

Cynicism and Optimism with In Situ Remediation: The other lessons learned



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Needed for successful in situ remediation?

- **Contaminants of Concern**

- What are they
 - Organics, metals, rads, **NAPL**, volatile, other
- Where are they
 - Shallow, deep, continuous, intermittent, other (unknown)
- How low do we need to go

- **Geology**

- Unconsolidated, rock, both, other
- **Heterogeneity (homogeneity is unlikely)**
- Vadose, Groundwater direction, flow, chemistry, biology

- **Other stuff**

- Background and current chemistry
- **Remove, destroy, or immobilize/contain**
- Budget
- Time window
- Planned Future Use

Understanding Delivery and Distribution of Amendments

- **Flowpaths are important**

- Movement of contaminants
- Delivery of amendments
 - Why don't we track?

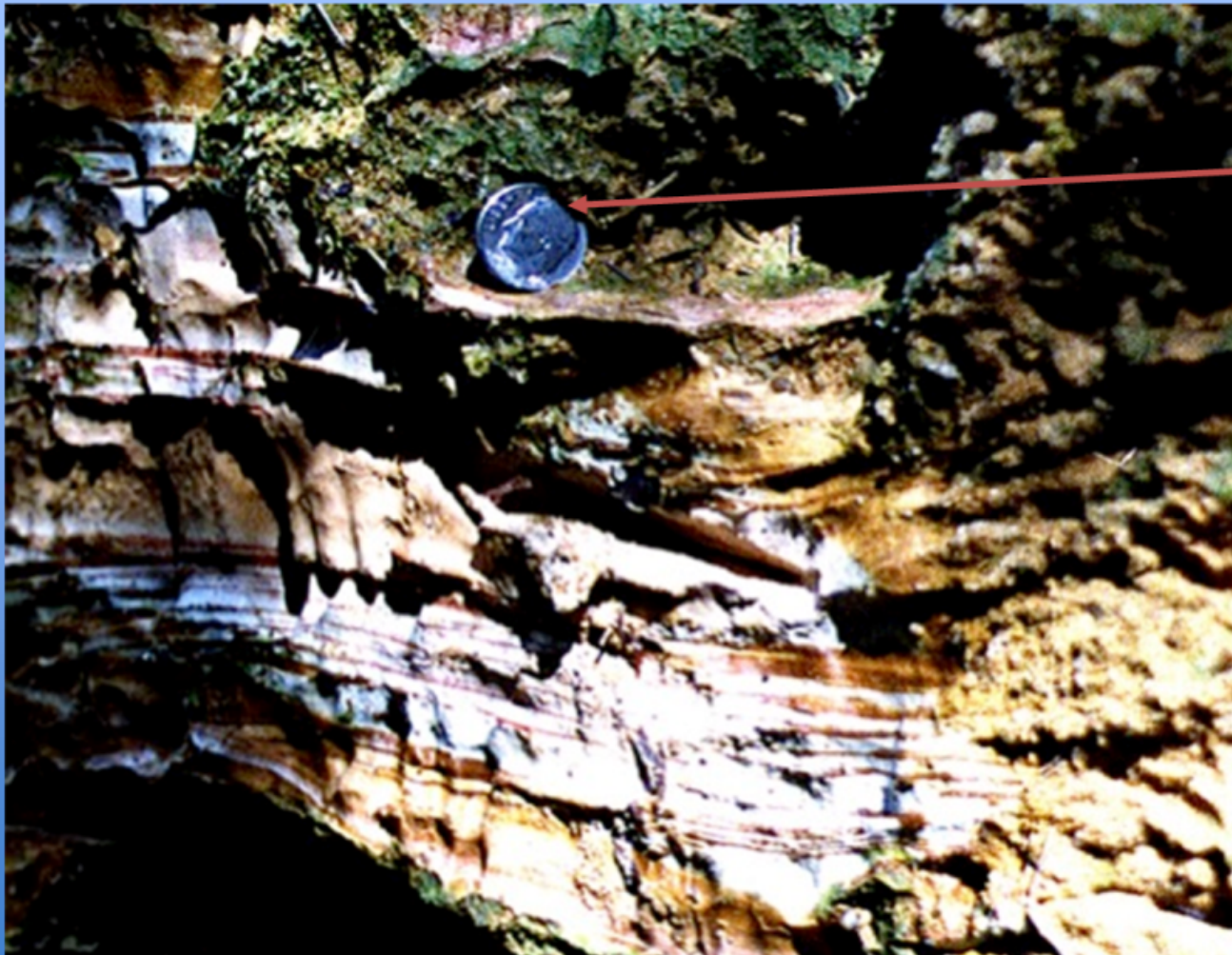
- Dealing with Flowpaths/heterogeneity

- Why scared of "Fracking" unconsolidated materials?
- Soil blending

- **Other Considerations**

- Some contaminants will be displaced
- Some contaminants are really hard to oxidize
- Nano becomes micro
- Control of electrokinetics is hard!
- Hydrolysis can be important

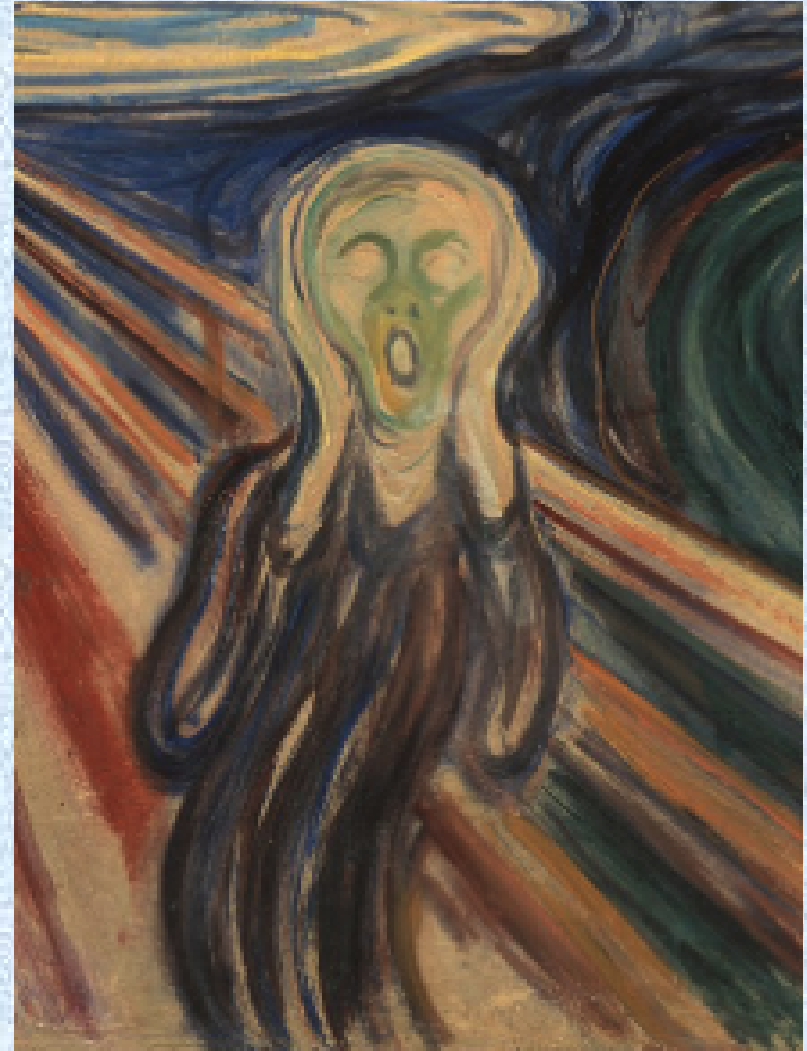
Natural Heterogeneity: **The Crux**



Coin - dime

The Other Things

- Access
- Water
- Deliveries
- Rentals
- Materials
- Personnel
- Subsurface Interference
- Belief in Fallacies
- Bad Trends
- Weather



E. Munch, 1893

Only Minor Access Issues?

- **Getting Equipment to Site**

- Will 2 parking spots be enough?
- Ceiling clearance is fine, just stay between rafters.



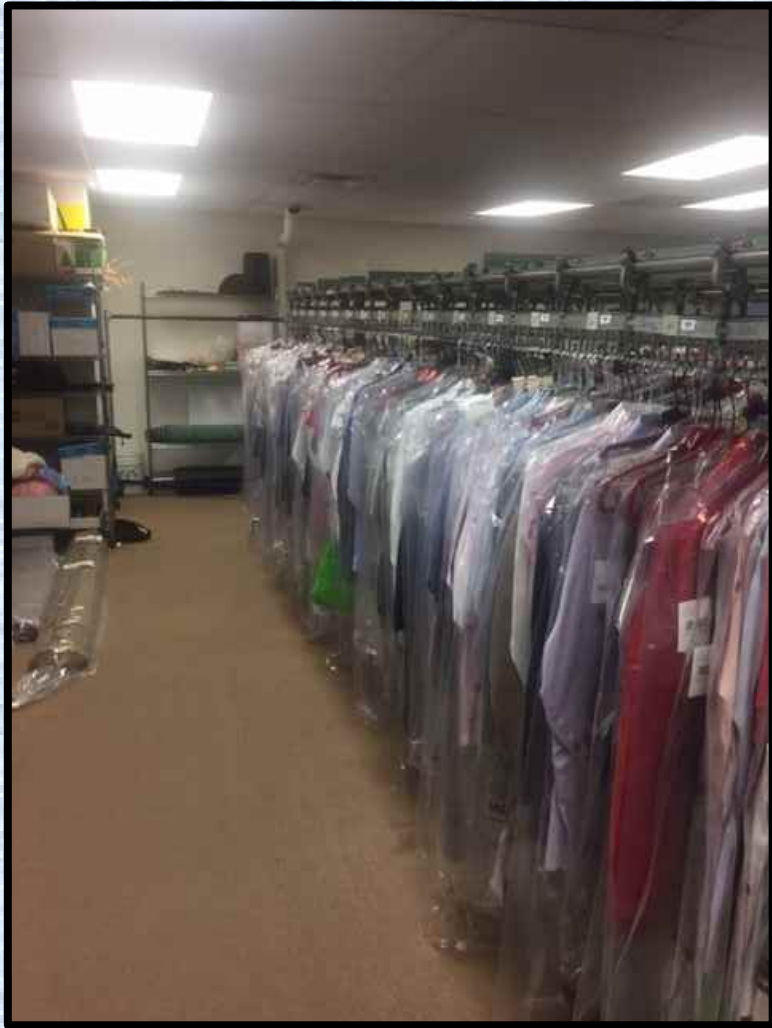
The semi should have no problem going down this road...

- **Active Sites**

- Customer traffic
- H&S, stress
- Night Work
 - move equipment daily



**Safest/easiest approach
not acceptable to owner**



“We thought you were going to move the clothes”

“You can drill in between the racks,
right? Because the tenant’s property
can’t be moved or damaged!”



Water, water everywhere...

- Hydrant - Permission to use?

- Certified meter and backflow preventer.
- Field verified air gaps.
- Can't use hydrants in winter.
- That person is here every other Monday, \$2,000 deposit.



- Other sources

- Don't worry, they've got a hose bib.
 - But the workplan says > 2500 gpd
- Could you just get a water truck out there?
 - CDL, availability?
- How about a delivery?
 - Pool filling season?
- Looks like below zero this weekend

PFAS in water supply. You can drink but you better not inject!

Deliveries

And if you give me weed, whites, and wine...

- **Loading/Unloading**

- Where's your loading dock?
- No pallet jack?
- Hazardous materials?
- Received 12 of 14 pallets, can't find the 2 that we need to start.
 - Usually when more than 1 crew, the client, and regulators waiting

- **Schedule**

- Can we drop it off on Friday before?
- Couldn't make the guarantee, so we'll only charge you regular price
- 95% reliable = 1 of 20 shipments delayed/lost

Main reason Mondays aren't productive!

Rentals are great!

(When they show up and they work)

- **Availability**

- Since we were bought, the national rep hasn't called.
- But we reserved that excavator two months ago!
- What do you mean it's irrigation blow down season?
- Water truck? Haha, that's a good one.

- **Operability**

- The compressor died again.
- Tech must visit, maybe today
- Can't be fixed, send a replacement, maybe tomorrow

But we always send out a lien warning letter before the payment is due.

Materials are material to success

• Properties

- Polysulfide will dissolve rods
- Nano iron is stuck in the well screen...
- Chemical is really viscous when it's cold.
- Secure staging area
 - No pallets of oxidant in the 7-Eleven parking lot.
 - Trailer is missing?!

• Economics

- Chemicals – commodities or brand names?
- Yes they're cheaper, but that chunk in the iron powder just broke my pump
- Guar price is tripled because of spray seeding?!
- Shipping costs higher because fuel price doubled



5 cm shaving found in < 100-micron iron powder

Subsurface Interference

(Not so easy to detect)

- GPR Issues
 - Buried Train
 - Buried concrete tanks
 - Buried footers
 - Buried NAPL - filled drums



It's nothing personnel...

- **Experience and Mentoring**

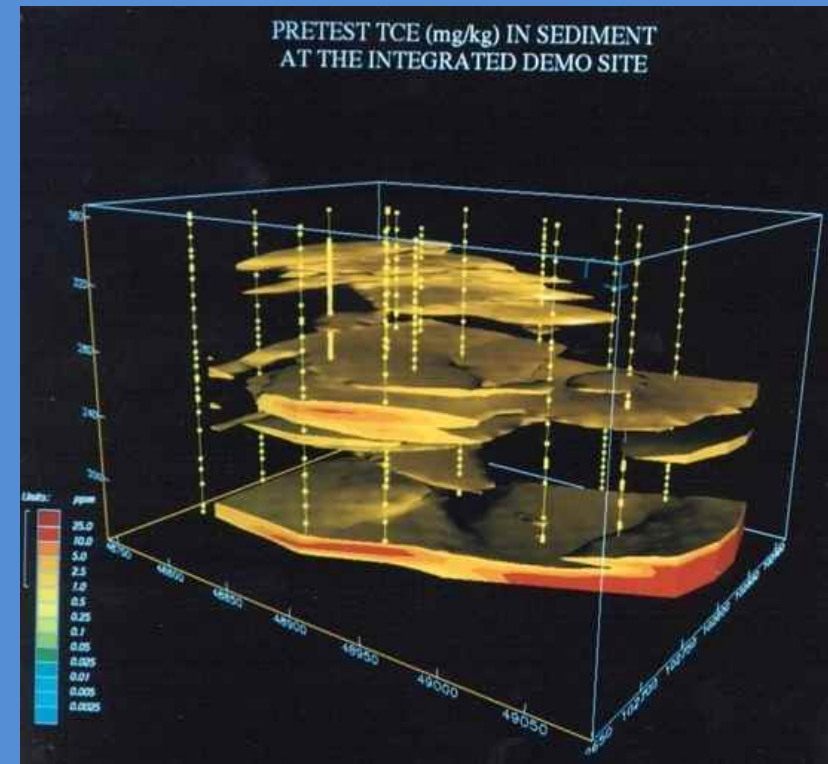
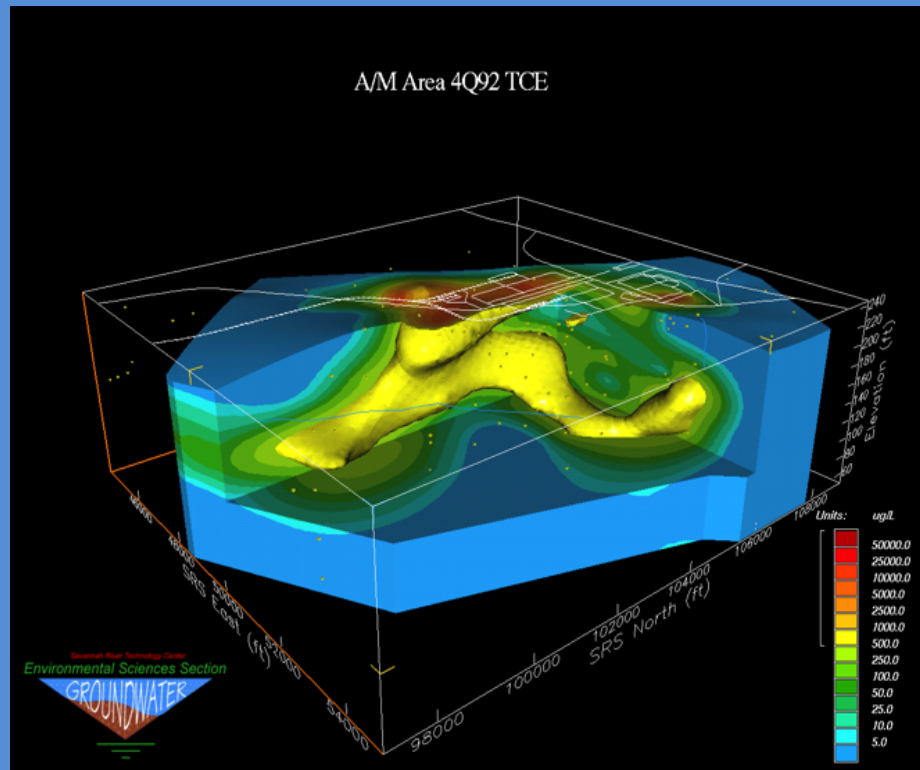
- I'm waiting on call back to confirm injection depths
- So this is your first time doing oversite?
- Shouldn't cost that much extra to angle drill, right?

- **Communication**

- It's college graduation week!!?
- I thought we said the asphalt needed to be cored.
- Decon between remediation injection points?
- Unfortunately, can't work weekends like we thought.

We need to put the injection point right on the contour line!

Great for framing and communicating conceptual models, not great for precise location of contamination.



On us

- **Equipment**

- Well, I checked the tires on this side of the trailer.
- I thought we put a shovel in the truck.
- I know we injected polysulfide last but the rods looked pretty good.
- How many tips did you say we needed?

- **Experience**

- There was only a little iron in the bottom.
- We didn't think it would get that cold overnight.
- You didn't put the water in first?!

- **Design**

- I think I copied the wrong excel box.
- I might have left off a digit or two.
- I rounded but there are 7,000 points.
- How hard is it to measure out 27.35 lbs in the field?

Fallacies

- Science

- Base activated persulfate
 - sulfate radicals?
- Fracking is bad
 - Unconsolidated materials?
- Slow injection rates = better distribution?
- Biological degradation of PCBs, PFAS.
- Careful of cometabolism (e.g., 1,4 dioxane)
- Indigenous powdered ZVI is commonly found in the subsurface

- Technology

- Environmental market is huge
- Pressure pulse is novel
- Remediation locations must be precise even when characterization is not?
- Supercritical fluid, plasma torch, sonolysis are new.
- Trap and Treat?
- Activated carbon is remediation?

Matrix Diffusion and Activated Carbon

- Activated carbon is not new
 - There was a reason early EPA rejected it as an in situ treatment
- Maybe reducing flux rate is ok?
 - Definitely not for very low toxic thresholds
- Limited proof of trap and treat
- Intentionally forcing matrix diffusion, so limited access for future technologies

Bad Trends

- **Economic**

- Pay when paid +
 - That's not how chemical or rental companies are paid
- You need to sign up for our third-party H&S verifiers
 - Assume no liability?
- Liquid damages in contracts?

- **Technical**

- There is NAPL but still need to guarantee < 1 ppb
- We want you to guarantee performance on our design
- You'll carry trash off site, right?
- Track amendment, no don't track amendment

These things lead to fewer quality contractors, and much higher prices.

Good Stuff

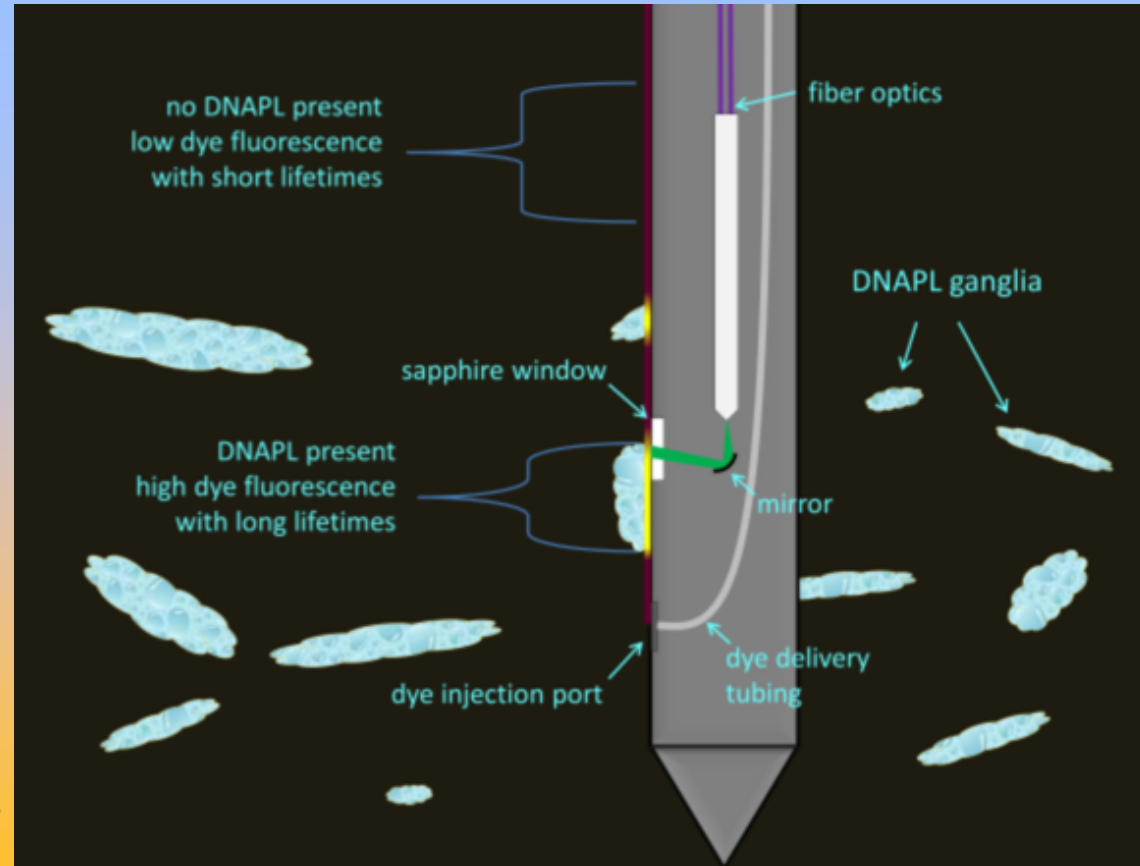
- Acceptance and use of screening techniques
- Growing use of new remediation techniques that better overcome heterogeneity
- Better understanding of chemicals and commodities
- Advances in microbiology analysis, breeding, and understanding of limitations (biological infallibility notwithstanding)

Dye LIF:

High vertical resolution NAPL screening

- Injected hydrophobic dye interacts with NAPL
- Normally non fluorescing NAPL now becomes fluorescent

Supplier: Dakota Technologies



Rotary Drum Soil Blenders



Direct Sonic Injection:

Extends injections beyond refusal



Rapid DNA analyses are cool!

- Microbial community analyses – DNA
 - qPCR and Omics
 - functional genes
 - Biotraps – similar to DNAPL techniques
 - Positive is positive, negative maybe not...
 - Representativeness of samples?
 - Depends on phase, connectedness of media and pathways.

Future: Still bright and challenging

- We're all working towards the same goals!
- Better understanding of standard and niche applications = better remedial success, <\$
- Remediation as characterization tool in complex sites, phases of remediation
- Open site and technique data! Lots of LQ data.
 - Not standardized, multiple formats, multiple technologies, different sites, confidentiality concerns, etc. Yet...
 - With enough data, analytical capabilities (or even “AI”) can build better solutions
 - Cancer/medical diagnosis and treatment, Targeted advertising, DNA analysis, other heterogeneous systems

Sometimes field work is amazing!



Picture Courtesy of Geoff Ives