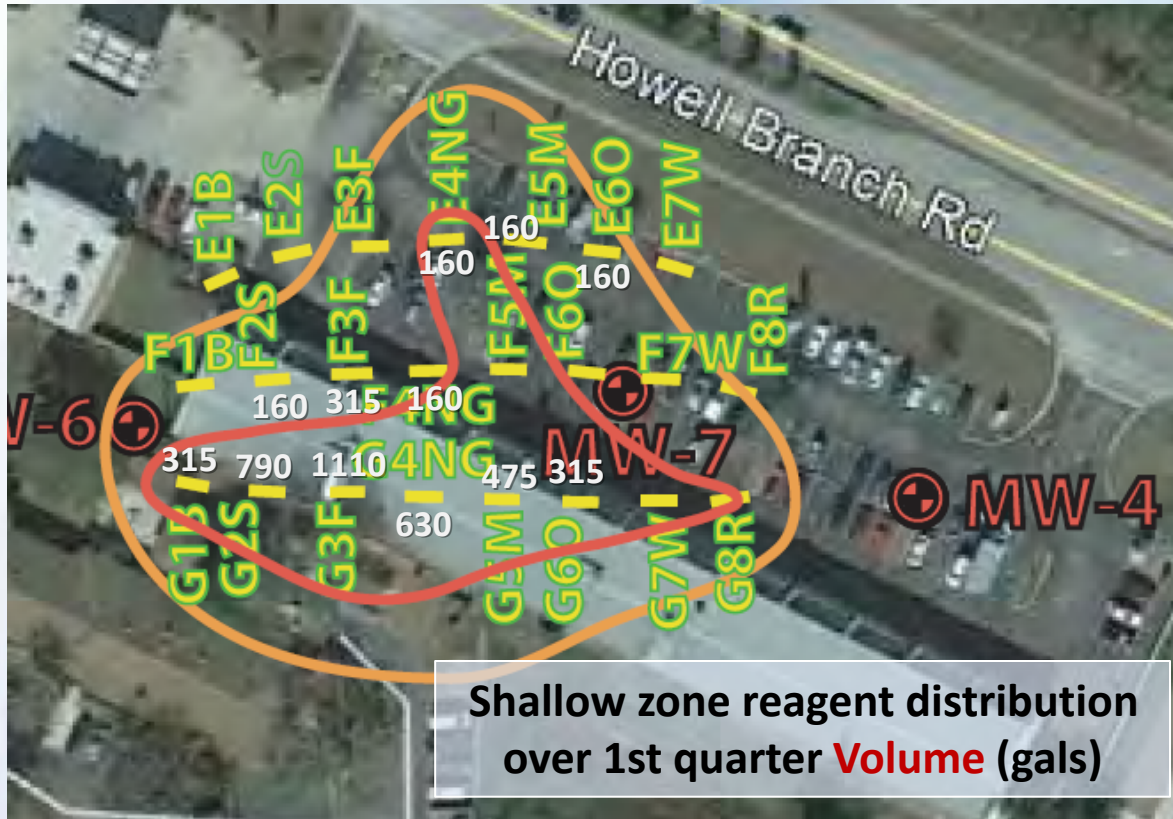
Dry Cleaner Site
Shallow Zone – Horizontal Data



Utility of Vertebrae

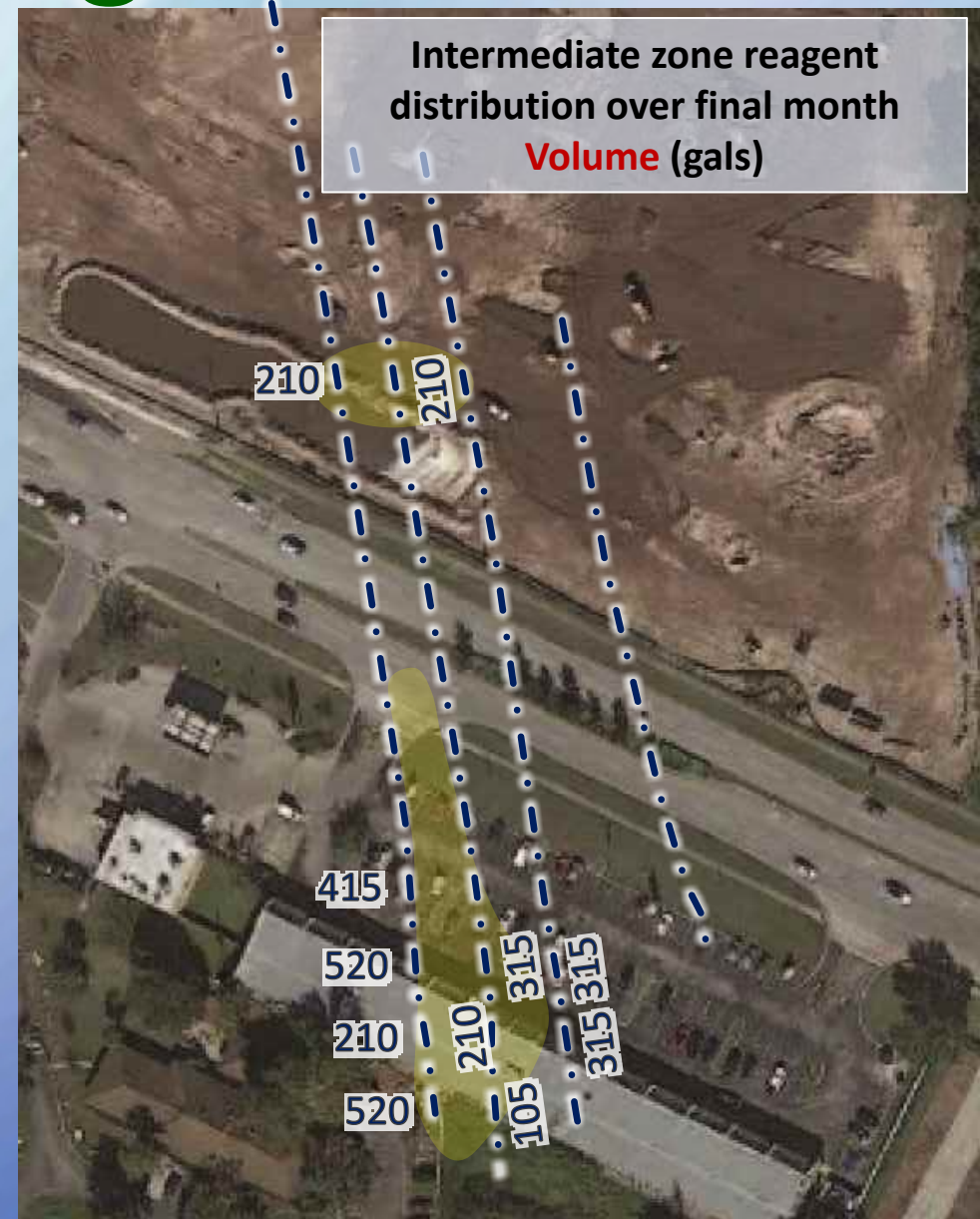
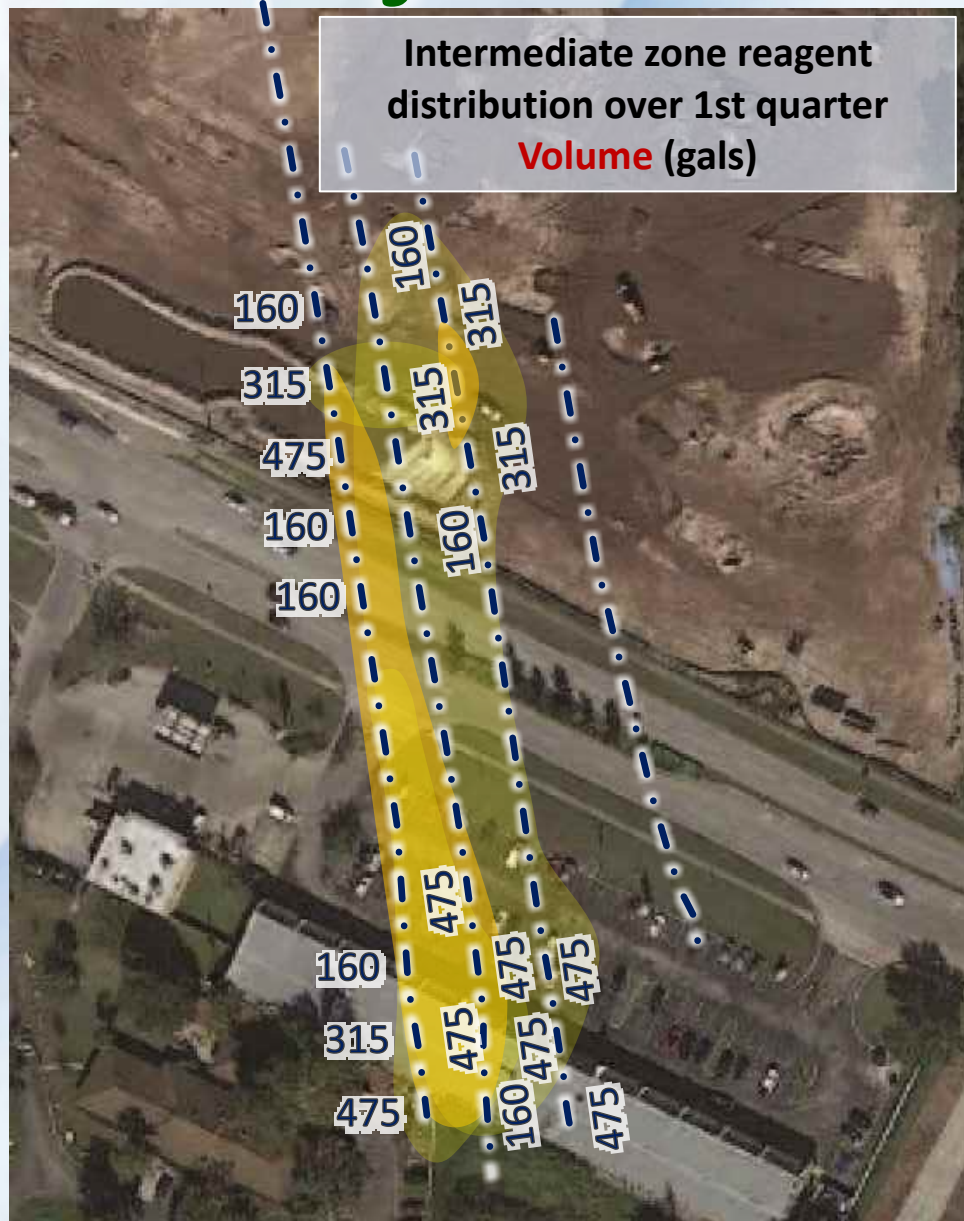
- Through enhancement of the CSM, Vertebrae provides:
 - Ability to precisely define impacted areas for targeted treatment
 - Better pinpointing of the source/plume center
 - Increased accuracy of mass calculations and remedial design
- Increased screened area and length allows for higher injection and recovery rates
- Customized distribution of wells within a single stratigraphic unit allows for active treatment where it's needed
- **Adjustments** are **simple** and this is the feature that sets it apart from traditional horizontal wells.

Injection through Vertebrae



- 32 total VWS injection wells were used during the active remediation in both shallow and intermediate zones
- Every 1-2 quarters adjustments were made based on sampling feedback to optimize contaminant reductions

Injection through Vertebrae



Performance Data

- Vertebrae individual screens were sampled throughout the remedial process
- Results ranged due to bias, desorption, and water table levels, but long-term decreases were measured

Shallow Zone Summary of Total VOCs					
Well	Aug 2018	May 2019	Aug 2019	Nov 2019	Feb 2020
E4NG	1547	196	73	NS	209
F4NG	267	NS	678	2281	7
G1B	4450	NS	NS	NS	315
G3F	24330	264	5230	10110	109
G6O	4880	NS	175	115	NS

Intermediate Zone Summary of Total VOCs					
Well	Aug 2018	May 2019	Aug 2019	Nov 2019	Feb 2020
MW-7	1090	1330	514	584	883
A7W	1245	NS	131	149	NS
A11GO	2624	NS	132	246	NS
A15G	1642	NS	NS	1276	NS
A18Y	NS	NS	834	1420	137
C5M	1371	7	149	214	NS

Sequence Notes

- The sampling data was used to fine tune the quarterly injection plan. Initially all injection wells ran for 20 minute cycles, and after blanketing the site, specific wells were targeted from 10-60 minutes each.
- Injection was discontinued 1-2 weeks prior to sampling events. Sampling bias was seen, but overall reduction patterns were used to make reagent injection adjustments and gauge success.

Be Consistent



Reduction Data

- **Several factors are discussed for net reduction:**
 - Initial mass estimates were low and remedial approach static
 - Escrow funding locked ability to increase injection amount
- **Goals were met:**
 - The ability to control Vertebrae and target hidden mass allowed best use of the funding provided
- **Reduced Mass**
 - Shallow zone VOC mass decreased **98%** from an estimated 82.3 lbs to 2.02 lbs
 - Intermediate zone VOC mass decreased **88%** from an estimated 44 lbs to 5.3 lbs

Total Halogenated Volatile Organic Compounds
HVOCs in ppb



1-Year From Start of Active
Remediation Using Vertebrae™
and FOCIS™

~98% reduction
in mass!

Dry Cleaner Site - Orlando
Shallow Zone



Total Halogenated Volatile Organic Compounds
HVOCs in ppb

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Dry Cleaner Site
Orlando
Intermediate Zone



Additional Thoughts

- **A common lesson learned for many of our various clients' centers around mass (pun intended)**
 - You can't treat what you don't understand
 - Mass beneath object must be properly identified
 - Preferable before Feasibility studies/ Money Allotments /etc.
- **Data Gaps include conventional spaced data areas**
 - HRSC has been saying this for years now, however vertebrae can horizontally average many of these zones providing another sufficient way to increase understanding and reduce risk (what vertical compositing is often used for)



Data Gap Findings

?
Extrapolation

?
Interpolation

Groundwater Sample Location

?
Under Obstacles

?
Between
Normal
Spacing

Shallow Zone

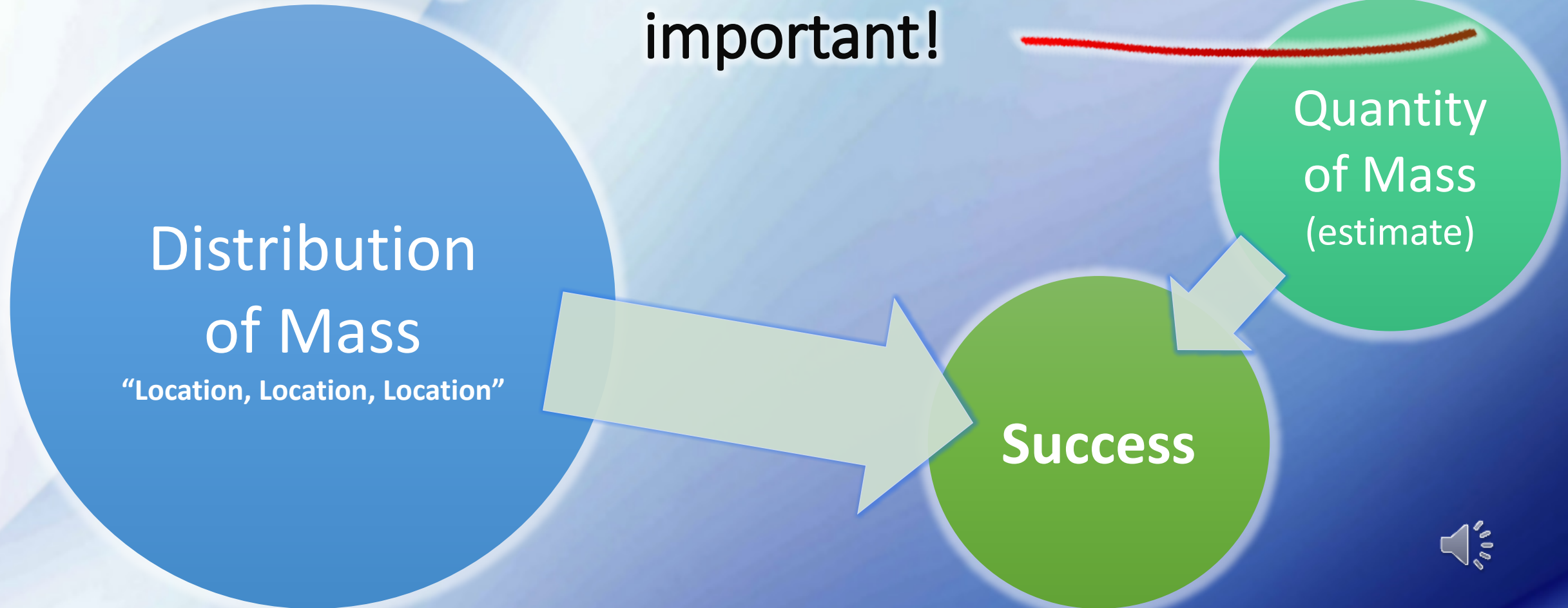
Data From Vertebrae Wells Improved CSM!

- Most sites are currently installing Vertebrae well systems during the remedial action phase
- Site where Vertebrae were used to update the CSM it has led to:
 - Higher mass estimates
Average of 4 times more!
 - Better pinpointing of the source/plume center
Always as Density Changes!

Sites With Vertebrae for Gaps				
Site	Initial Mass Estimate (lbs)	Updated Mass Estimate (lbs)	Mass Change	Change In Plume Center/Mass Distribution
Light Industrial SW FL	820	7,022	8.56 X	Y
Elegance Central FL S	10	82	8.20 X	Y
Elegance Central FL I	64	44	-0.68 X	Y
NASA (SE US)	3,120	16,290	5.22 X	Y
C-Store Pensacola, FL	19	37	1.95 X	Y
C-Store Milton, FL *	785	1,406	1.79 X	 Y

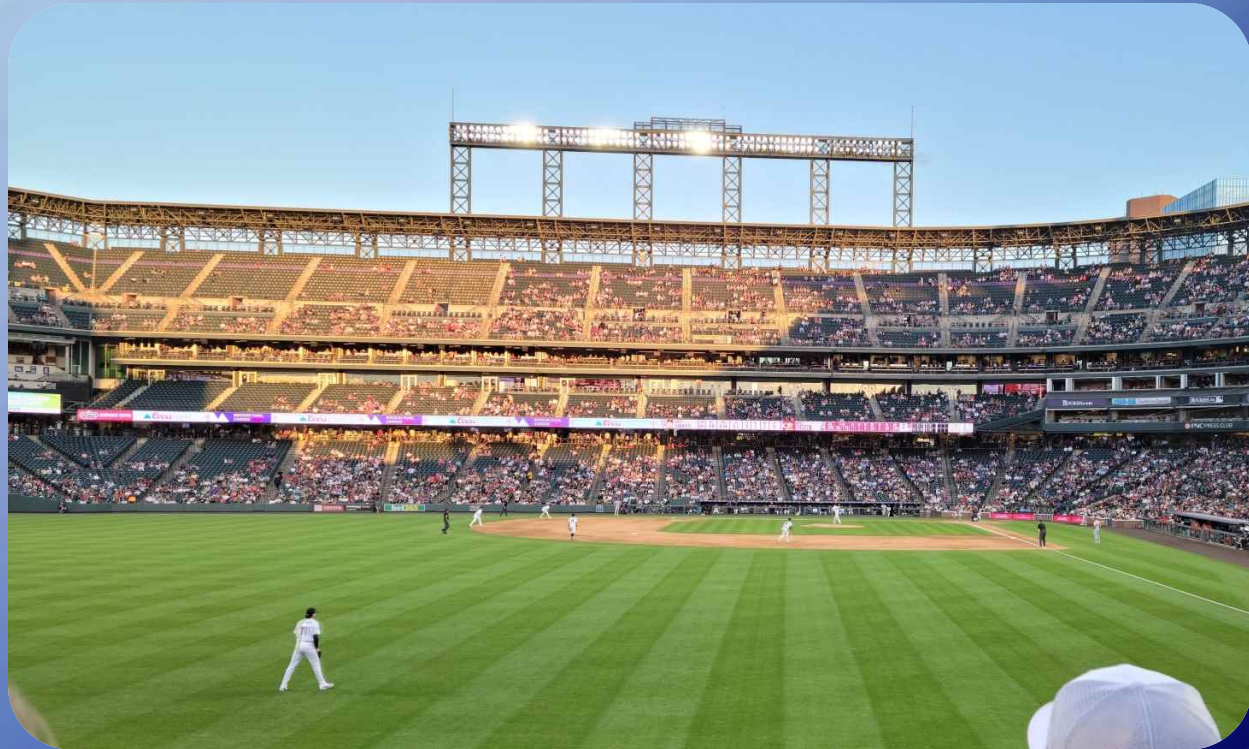
Keys to Success:

Although quantifying the mass is critical,
Treating the mass at its location is more
important!



Final Thoughts

- Horizontal data can be useful at **all** phases of a project!
 - During characterization it is a must as it adds history to the data
 - Performance monitoring during the project adds guidance to treatment schemes in difficult locations
 - Data post remedial activity is also valuable in these difficult to reach areas
- Horizontal treatment delivery can be **Surgical** and **Adjustable**!
 - Proportioning treatment using individual horizontal screens is more efficient
 - Adjusting for the dynamic nature of the plume is not only possible it is prudent





Thanks!

Questions:

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