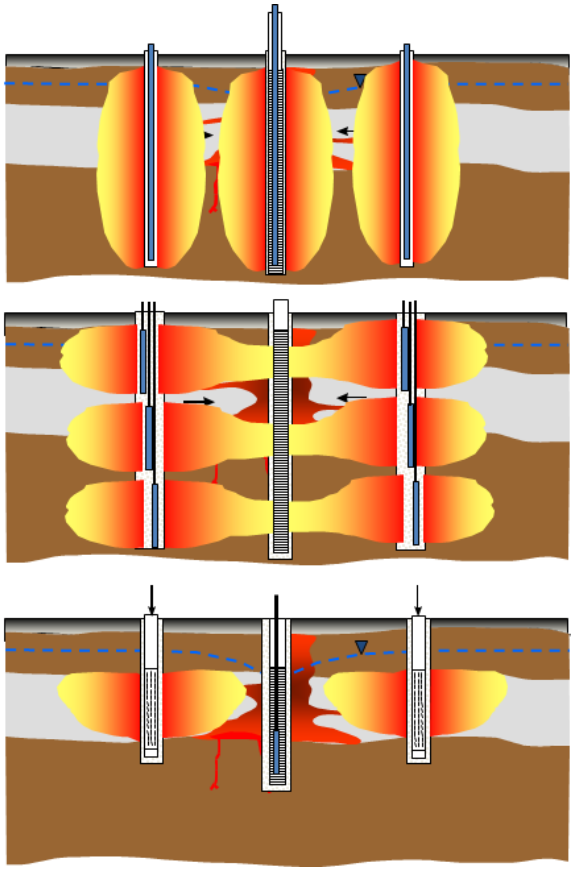
CASCADE
DRILLING | TECHNICAL SERVICES

Combining ERH and TCH for more Effective Remediation – Don't Restrict your ROD or RFP to a Single Heating Technology



Gorm Heron, Jim Galligan, Michael Dodson, Robert Flatley

Cascade Thermal

Facts

1. The cost of energy is less than 20% of the total project cost

2. Steam is 70% cheaper per BTU

3. Cost of ERH and TCH are within 15%

4. TCH used to reach more stringent goals

So WHY?

- *Do so many RODs specify ERH?*

- *Are so many RFPs written for just one thermal technology?*

Technologies

TCH - governed by **thermal conductivity** (*f*~3)

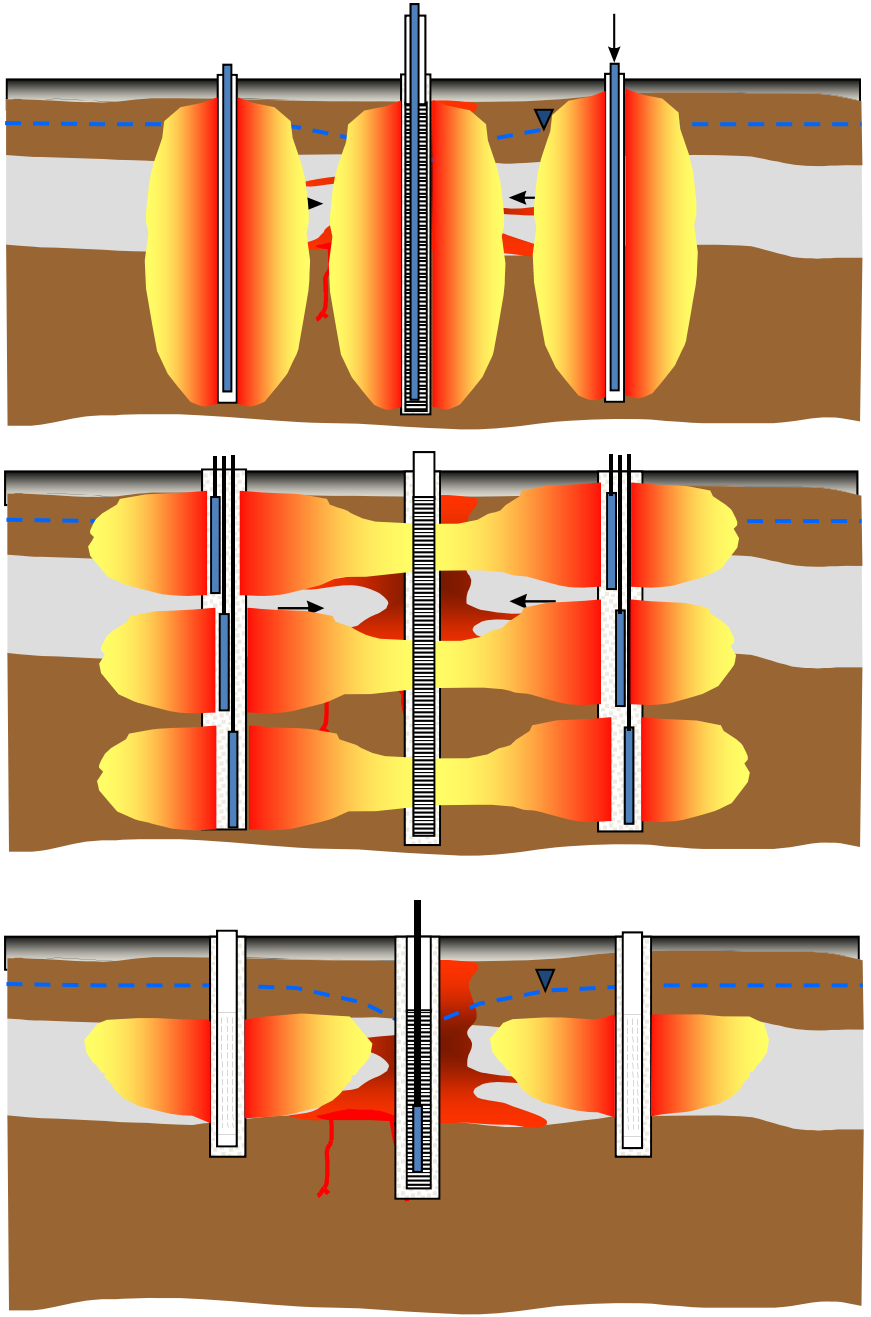
60 sites treated

ERH - governed by **electrical conductivity** (*f*~200)

70 sites treated

SEE - governed by **hydraulic conductivity** (*f*~10^6)

20 sites treated

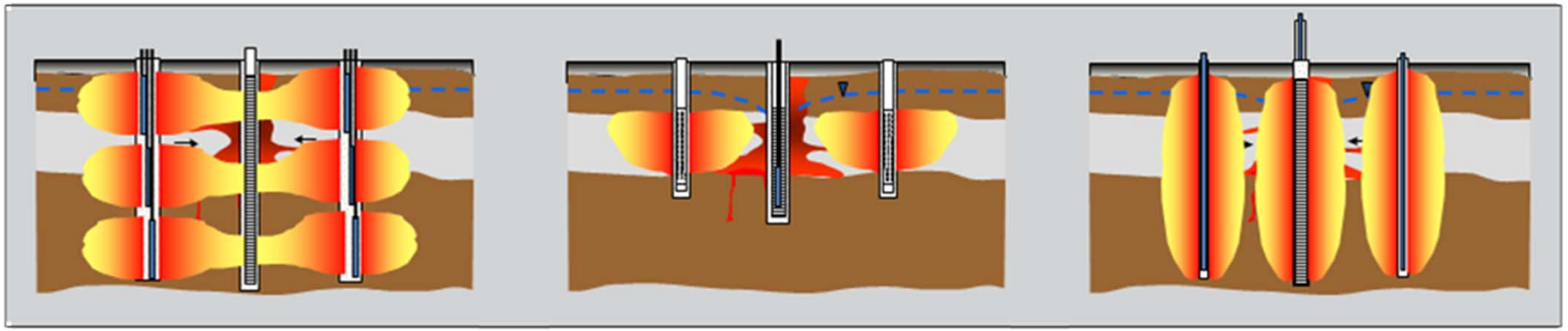


What are the differences?

Electrical Resistance Heating (ERH)

Steam Enhanced Extraction (SEE)

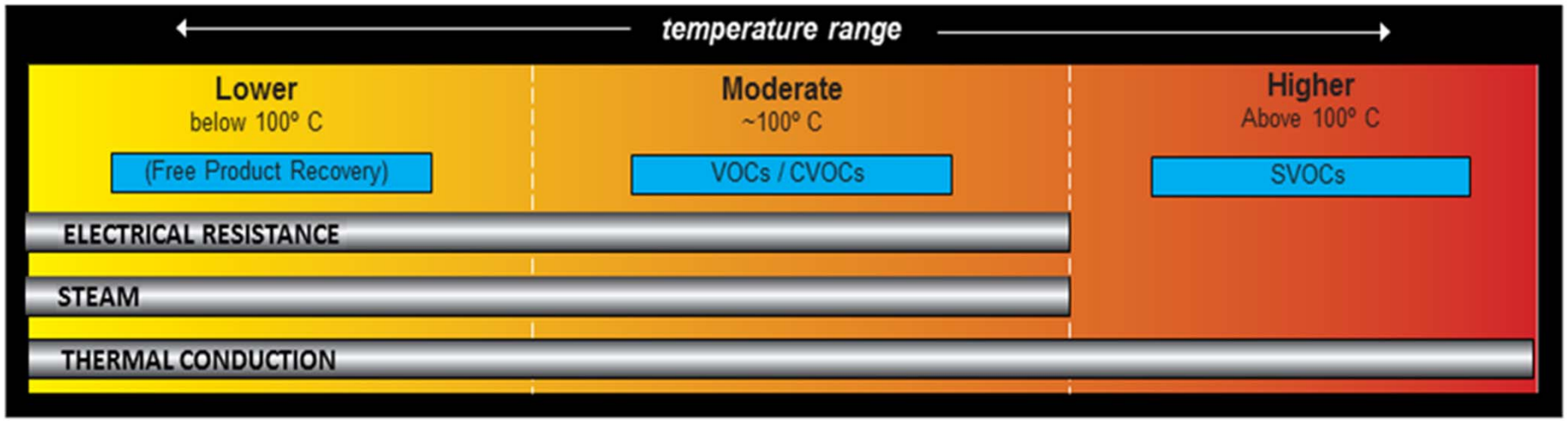
Thermal Conduction Heating (TCH)



For sites with volatile or moderately volatile contaminants particularly in shallow settings.

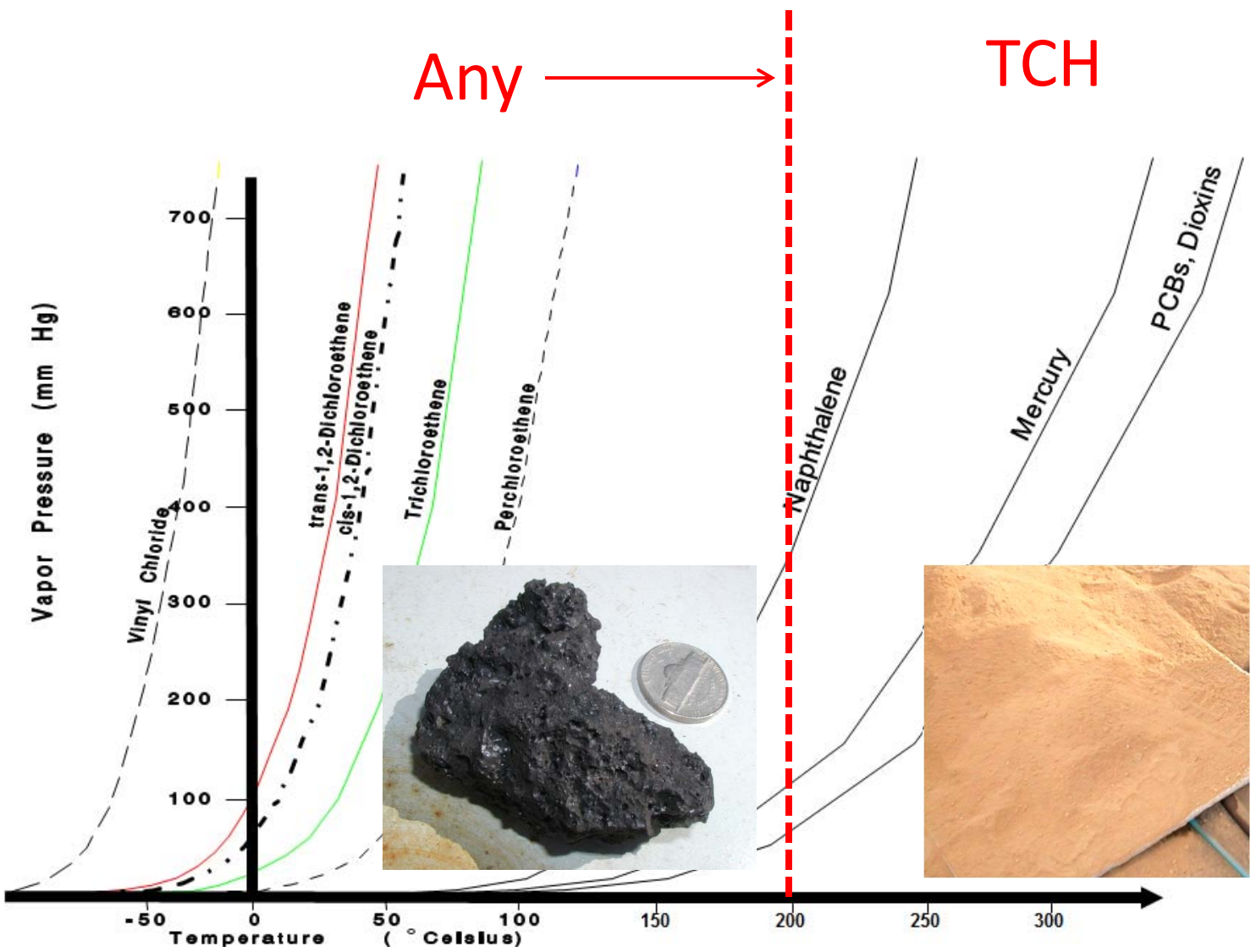
Applicable in permeable sites with significant groundwater flow and for sites with volatile or moderately volatile contaminants.

For all sites with low to moderate groundwater flow rates and either VOCs or SVOCs.



Contaminants

Boiling points rule



Often this is the case:

- *A combination of SEE and ERH or TCH is better and cheaper,*

- *There are things under the buildings, or utility lines that make one technology a better fit,*

- *One technology is safer, or*

- *You could get more competitive pricing if the technology was not specified*

Cheaper – more reliable solutions!

Long plume? Water flows through NAPL

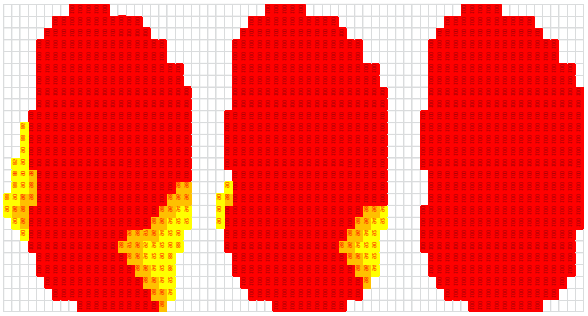
- *Need to keep hydraulic control*
- *Be aware of cooling*
- *Use SEE if you can*

Groundwater Flow Impacts

Issue:

Water flowing faster than expected

Site heating slower than predicted



Solution:

Cut off water

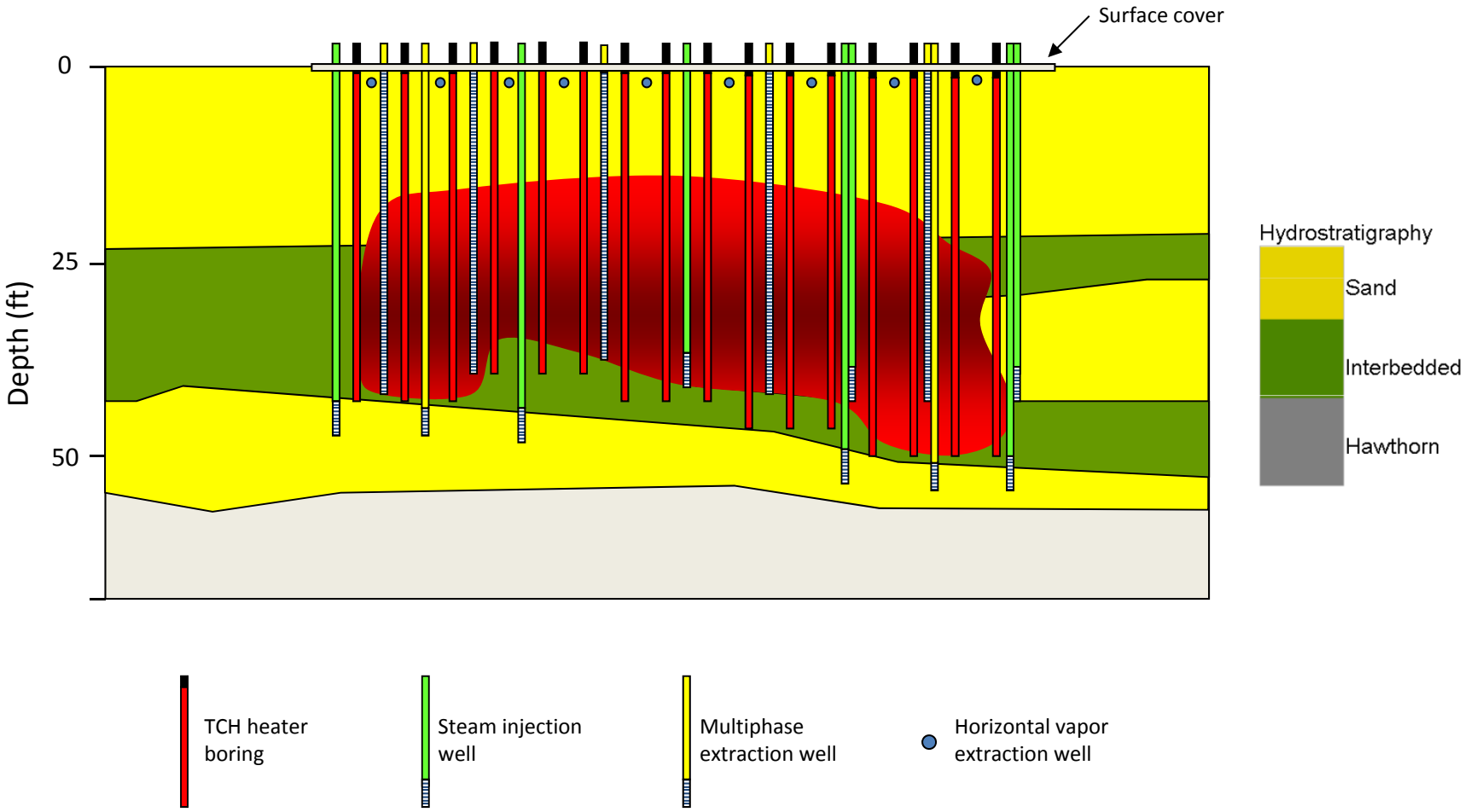
Install more heaters

Add heating capacity

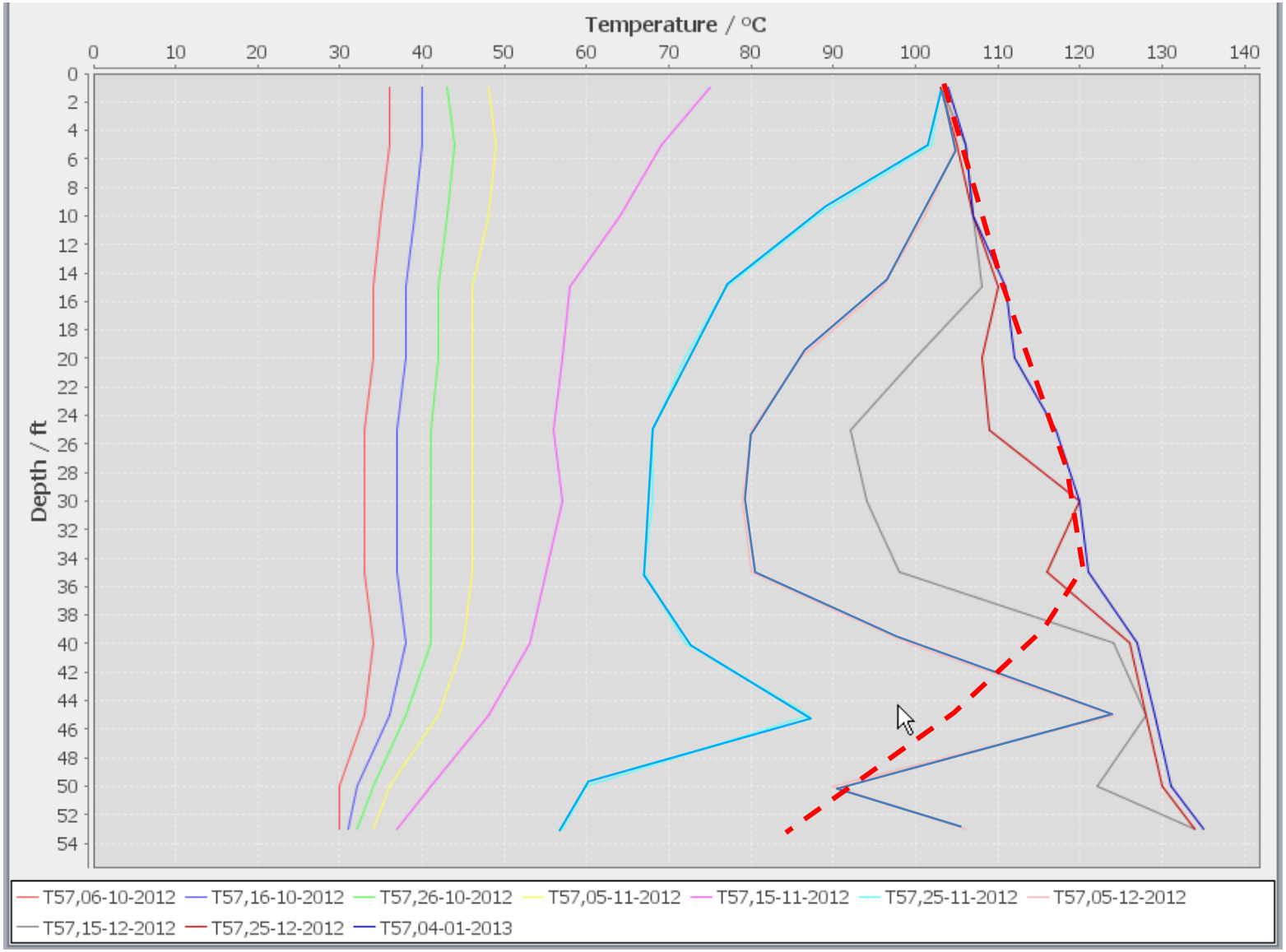
TCH or ERH combined with Steam

- Improves overall effectiveness
- Reduces costs
- Addresses high groundwater flux areas while TCH or ERH address low permeability areas

TCH+SEE


Surface cover
0
25
50
Depth (ft)
Hydrostratigraphy
Sand
Interbedded
Hawthorn
TCH heater boring
Steam injection well
Multiphase extraction well
Horizontal vapor extraction well

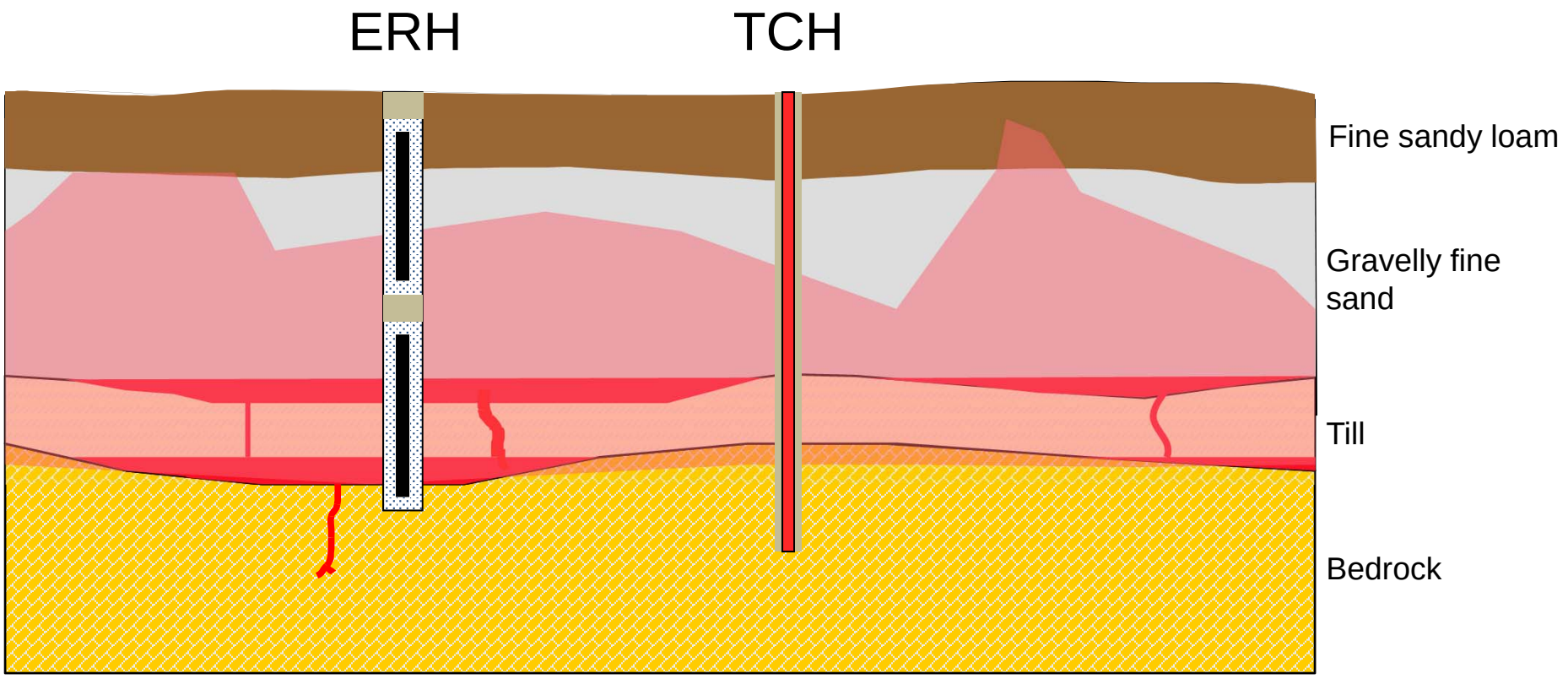
TCH+SEE


Temperature / °C
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
Depth / ft
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
T57,06-10-2012
T57,16-10-2012
T57,26-10-2012
T57,05-11-2012
T57,15-11-2012
T57,25-11-2012
T57,05-12-2012
T57,15-12-2012
T57,25-12-2012
T57,04-01-2013

DNAPL spreading risk

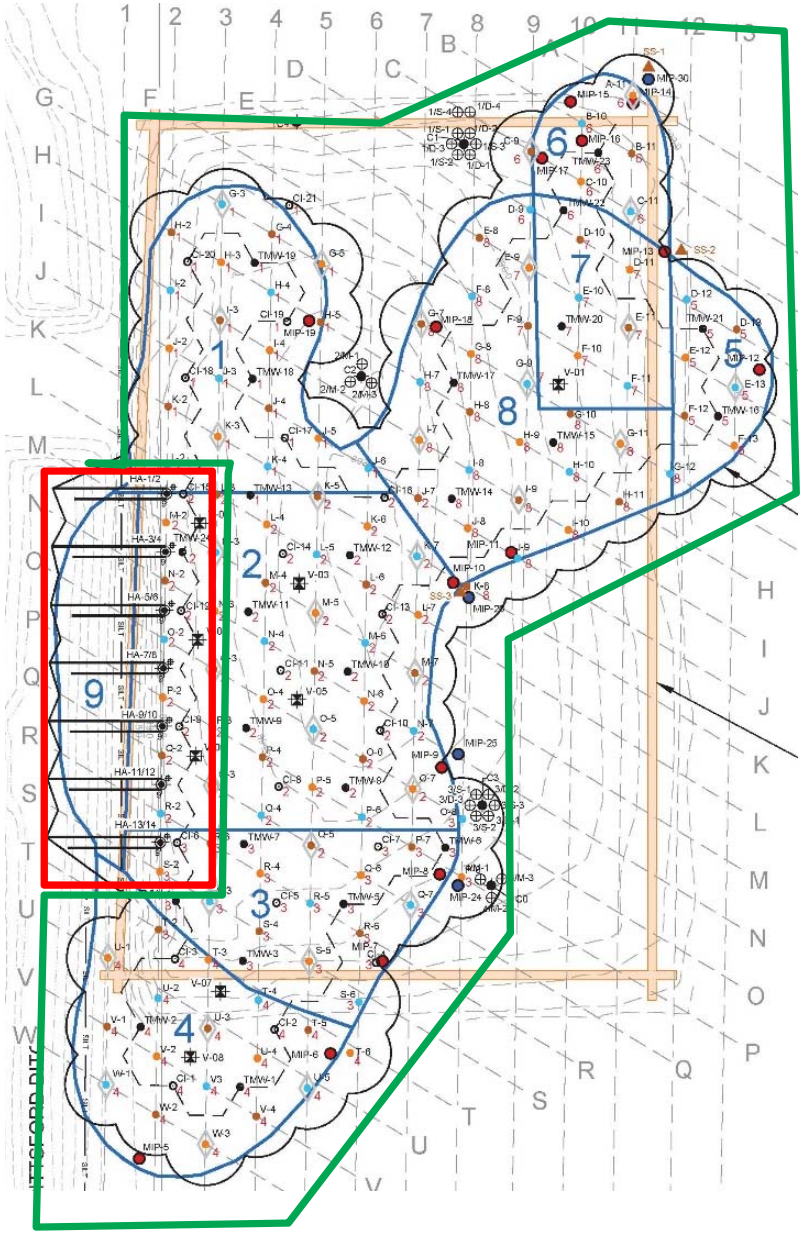
(case: SRSNE Superfund Site, Southington CT)

DNAPL pooled on bedrock



SRSNE - TCH

Indiana: ERH or TCH near surface water



Indiana: ERH-TCH

Access

(case: Knullen, Denmark)

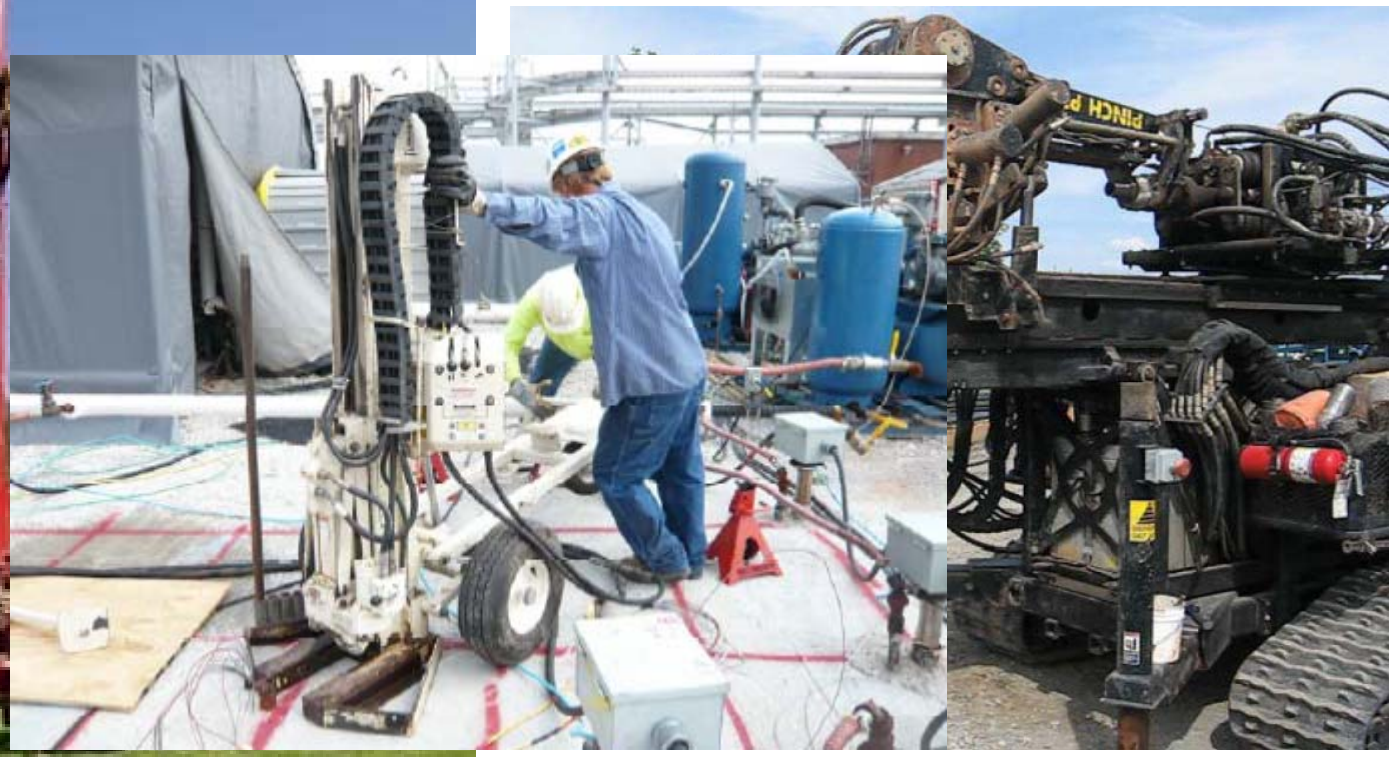
TCH

Small diameter boreholes

Drilling space limited

Drilling

ERH electrode installation (10-14”)

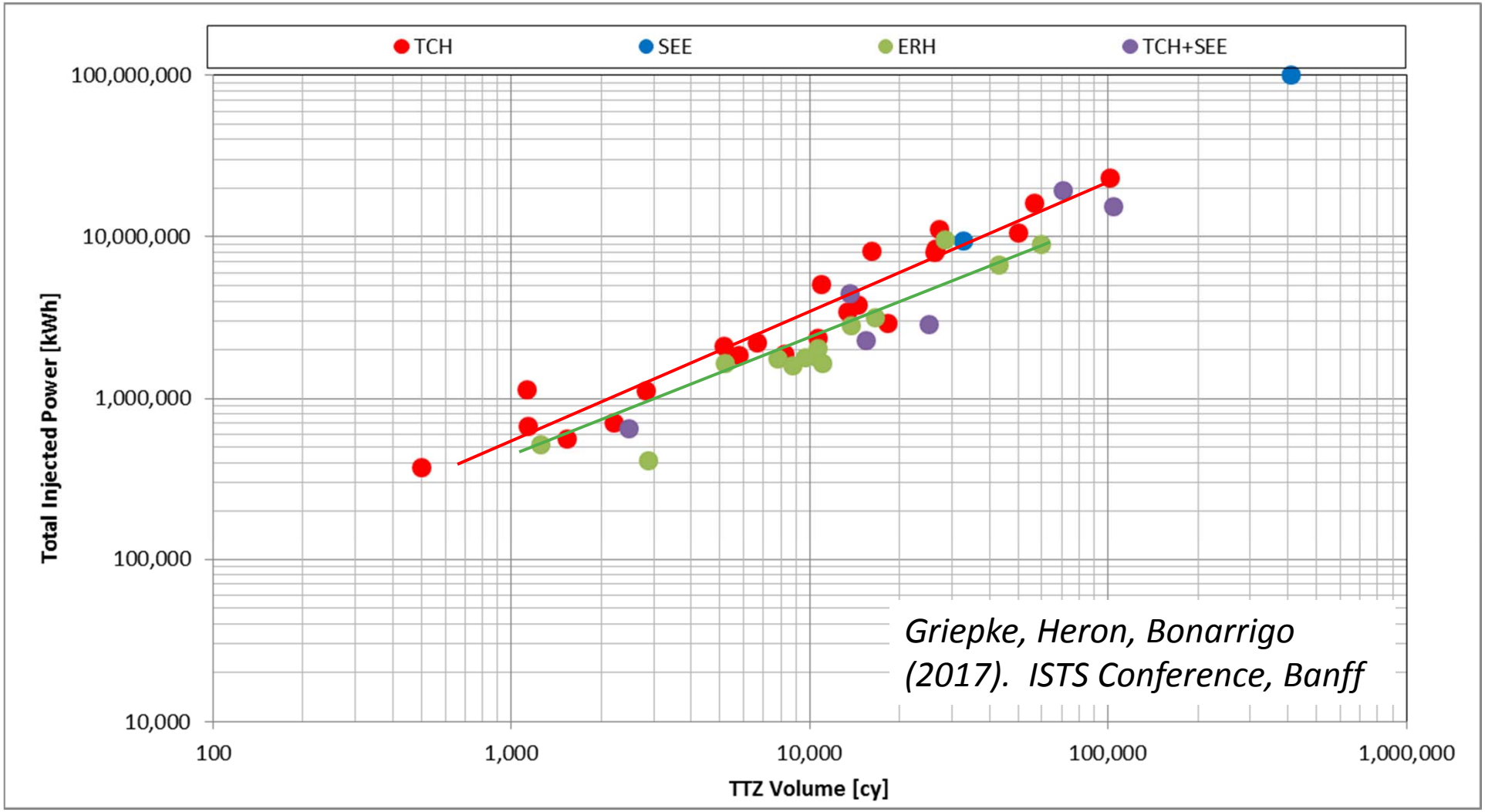


TCH heater installation (6-8”)

Subsurface Installation

- ERH electrode cables and lines are easier to bury than TCH heater lines

Power usage
(60 sites)



Sweet-spot Analysis – blog post

How do you Choose between ERH, TCH and SEE?

Our clients request the most cost-effective thermal solution for their sites. Cascade has in-house Technology Centers for the implementation each of the three major *In Situ* Thermal Remediation (ISTR) technologies:

- Electrical Resistance Heating (ERH)
- Thermal Conduction Heating (TCH)
- Steam Enhanced Extraction (SEE)

So, how do we choose the best heating technology for a site? What makes one better than another, and when does it make sense to combine technologies? As the industry-leading practitioner of all three technologies, we will now answer those questions.

Cost always rules! Our first task is to quickly screen each site and select the best technical option. Often, one technology is clearly a superior fit. However, on many sites choosing between technologies can be a close call. In these cases, our Technology Teams prepare conceptual designs and cost estimates for multiple options and we select the option that provides the Site Owner with the best value.

Some General Rules of Thumb:

- The three technologies have different effective heating ranges:

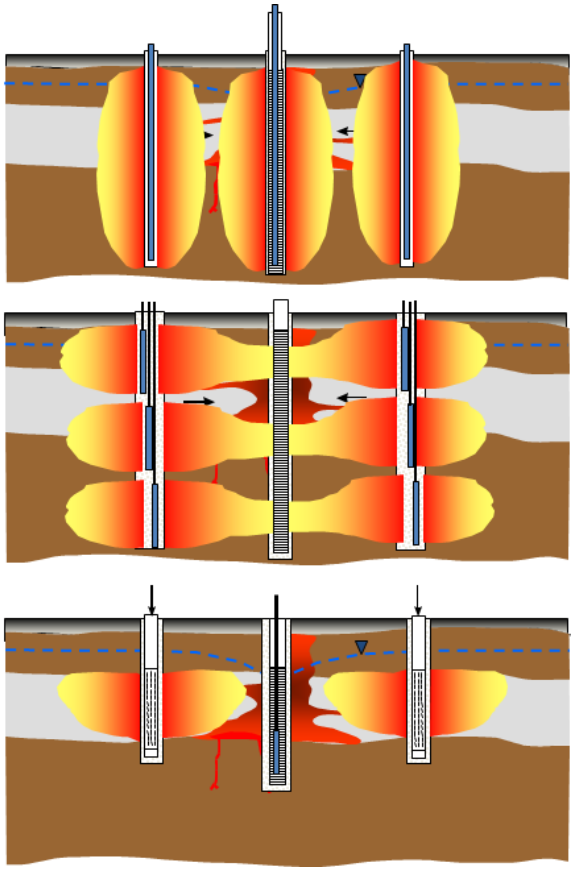
ERH	Ambient to boiling (typically less than 120 °C)
TCH	Ambient to 400 degrees °C
SEE	Boiling (typically 100 to 120 °C)

INSERT LINK HERE

Summary

Give us:

Target volume
Conceptual site model
Remedial goals
Site restrictions



Let us:

Evaluate if there are data gaps
Propose the most cost-effective option

Together:

Implement and adapt if needed – as a team

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