DETERMINING THE ACCURACY OF INITIAL CHEMICAL ANALYSIS OF GROUNDWATER SAMPLES COLLECTED FROM NEWLY INSTALLED MONITORING WELLS AT UNDERGROUND STORAGE TANK SITES

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Who, what, when and why?



Suspicion of Release cases vs Confirmed Release cases

1987 - Today

?

Protection of Human Health & Environment



SOR vs NOCR

- -Suspicion of Release (SOR)
 - +20 days to hire consultant and submit SOR report
 - +1+ monitoring wells installed
 - + 1 groundwater sample collected
 - +2 3 months before potential case closure

+Notice of Confirmed Release (NOCR)

+ 20 days to hire consultant and submit Initial Response and Abatement and Initial Site Characterization Report (ISCR)
+ Multiple samples collected over many years



Only 1 Groundwater sample?!

- +That's right. Only 1...
- +OES observations:
 - + Case closure is determined off that 1 groundwater sample, but...
 - + Benzene in groundwater concentrations have increased during second groundwater sampling.
- +Human Health & Environment truly safe??











Step 1: Compile the Data

Install Date	1st Sam Date	pling Ə	nterval (Days)	2n Samp Dat	d Ir bling 2 te	terval (1st to 2nd Sample) (Days only)	Interval (1 Sam (Years,Mon	st to 2nd ple) ths&Days)
10/14/1998	11/12/1	998	29	4/7/2	000	512	1Y 4M	26D
11/29/2018	12/4/20	018	5	8/8/2	019	247	0Y 8N	/I 4D
6/12/1997	6/19/19	997	7	5/5/1	999	685	1Y 10N	/I 16D
5/30/2002	6/18/20	002	19	5/20/2	2005	1067	2Y 11I	VI 2D
8/4/2016	8/17/20	016	13	1/3/2	017	139	0Y 4M	17D
First Sampling					Second Sampling			
MW1 Conc. (mg/L)	MW2 Conc. (mg/L)	MW3 Conc. (mg/L	∩ C) (n	IW4 onc. ng/L)	MW1 Conc	MW2 c. Conc.	MW3 Conc.	MW4 Conc.
9.32	12.1	5.70	1	3.3	8.77	14.4	<mark>7.91</mark>	<mark>18.7</mark>
6.97	6.95	5.49	3	3.25	<mark>8.73</mark>	5.72	5.37	<mark>4.64</mark>
3.075	0.321	0.034	3	31.8	1.90	<mark>0.748</mark>	0.006	<mark>46.5</mark>
0.568	0.002	1.67	0	.002	<mark> </mark>	0.002	<mark>5.63</mark>	0.002
0.005	0.005	0.005	0	.005	0.005	5 0.005	0.005	0.005

How often does the benzene concentration increase at second sampling?!

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44.39 mg/L is equivalent to Free Product



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Background Information and Calculations

	Inc. MW1 Yes/No	% Inc./ Dec.	Screen Interval	Distance from Source (ft)	Direction	Develop Free Product?	Free Product Present (Year)	Time Between Installation and Development of Free Product	
	No	6%	10-25	<50	Upgradient	Yes	5/6/2010	11Y 6M 22D	
	Yes	25%	25-45	<50	Downgradient	No			
	No	38%	16-26	<50	Downgradient	No			
	Yes	7715%	5-25	<50	Downgradient	Yes	5/20/2005	2Y 11M 20D	
	No	FALSE	2.5-13	<50	Cross-gradient	No			
Big % Increases = Free Product		 Background Information Collected: Screen Interval Soil type Distance and direction from source to monitoring well Did the well develop Free Product during history of the 							

case? If so, how long between installation and development of Free Product?

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When monitoring wells examined individually:

Increased/Decreased Concentrations Following Second Sampling								
	MW1	MW2	MW3	MW4	Average			
Increased	40%	37%	39%	44%	40%			
Decreased	60%	63%	61%	56%	60%			

However, the results were drastically different if the monitoring wells were not analyzed individually.

If at least one monitoring well per site reflected an increased concentration, approximately **78%** of the one hundred sites exhibited an increase.

Step 2: Statistical Calculations



Does the time lapsed make a difference?

If Increased, Time Lapsed Averages									
	MW1	MW2	MW3	MW4	Average	Y/M/D			
1st Sampling (Days)	38.85	33.22	30.74	8.11	27.73				
2nd Sampling (Days)	307.6	380.43	386.31	392.02	366.59	0 Years 11 Months 31 Days			

If Decreased, Time Lapsed Averages									
	MW1	MW2	MW3	MW4	Average	Y/M/D			
1st Sampling (days)	6.9	11.73	12.61	28.77	15.00				
2nd Sampling (days)	376.43	330.38	324.98	315.02	336.70	0 Years 11 Months 1 Days			

Either way, it takes almost 1 full year to see any difference!

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~30 days



Step 3: Statistical Analysis

- +Gaussian Perspective +Normal distributions
- +Boxplots
 - + No significant changes seen, but mean appears to increase from 1st to 2nd sampling
 + Highly skewed and long tailed

+Bayesian Perspective +Non-normal distributions

+Algorithm constructed to plot differences in concentration for each well with respect to time difference between measurements.





-20

-40

20

0

Histogram of Residuals

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While roughly symmetric, heavy tails are present = non-normality

° 0

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Trend line fitted to plot to reflect difference in concentrations. Trend line is not reliable because the residuals are not normally distributed. Thus, this analysis needed to be fitted to a Bayesian model.

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Bayesian Model Plots

Fourteen (14) plots were run that represent the probability of change over time. Values at 0.00 on the slope axis represent 50% chance for that scenario If a greater % of the area is to the right of 0.00, then there is a larger probability that the increased concentration will occur.



Increased concentration of benzene over time exhibited a 65% chance that benzene increased, and the posterior mean is 0.0054 mg/L. There is a 51% posterior chance that benzene increases at 0.005 mg/L in one year.

Development of Free Product (dfp) plot was used to confirm the successfulness of the analysis. Increased Free Product means increased benzene.



Soil Type Analysis



+Clay soil exhibited the most probability for an increased concentration of benzene over time.

+Case decisions should remain site specific, but soil type is a large factor in decision making.



Outdated Regulations

EPA first proposed regulations in 1987.

- +40 CFR Part 280 Underground Storage Tank Laws
- +Law requiring action in 20-days was based on emergency response, not on long term change.
 - + Leaking Underground Storage Tanks (LUST)
 - +Water Supply Wells
- +USTs have undergone major modifications since 1987.

+The OCC adopted the 20-day time limit and has not adjusted it.

Time for Change

- + Regulations should be reviewed and updated.
- + SOR cases should be kept open longer than 2 3 months.
 - + Collect a second sample! Use that to decide on the future of the case.
 - + Risk Based Screening Levels (RBSLs) are never set for SOR cases.
 - + Consultants take a leap of faith when deciding to close an SOR site.





Thank you!