



# **In Situ Air Sparging – How to Avoid Blowing Money in the Ground**

Effective pilot testing for evaluating IAS feasibility

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# Co-Participants

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- Dr. Andrea Leeson – SERDP/ESTCP
- Dr. Rob Hinchee – Battelle
- Dr. Illa Amerson – OHSU
- Dr. Cristin Bruce – ASU
- Many others



# Information Available At:

Bioremediation Journal 5(4), 2001

<http://cgr.ese.ogi.edu/ias/ias.htm>

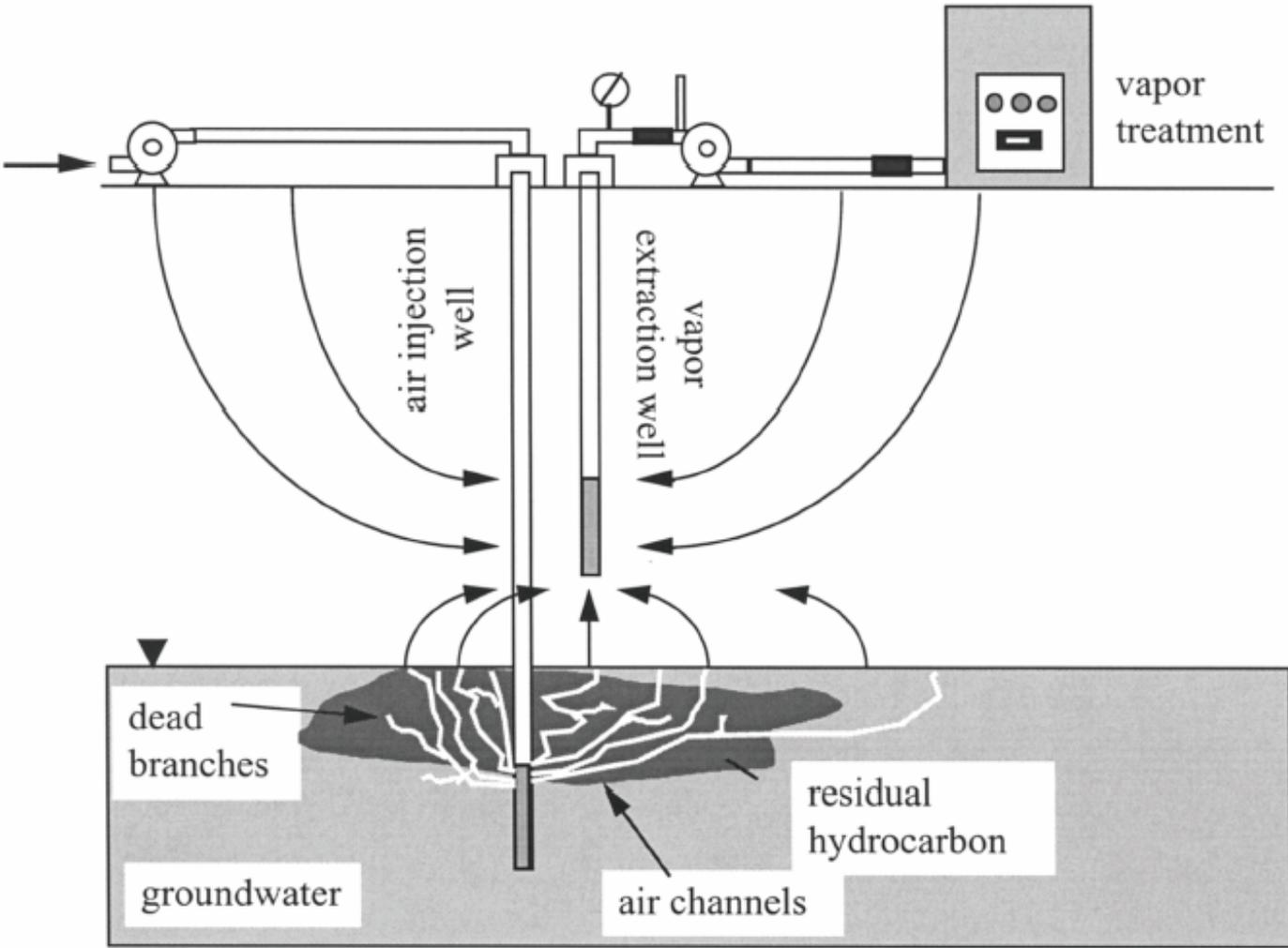
ESTCP reports

<http://www.estcp.org/documents/techdocs/199808.pdf>

[http://www.estcp.org/documents/techdocs/Air\\_Sparging.pdf](http://www.estcp.org/documents/techdocs/Air_Sparging.pdf)



# IAS Paradigm



*Promoting Readiness through Environmental Stewardship*



# IAS Paradigm

The 3 most significant factors affecting IAS are:

- The air distribution in the target treatment zone
- The distribution of contaminants relative to the air distribution
- The contaminant characteristics

All other things being equal, remediation is more effective in settings having a higher density of air channels in the treatment zone



# IAS Paradigm

Given current site assessment technologies and the sensitivity of air distributions to subtle changes in soil structure, it is unlikely that air distributions can be predicted.

At this time, long-term IAS performance cannot be predicted reliably during short-term pilot tests



# IAS Paradigm

As a result, the IAS Design Paradigm reflects the following philosophy:

- Given the importance of the air distribution and our inability to predict it, the actual air distribution should be characterized
- The degree to which the air distribution is characterized should be balanced by the system design (i.e., high cost and risk mean high characterization).
- Pilot-scale testing should focus on looking for indicators of infeasibility (i.e., clear indicators that it will not be successful) in addition to characteristics of the air distribution.



# One-Day Pilot Tests

Why focus on “one-day” tests?

- It is something that everyone can do
- Given the uncertainties, it is something that everyone SHOULD do.

So, what do we do?

- Preliminary observations
- Startup flow and pressure tests
- Air recovery test



# One-Day Pilot Tests

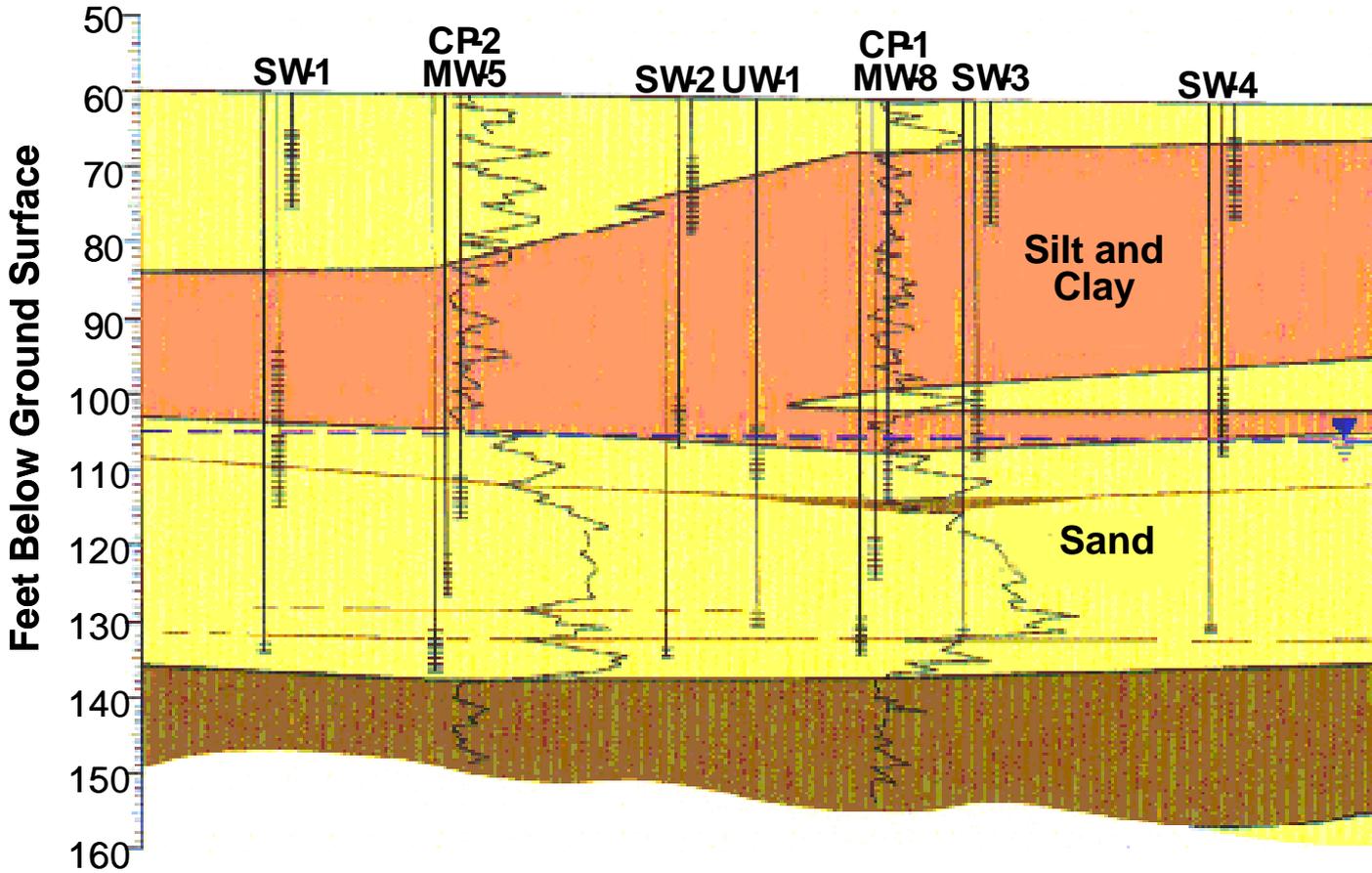
## 1. Preliminary Observations and Activities

- Analyze cores (visual or lab analysis)
- Identify target zone (vertical)
- Identify area to be treated
- Determine well network requirements  
(if well spacing of  $>15$  feet are needed, additional tests will be needed, see Design Paradigm)



# One-Day Pilot Tests

Hill AFB, Ogden Utah

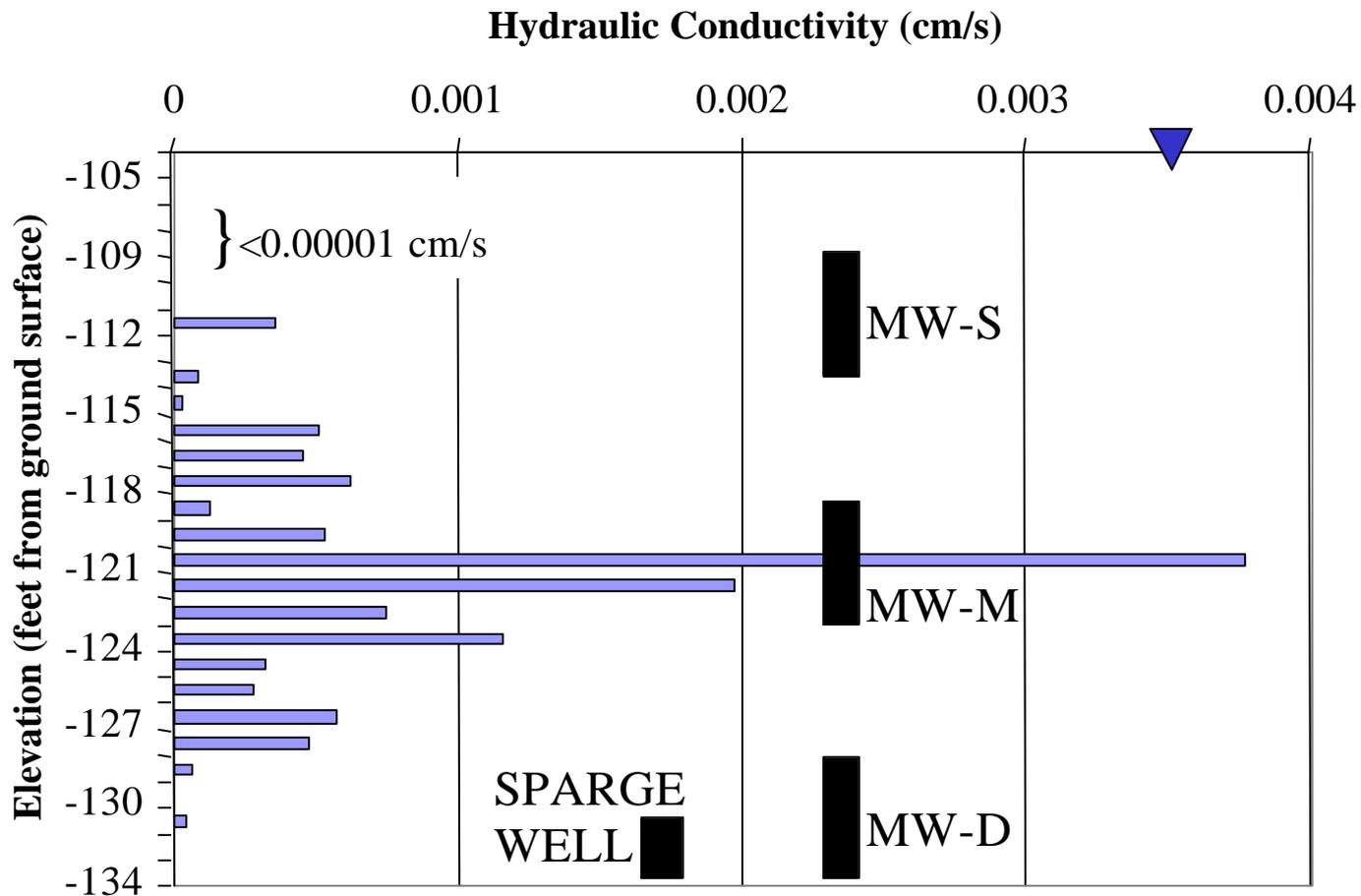


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# One-Day Pilot Tests

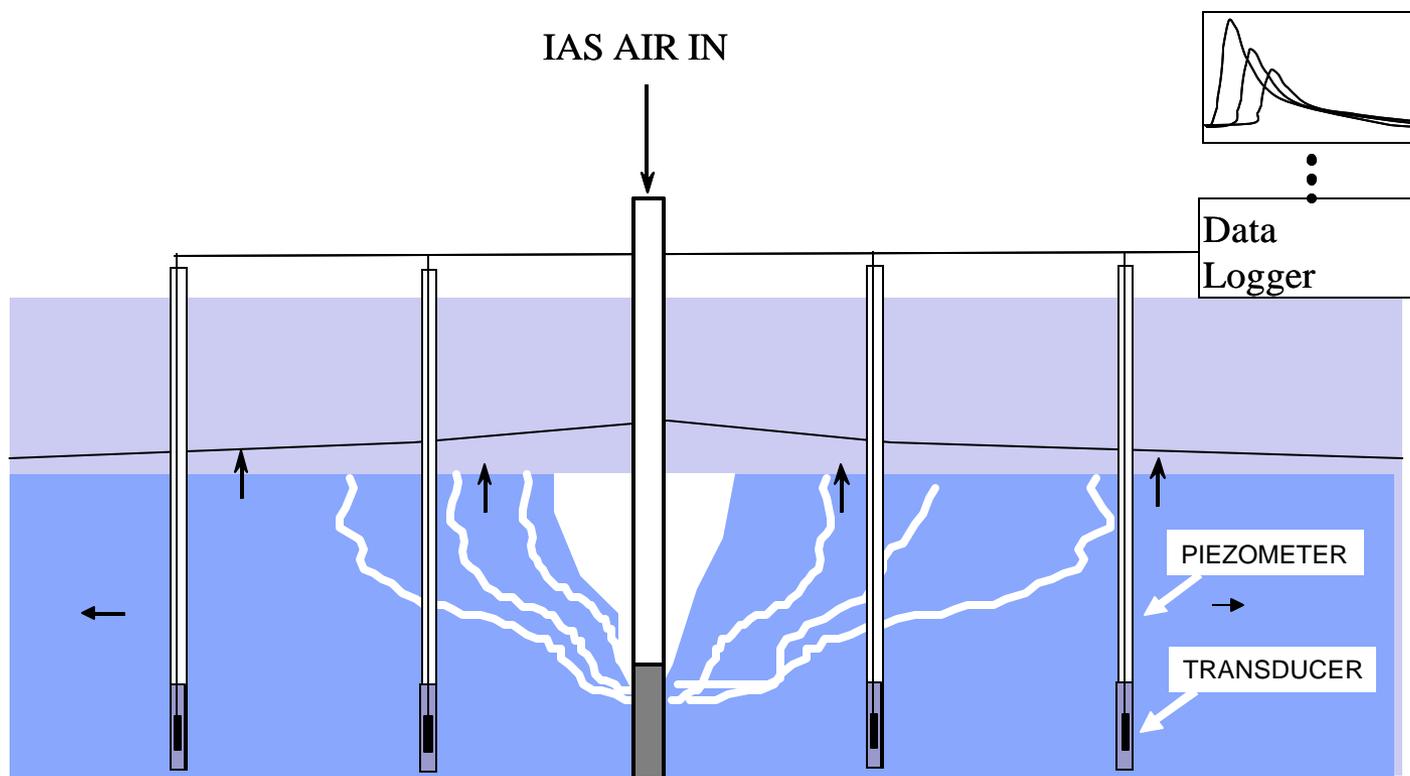
Hill AFB, Ogden Utah





# One-Day Pilot Tests

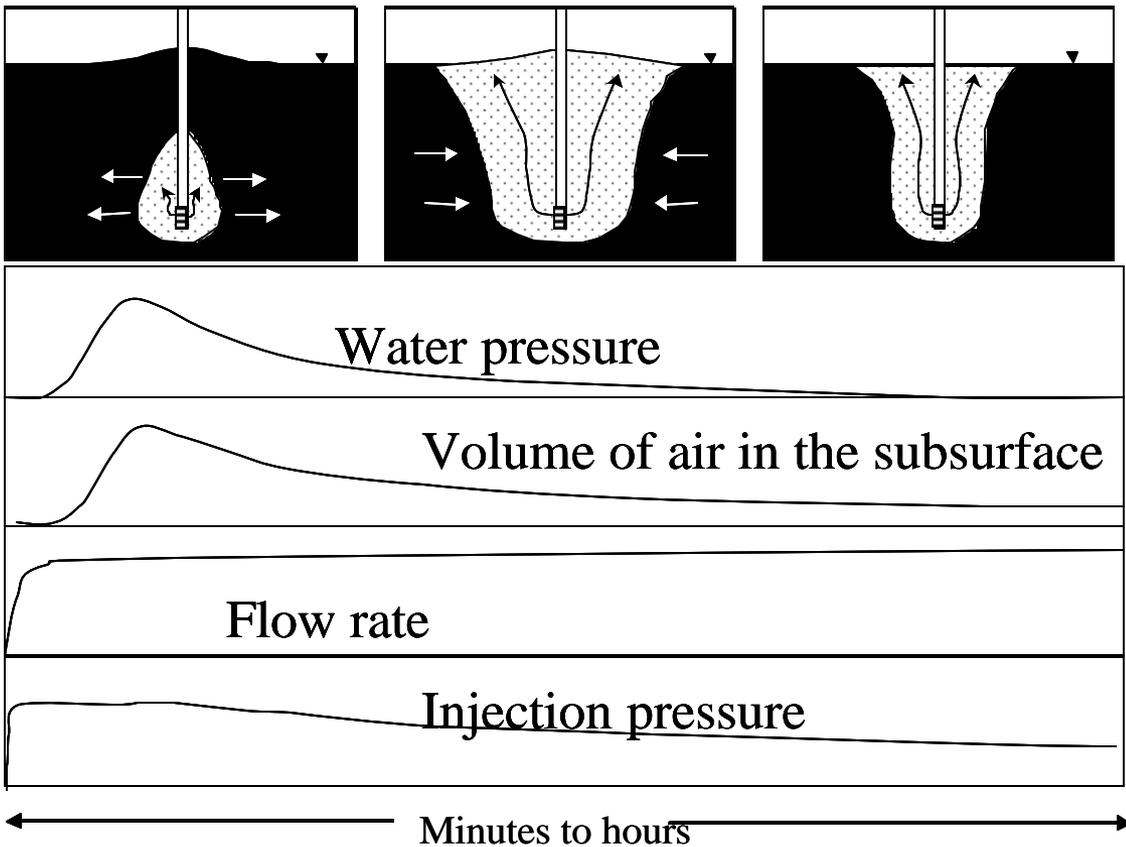
## 2. Startup Flow and Pressure Tests





# One-Day Pilot Tests

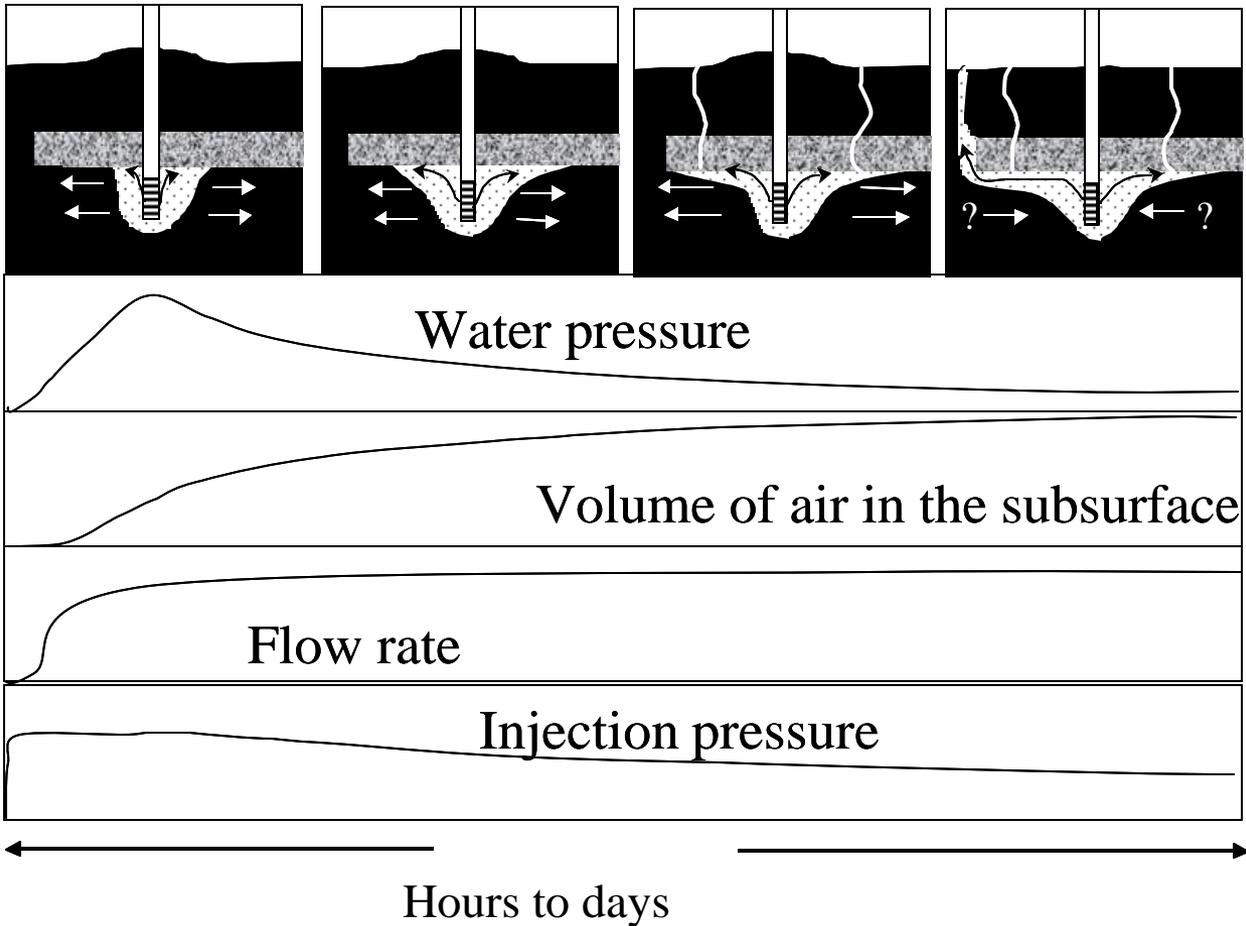
## Flow and Pressure Response in a "Homogeneous" Medium





# One-Day Pilot Tests

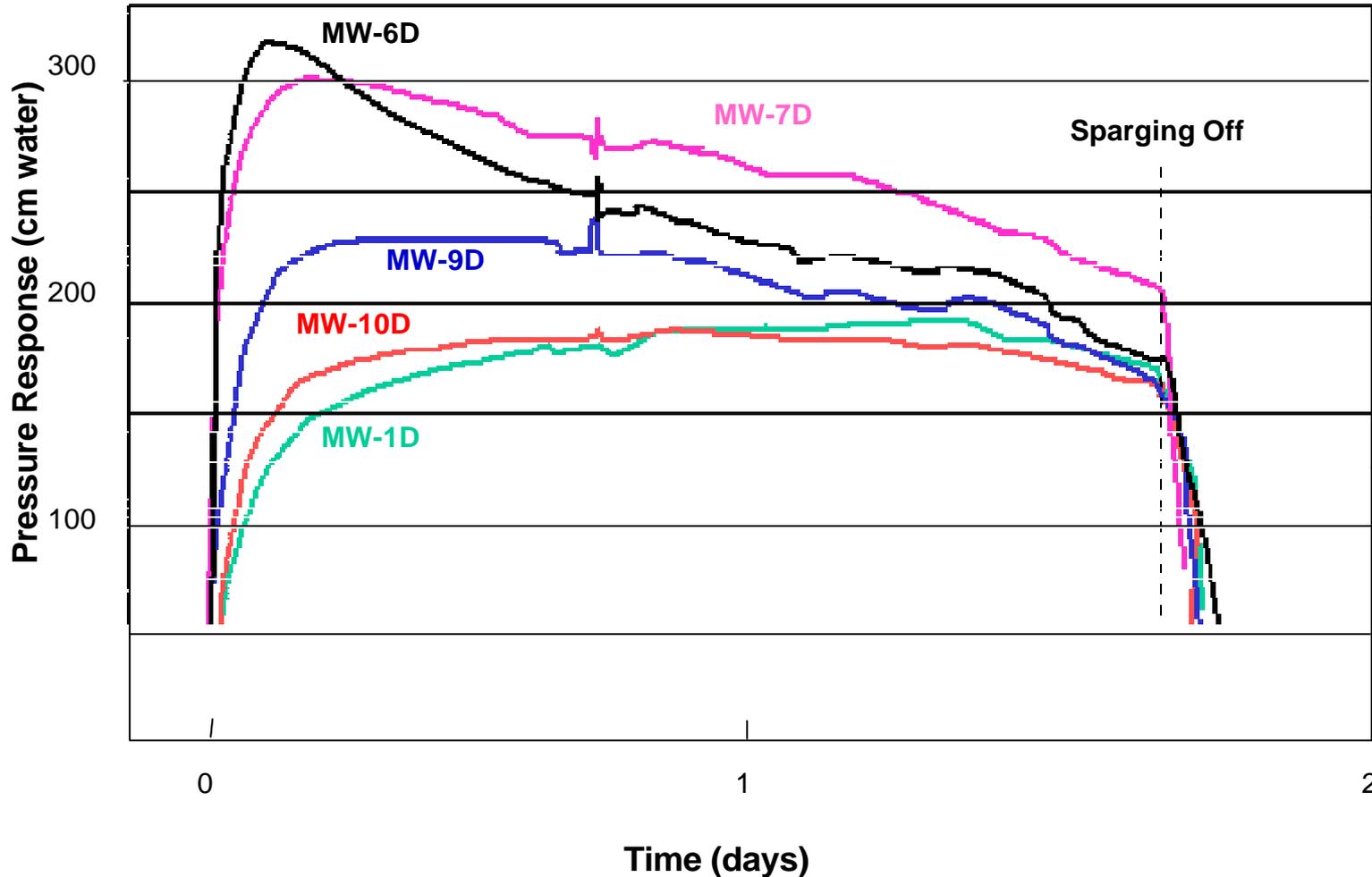
## Flow and Pressure Response in a "Heterogeneous" Medium





# One-Day Pilot Tests

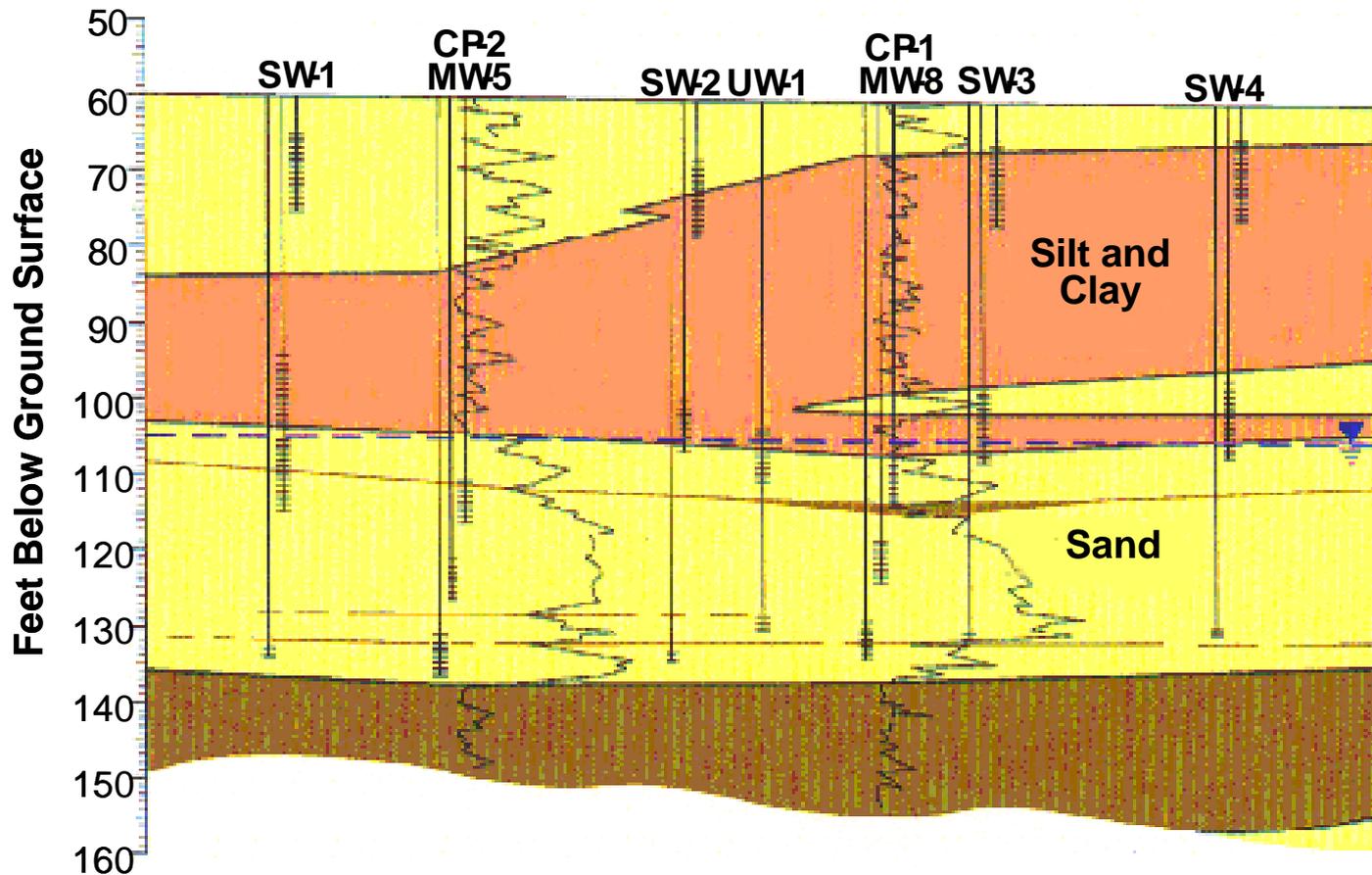
## Pressure Response at Hill AFB, Utah





# One-Day Pilot Tests

Hill AFB, Utah

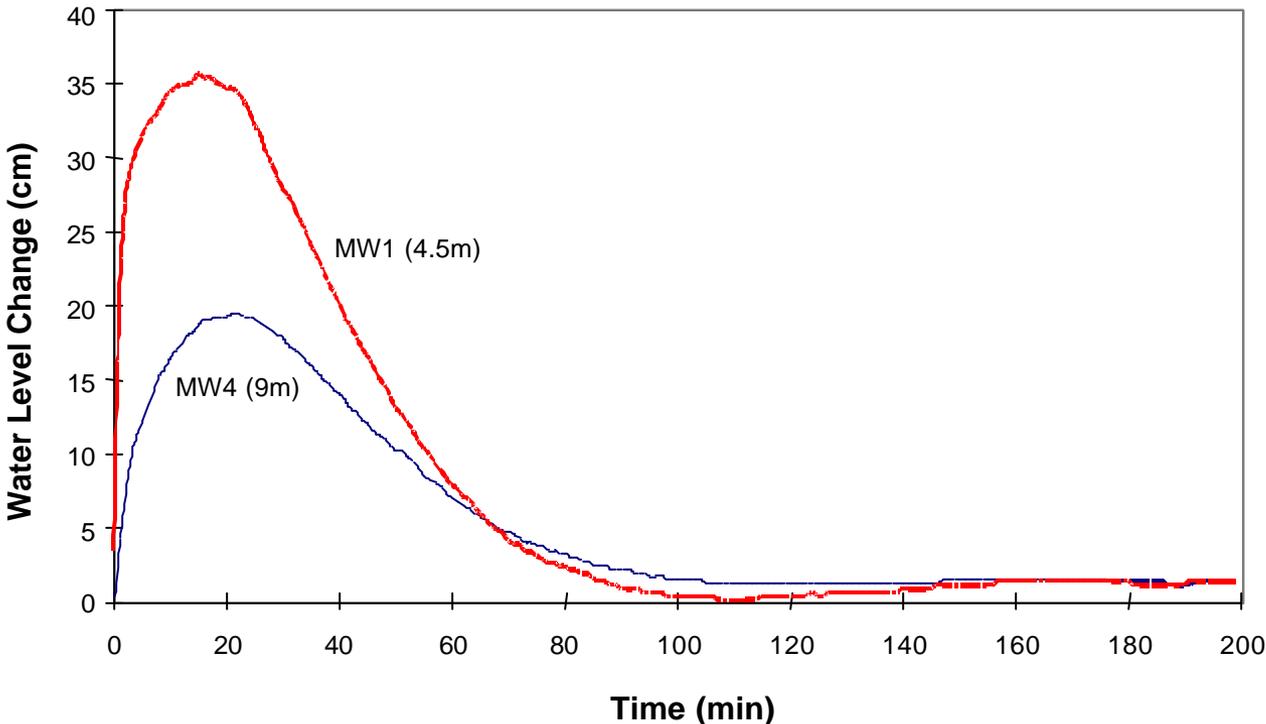


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# One-Day Pilot Tests

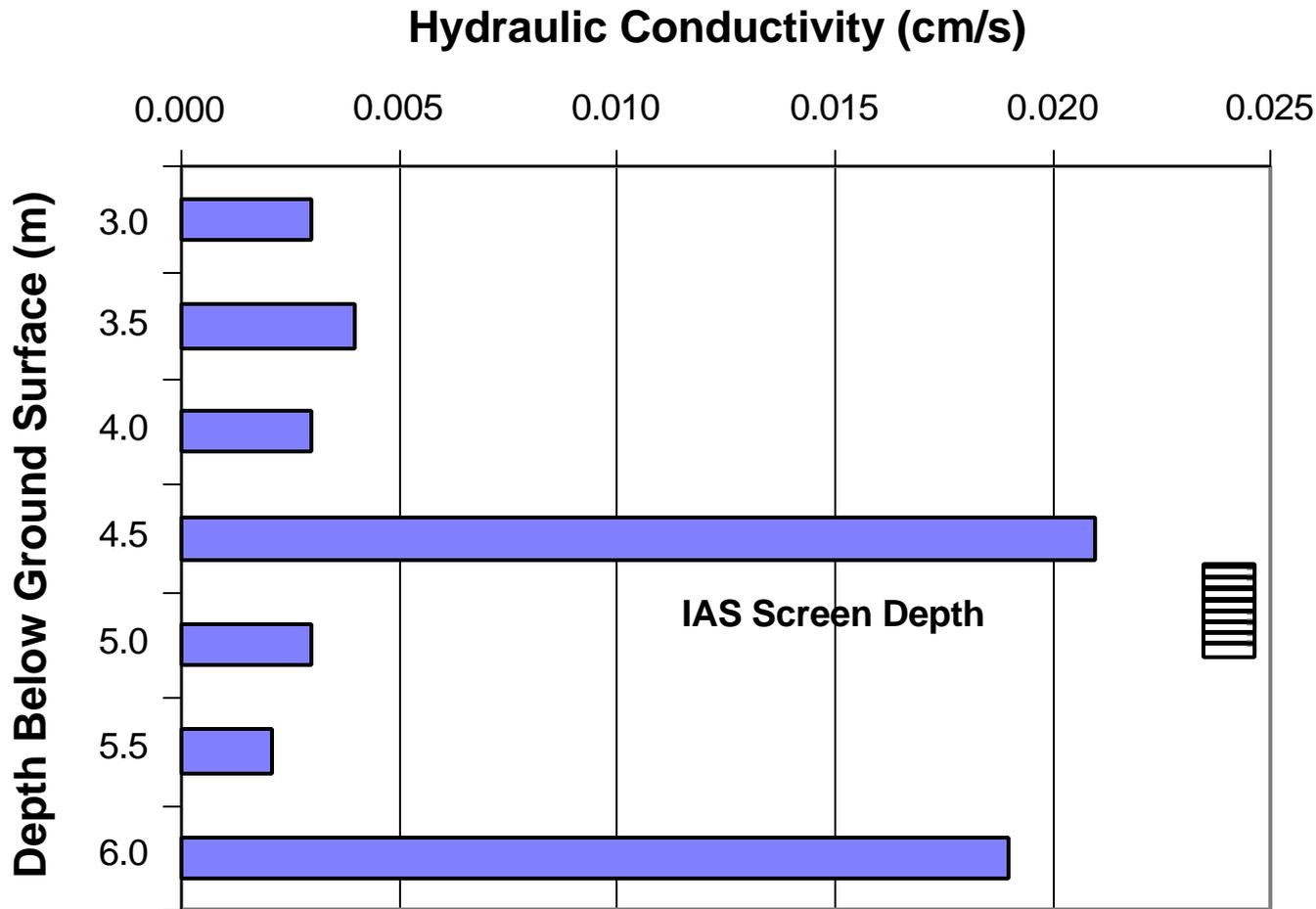
## Pressure Response at Port Hueneme, CA





# One-Day Pilot Tests

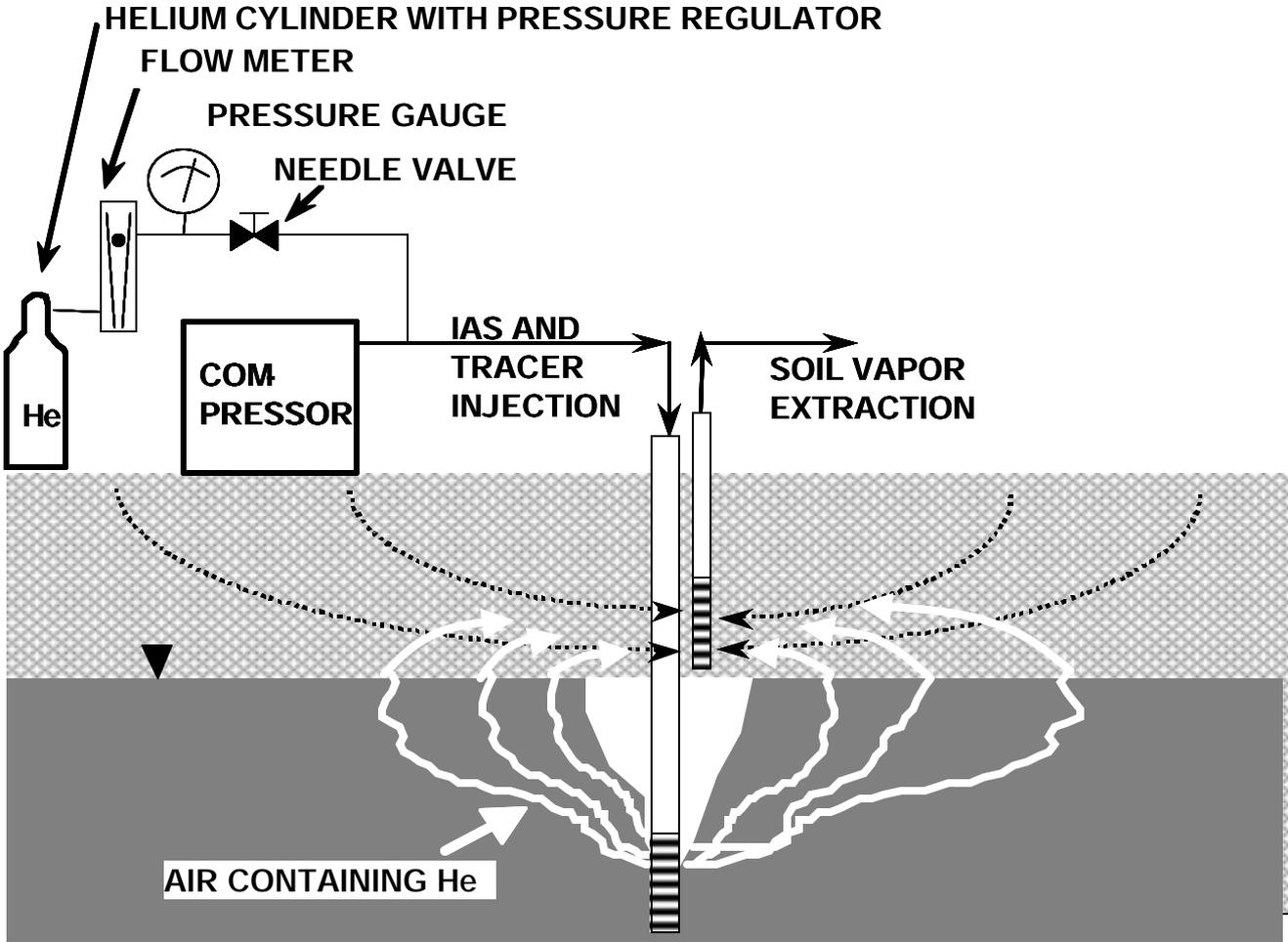
Port Hueneme, CA





# One-Day Pilot Tests

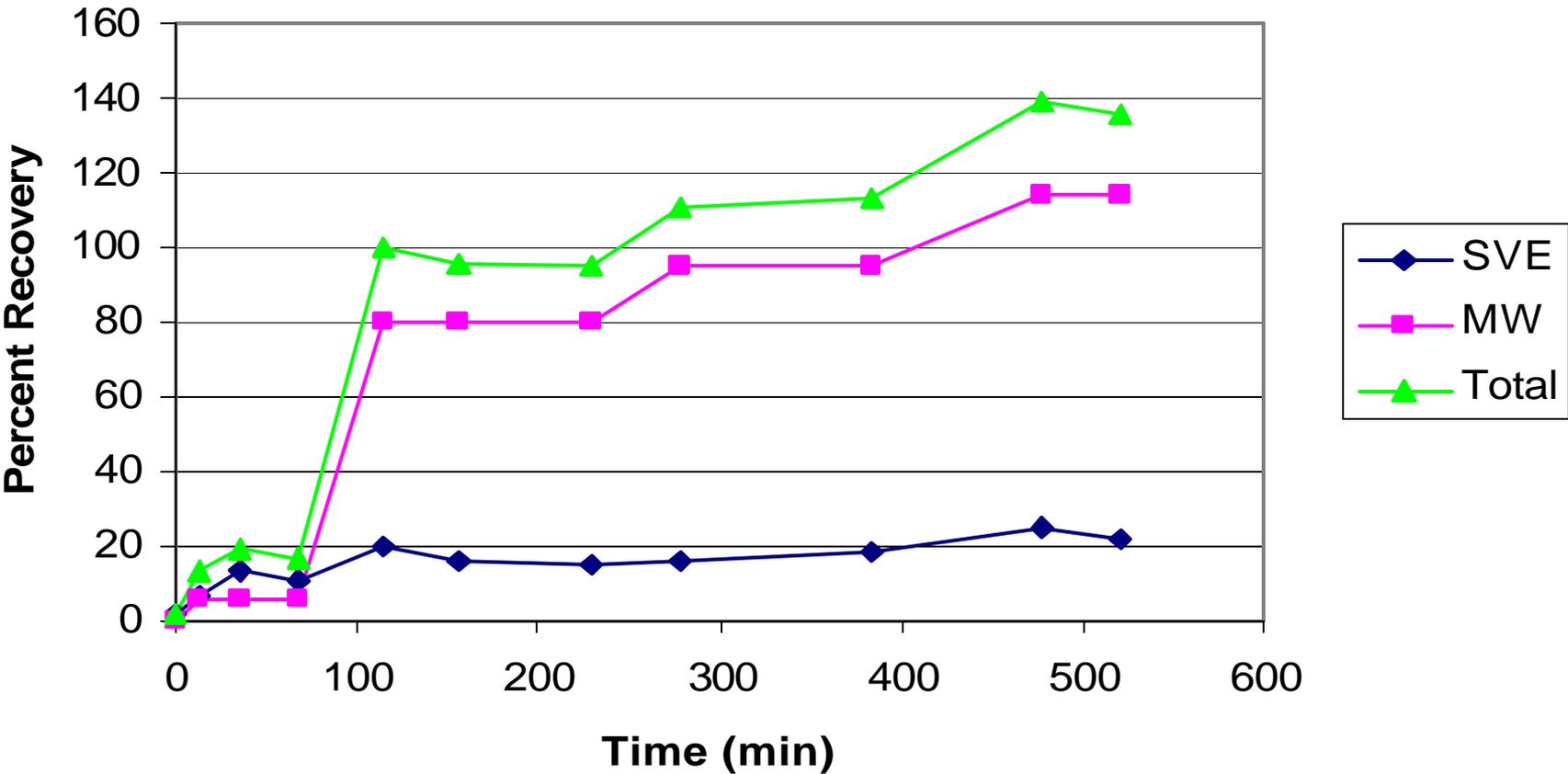
## 3. Air Recovery Test





# One-Day Pilot Tests

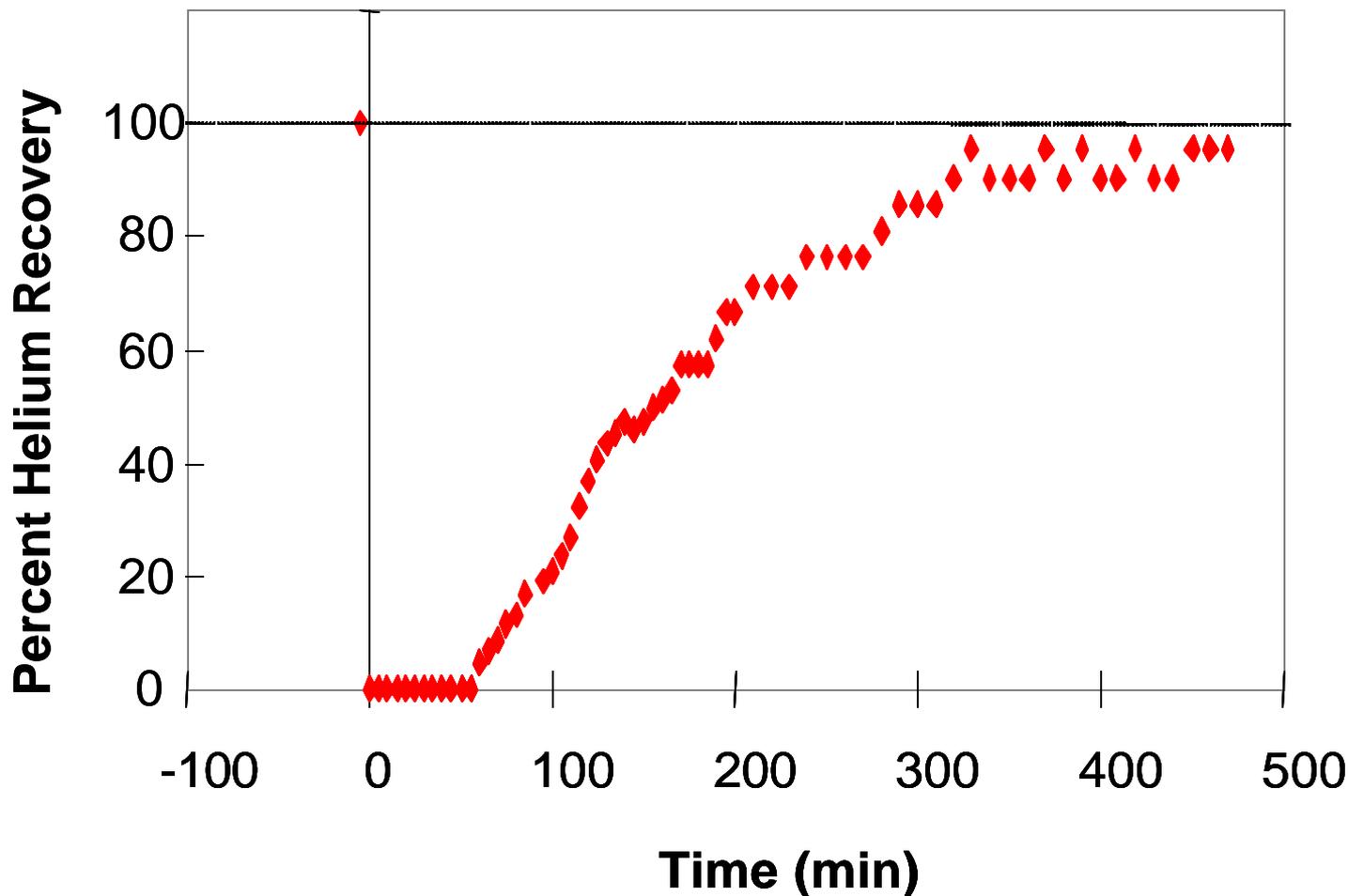
## Air Recovery at Hill AFB, Utah





# One-Day Pilot Tests

Air Recovery at Port Hueneme, CA





# One-Day Pilot Tests

What should you NOT do?

- Use pressure to determine ROI of IAS
- Extrapolate long term performance from one-day test
- Over-interpret dissolved oxygen or contaminant concentrations in wells

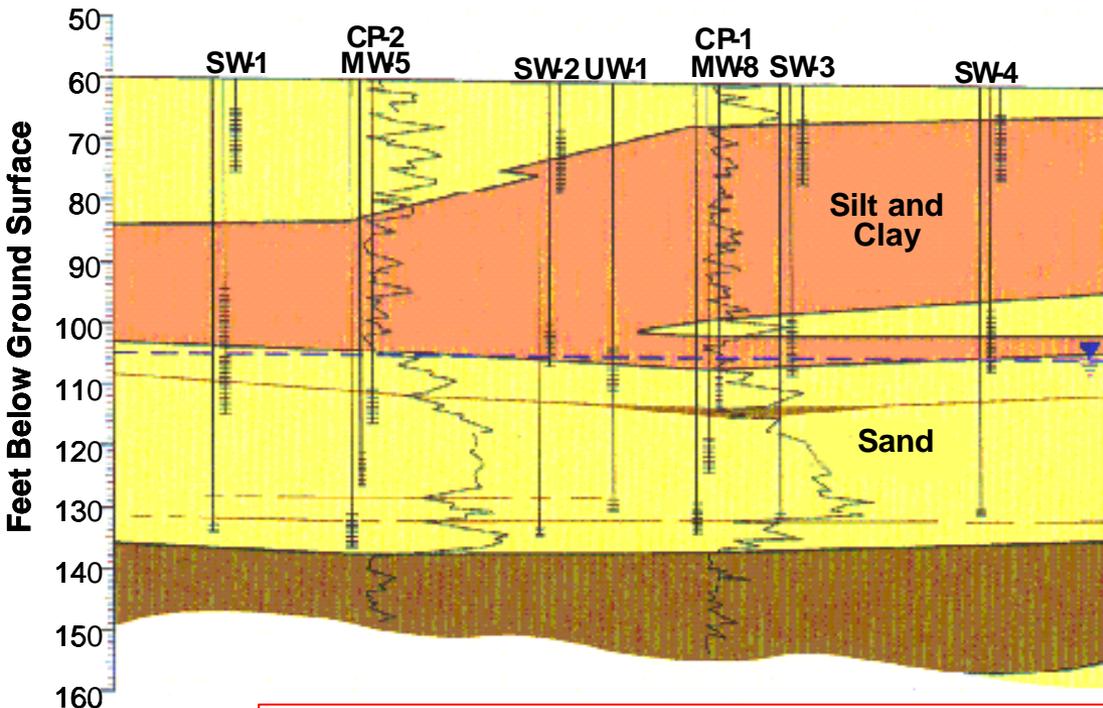
What can you do to get at ROI and mass transfer issues?

- SF6 tracer tests
- Push-pull tests
- Longer-term monitoring



# Interpretation of Pilot Tests

Hill AFB, Ogden Utah



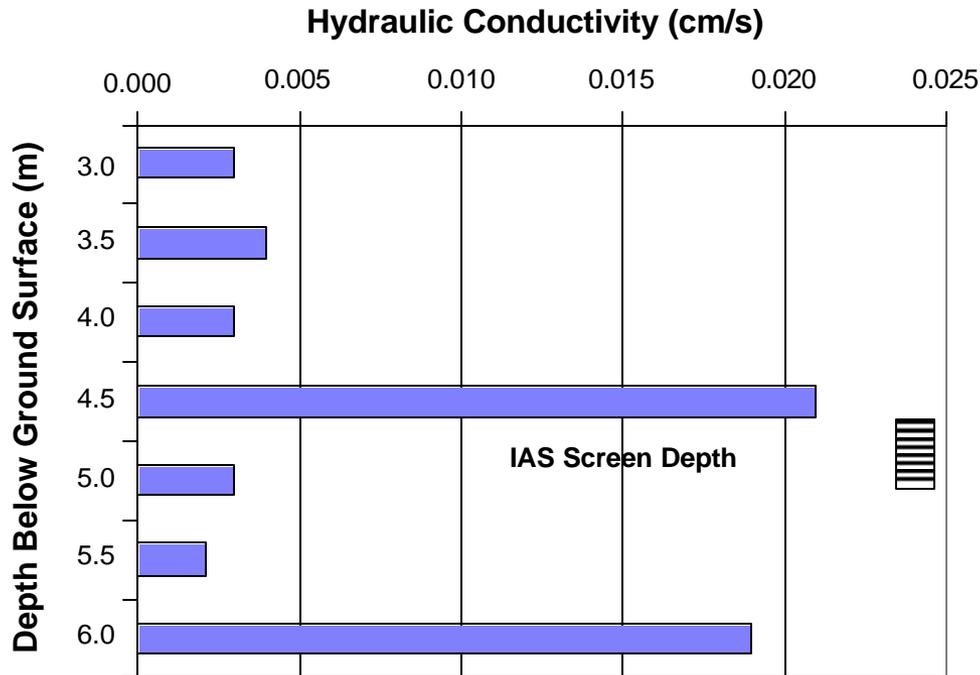
- Permeability data suggest serious layering (>40X)
- Pressure data suggest significant trapped air
- Helium data suggest confinement below silt layer

Bottom lines: Little treatment above lower sand layer.  
Air containment difficult due to layering.



# Interpretation of Pilot Tests

Port Hueneme, CA



- Permeability data suggest  $<10X$  differences.
- Pressure data suggest minor trapped air.
- Helium data suggest good air capture.

Bottom line: No red flags regarding performance. Apply technology with 15ft well spacings or perform additional tests.



# Evaluation of Multi-Well Performance

Well spacing will likely be an important issue

- If spacings of  $>15$  feet are desired, need to perform site-specific tests

In order to reduce O&M costs, it is often desirable to pulse injection

- Maintain per-well flow at  $\sim 15$  scfm
- Choose pulse duration based on pressure data
- Flow balance changes with time, actively monitor flow rates at EACH well



# CONCLUSIONS

- IAS is a complicated physical/chemical/biological process
- Simple diagnostic tools can be useful to identify red flags
- Those tests can be completed in one day
- Additional tests can provide well spacing and mass transfer data
- Multi-well systems are often necessary. Use pulsed IAS to minimize O&M and monitor air flow at each well