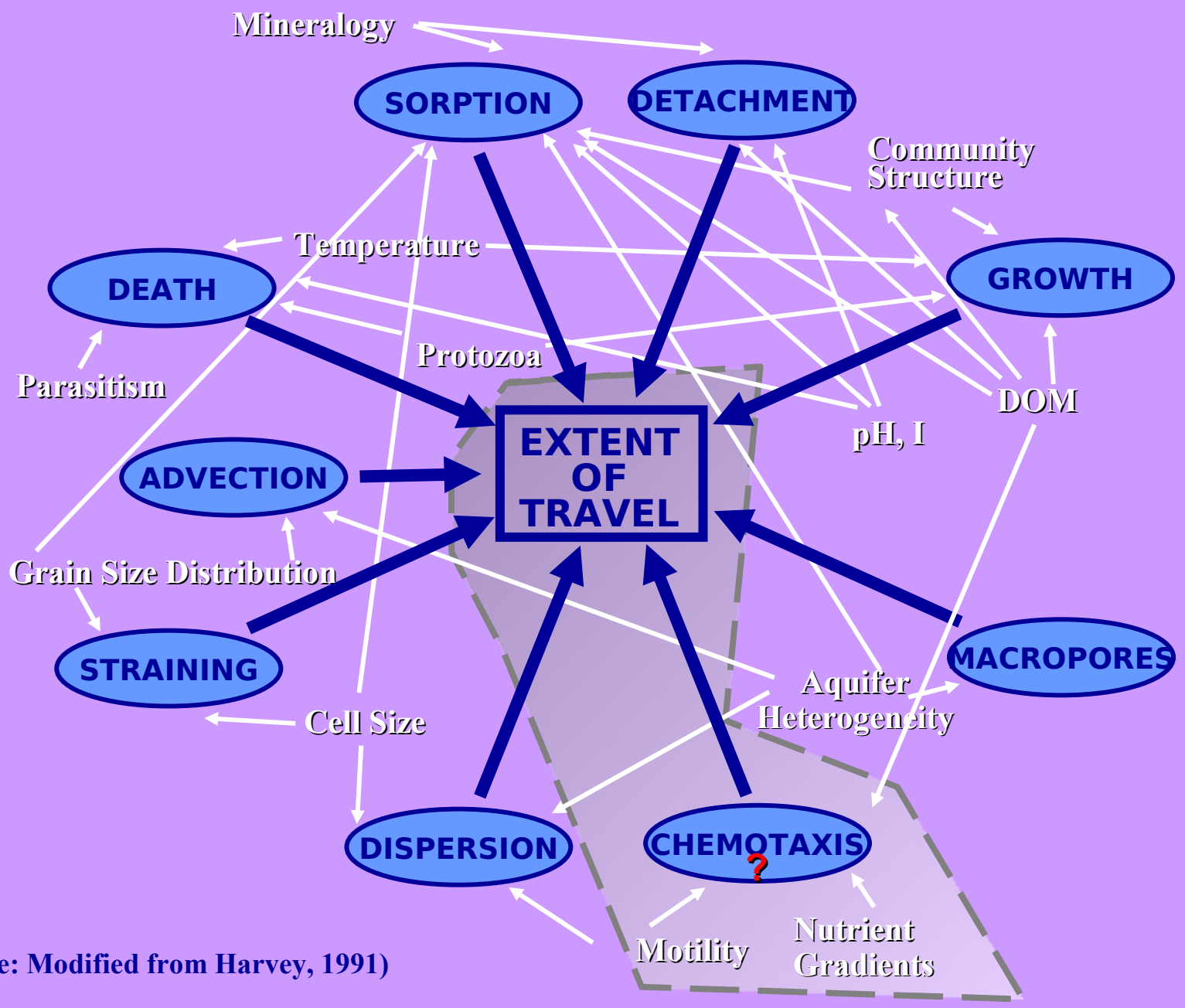
SUBSURFACE MICROBIAL TRANSPORT AT THE CAPE COD SITE

R. Harvey & D. Metge: USGS, Boulder, CO

USGS
science for a changing world

Factors Affecting Subsurface Bacteria Transport on the Field Scale



(Source: Modified from Harvey, 1991)

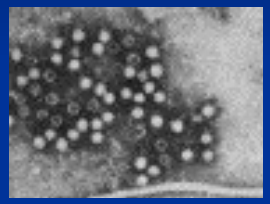
?

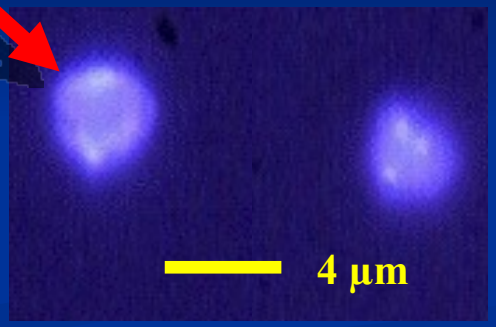
Different Scales = Different Answers!!

Field-scale
(USGS Cape Cod, MA array)

Transport of Waterborne Pathogens

- Chlorine-resistant
- Low infective dose
- Ubiquitous
- Long-lived





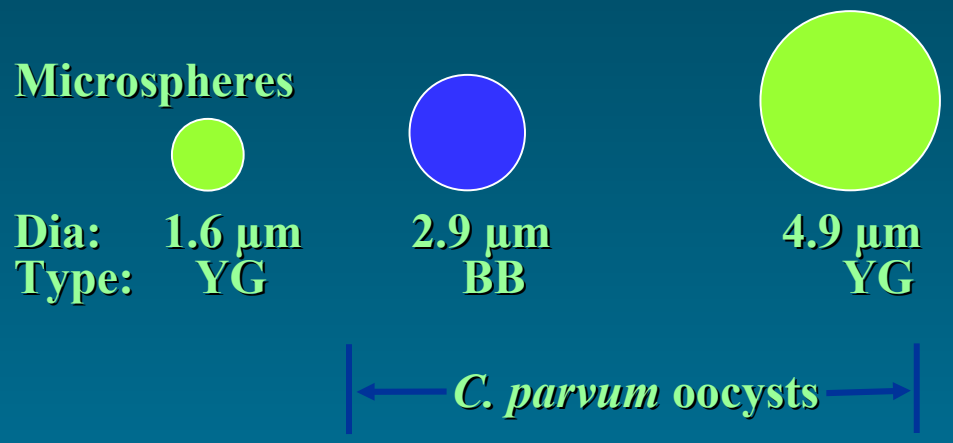
Hepatitis Virus

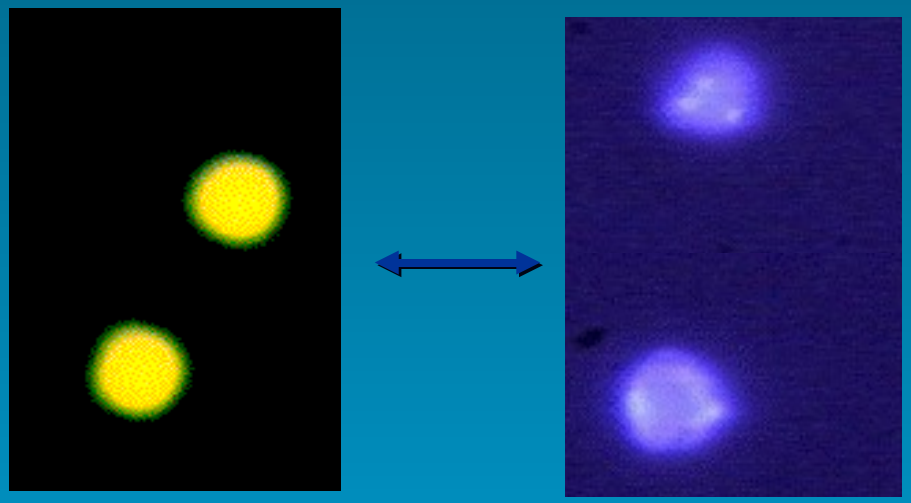
Streptococcus

Cryptosporidium parvum oocysts

Virus 0.01-0.2 µm → Bacteria 0.2-3.0 µm → Protozoa 1.5-10 µm

Fluorescent microspheres as surrogates for oocysts?



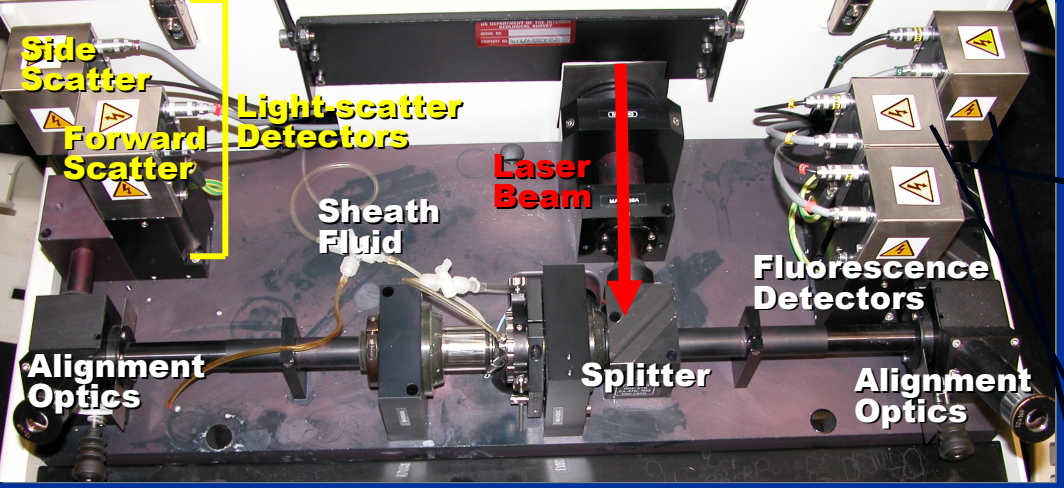


microspheres

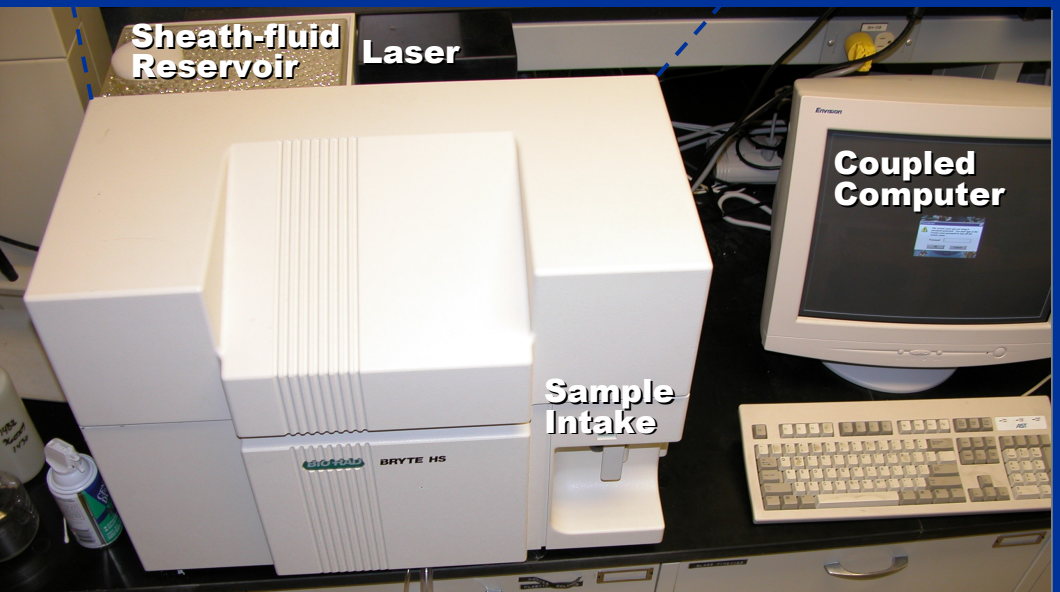
C. Parvum oocysts

Considerations:

- Size
- Aspect ratio
- Buoyant density
- Surface charge
- Attachment behavior

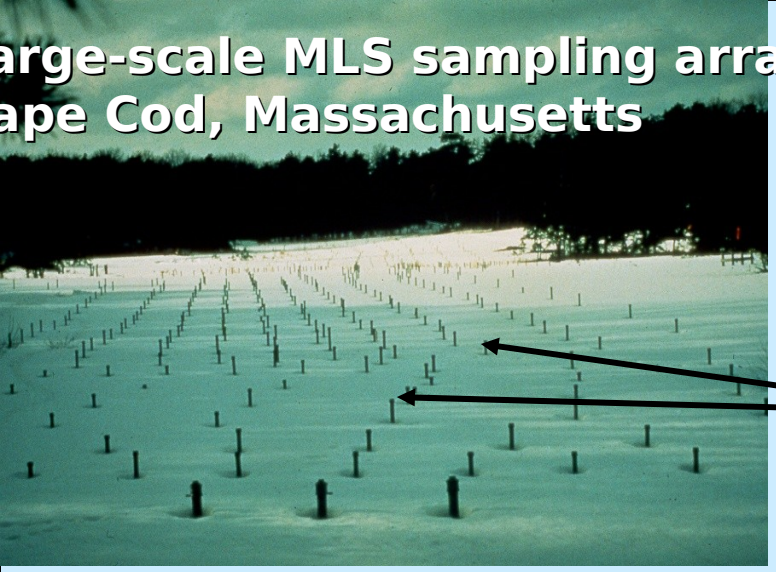


FLOW CYTOMETER, USGS, Boulder (Differential quantification of poly-disperse microsphere and oocysts)



Excit'n (nm)

430
440
450
460
470
480
490
500
510
520
530
540
550
560
570
580
590
600
610



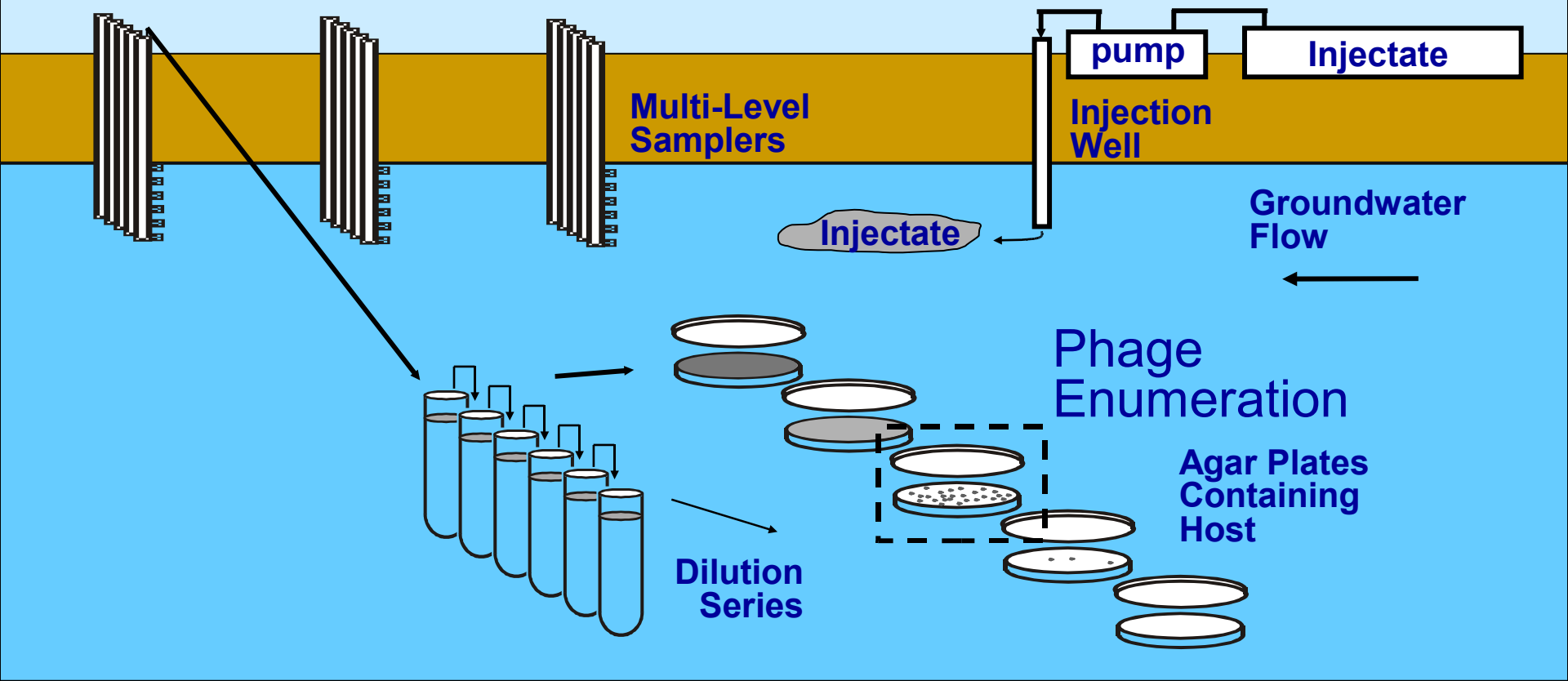
Injection sites

PRD1 (60 nm)

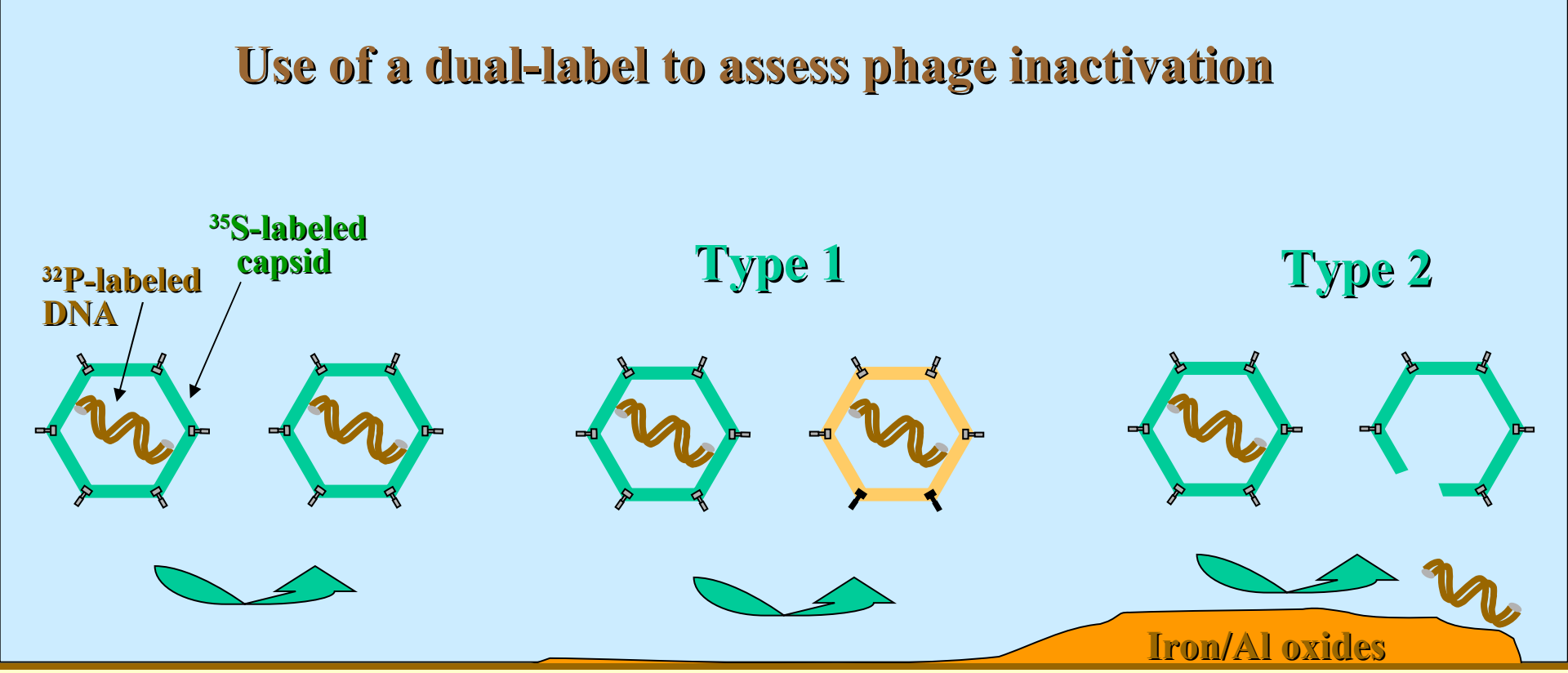
MS2 (20 nm)

Microspheres (100 nm)

Bromide



Use of a dual-label to assess phage inactivation



-Infective
-Intact

PFU
^{32}P
^{35}S

-Non-infective
-Intact

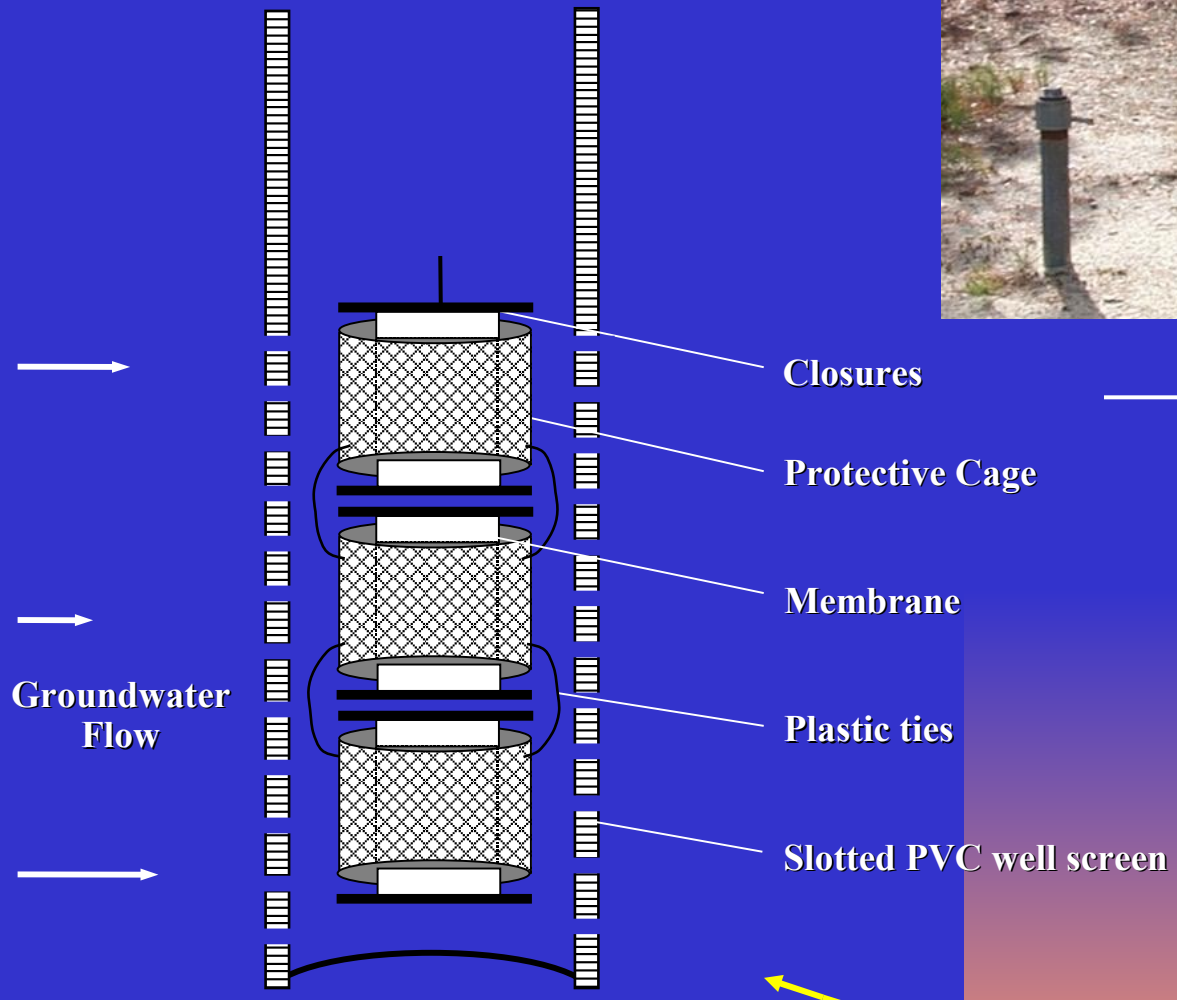
~~PFU~~
^{32}P
^{35}S

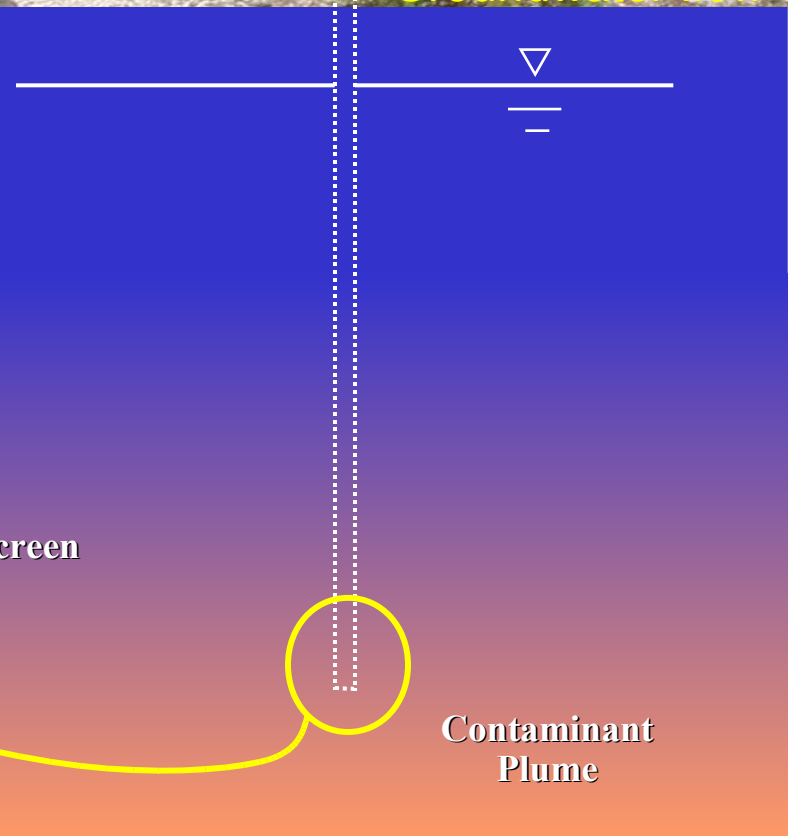
-Non-infective
-Disintegrated

~~PFU~~
~~^{32}P~~
^{35}S

Surface-Induced Inactivation

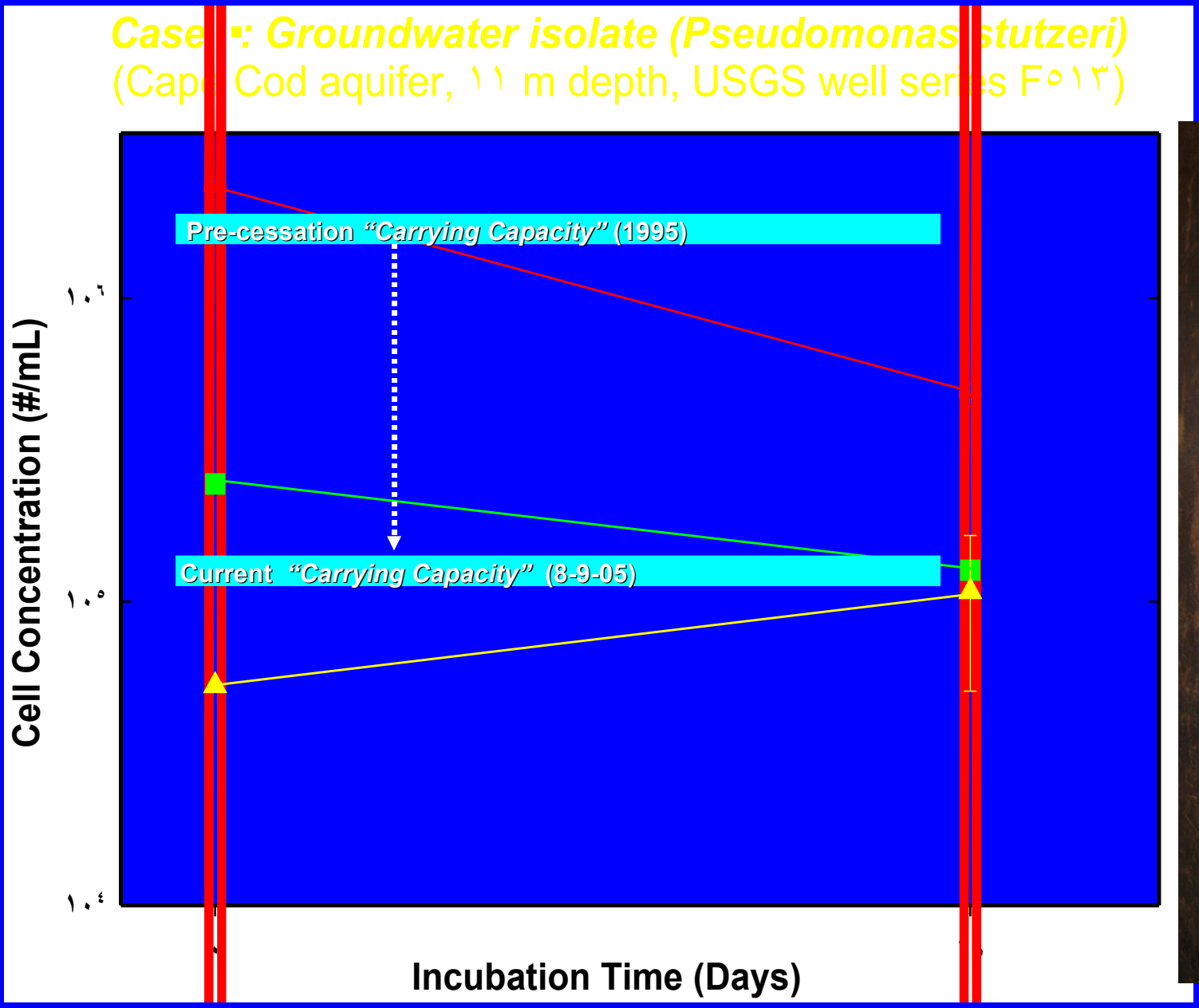
I. *In Situ* Survival Studies:
(Ex: Down-well filter-chambers)



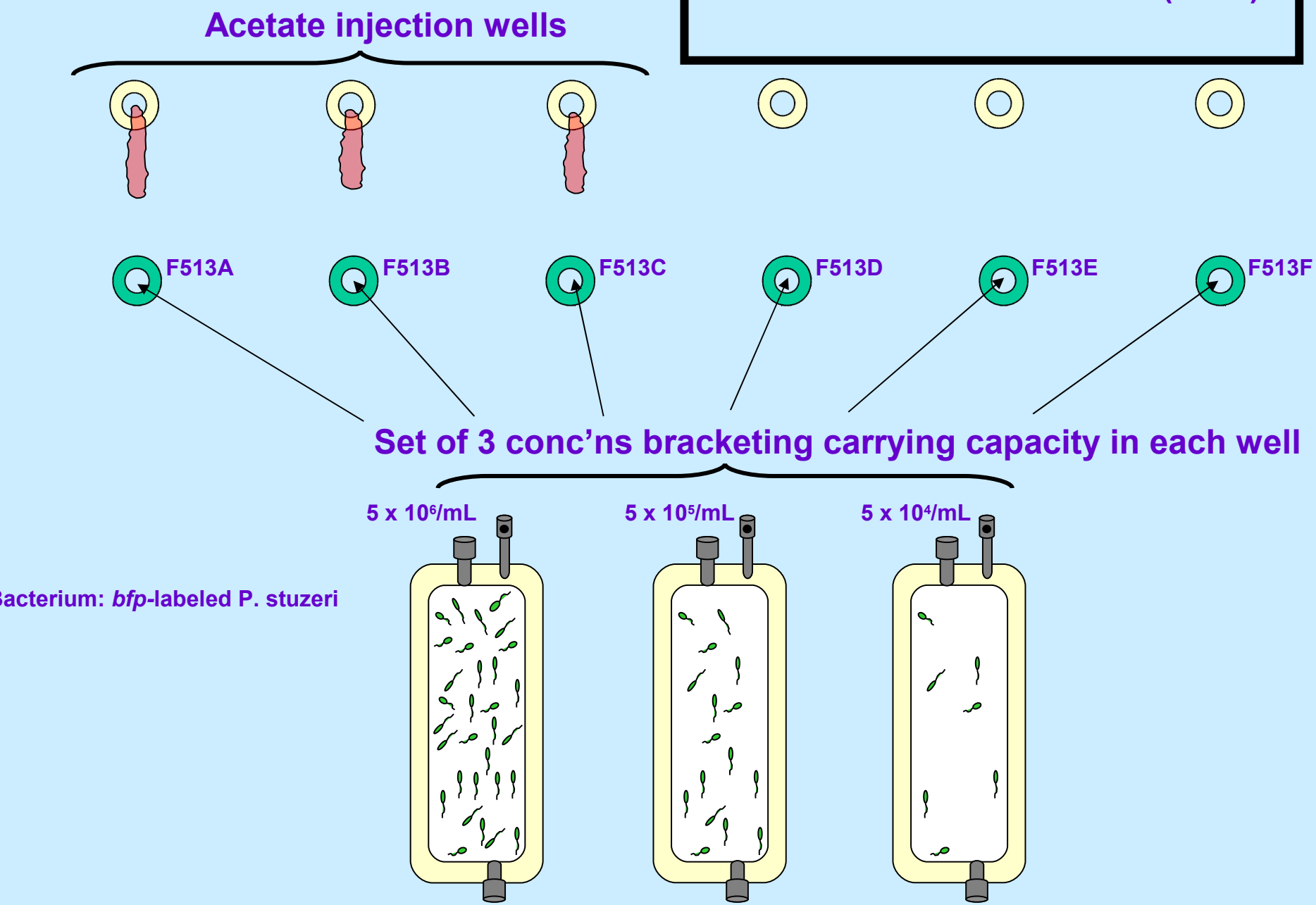


Case ٣: Groundwater isolate (Pseudomonas stutzeri)

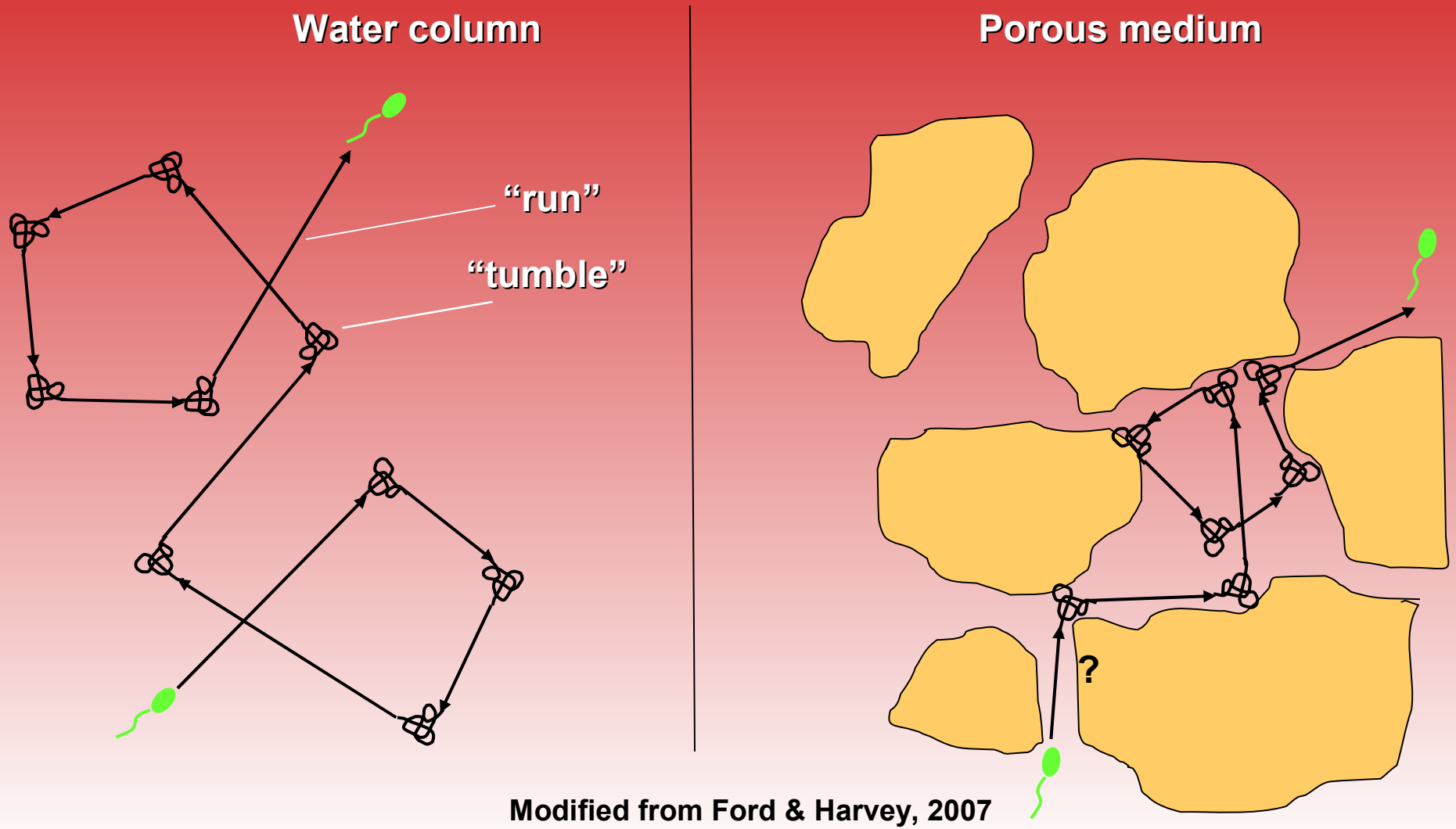
(Cape Cod aquifer, ١١ m depth, USGS well series F٥١٣)



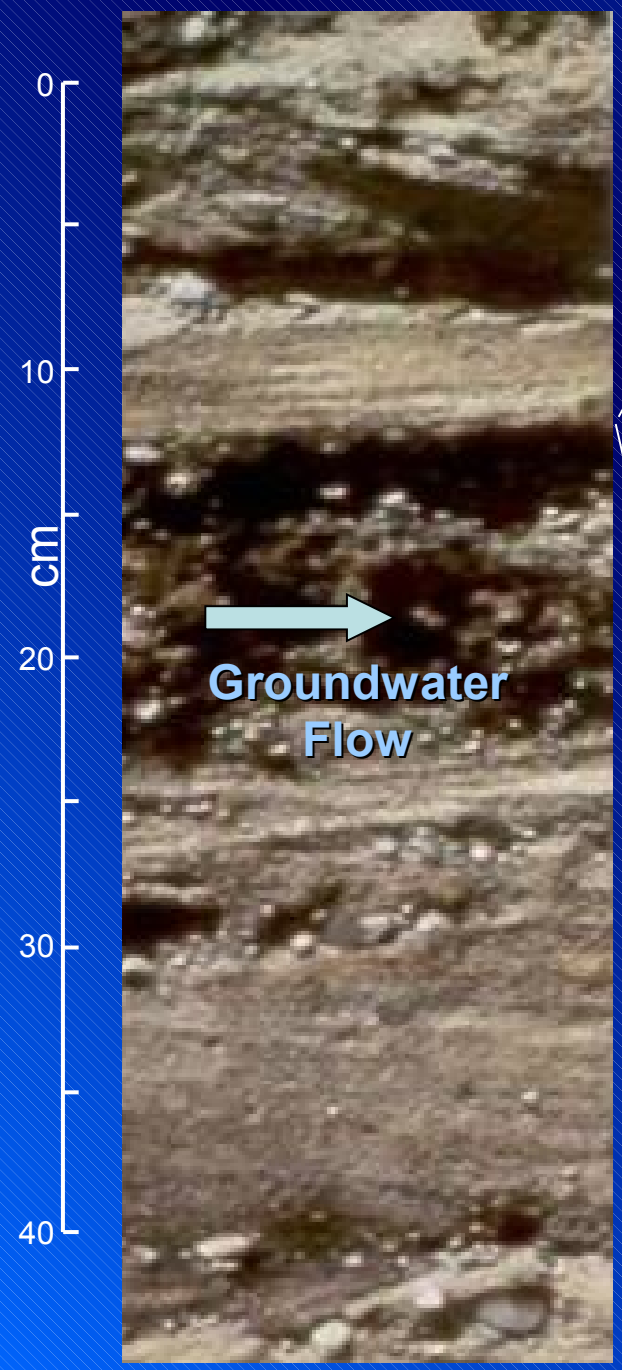
Down-well Survival/Growth (F513)

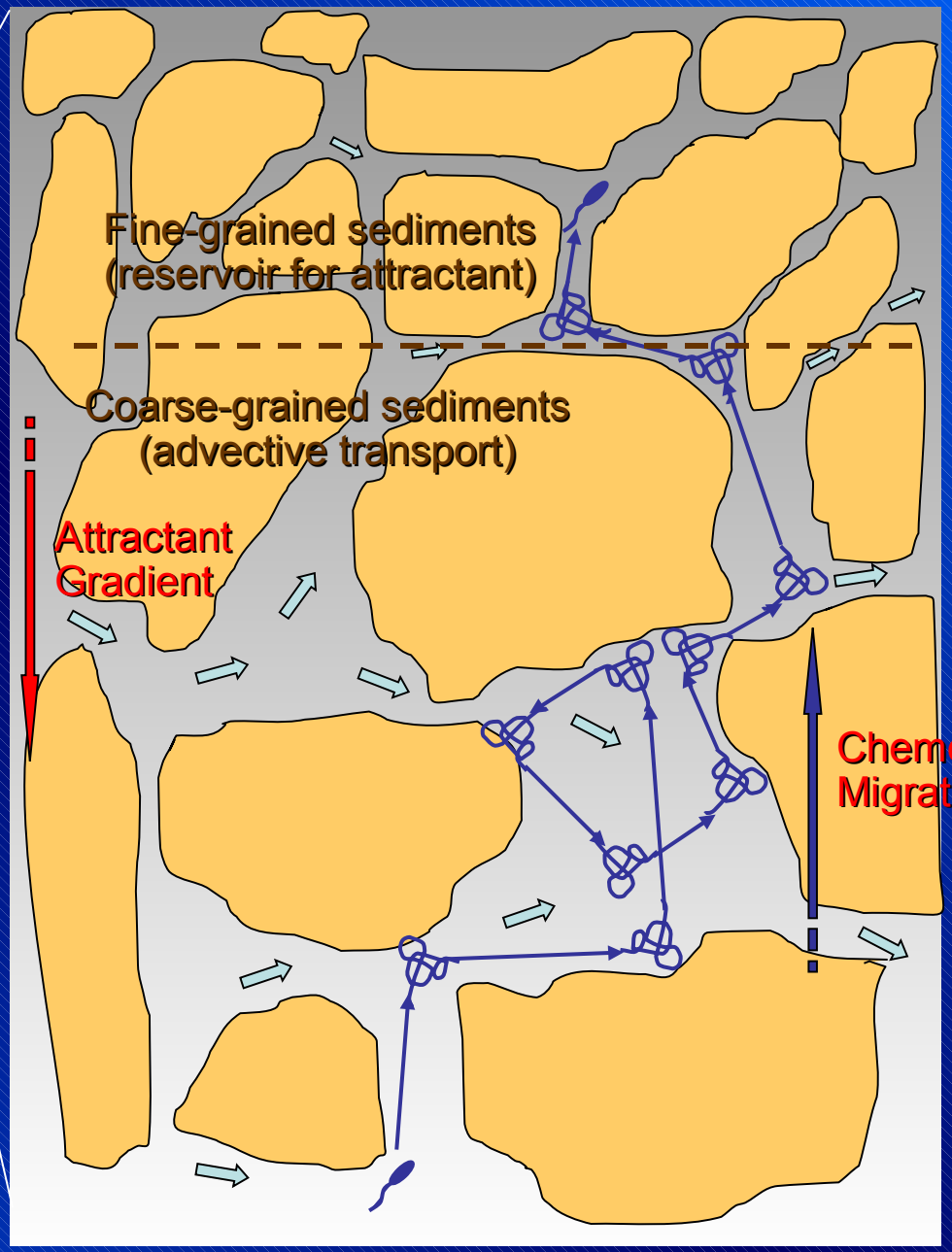


Classic "Run & Tumble" Bacterial Chemotaxis

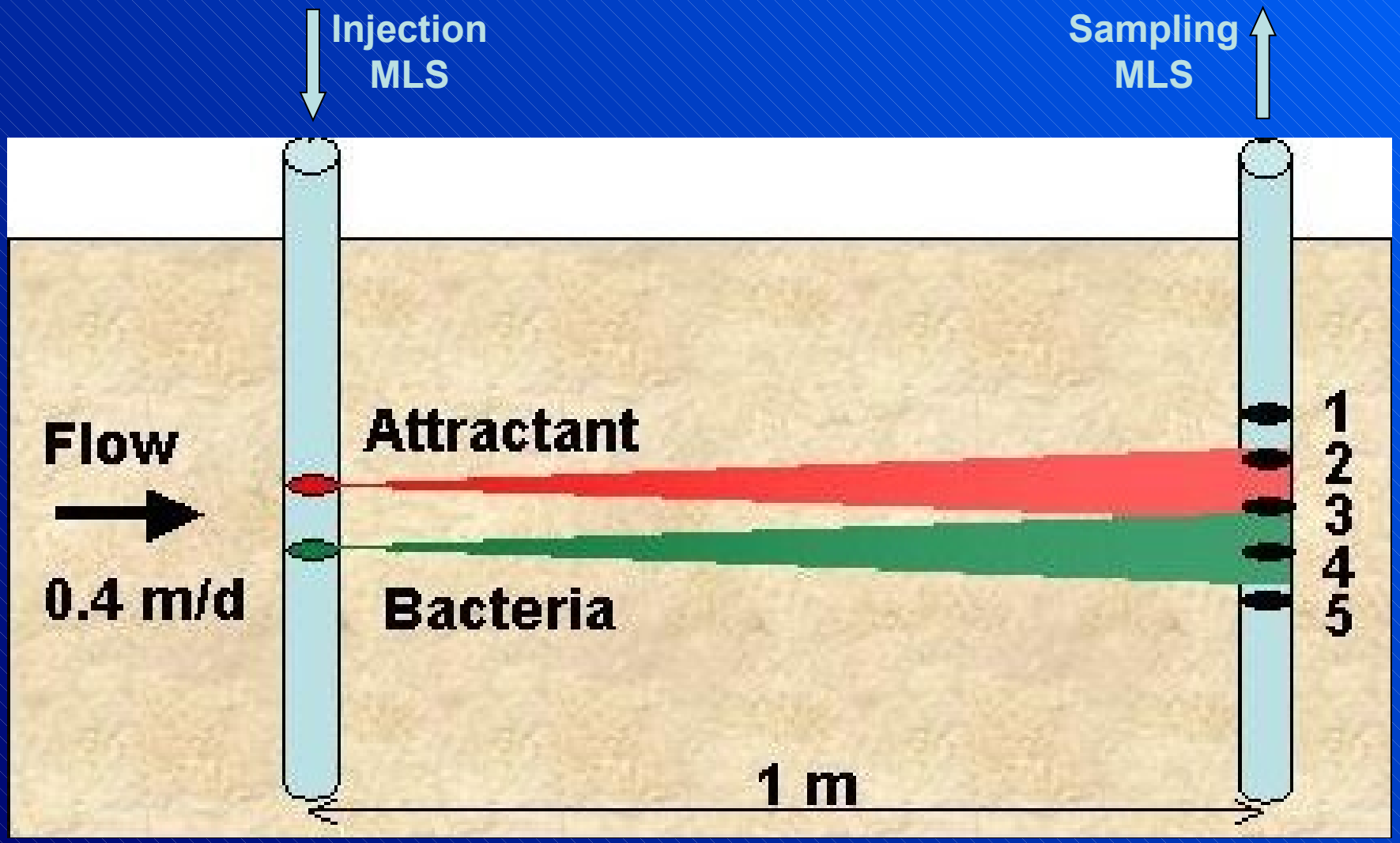


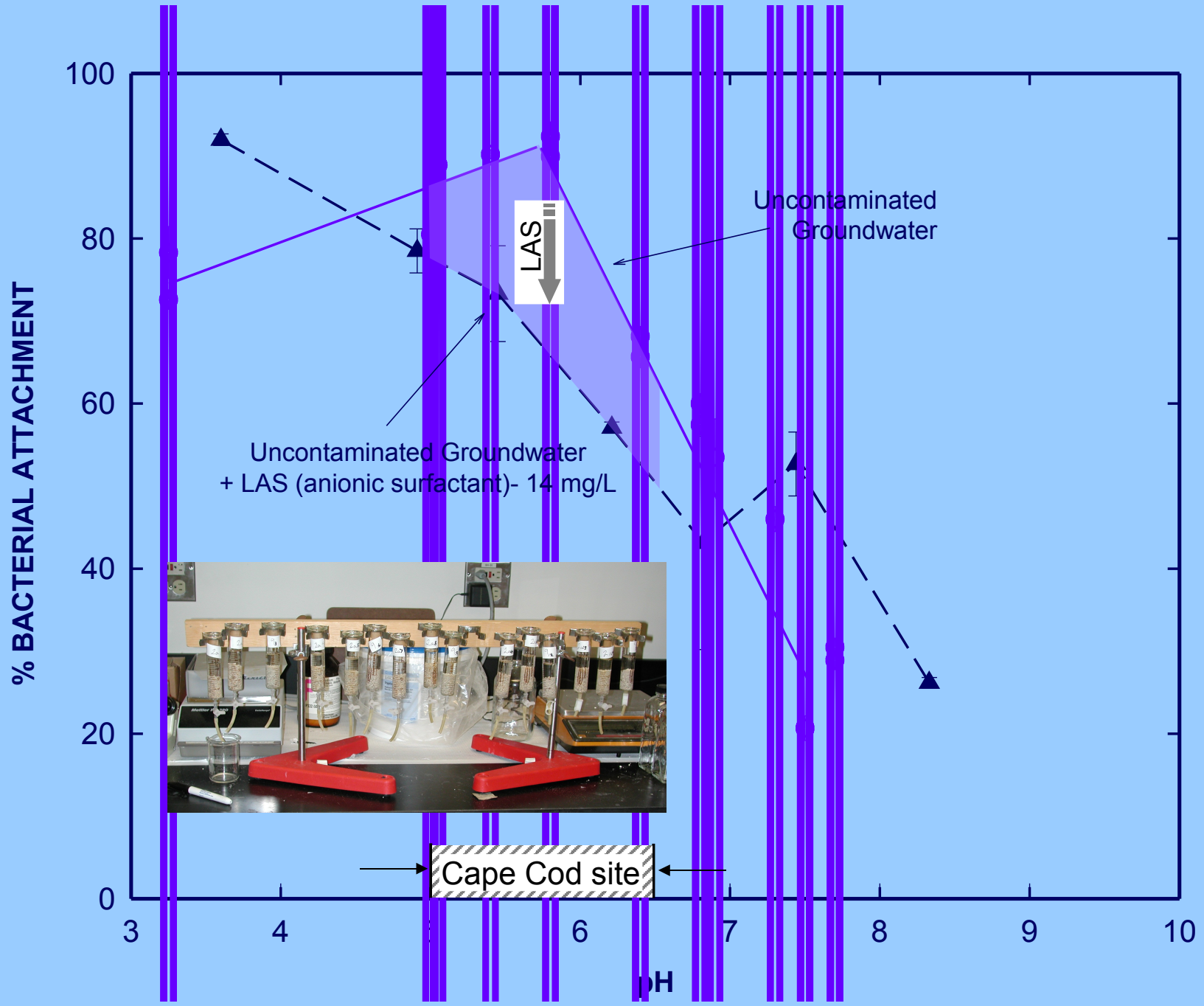
Modified from Ford & Harvey, 2007


0
10
20
30
40
cm
Groundwater
Flow

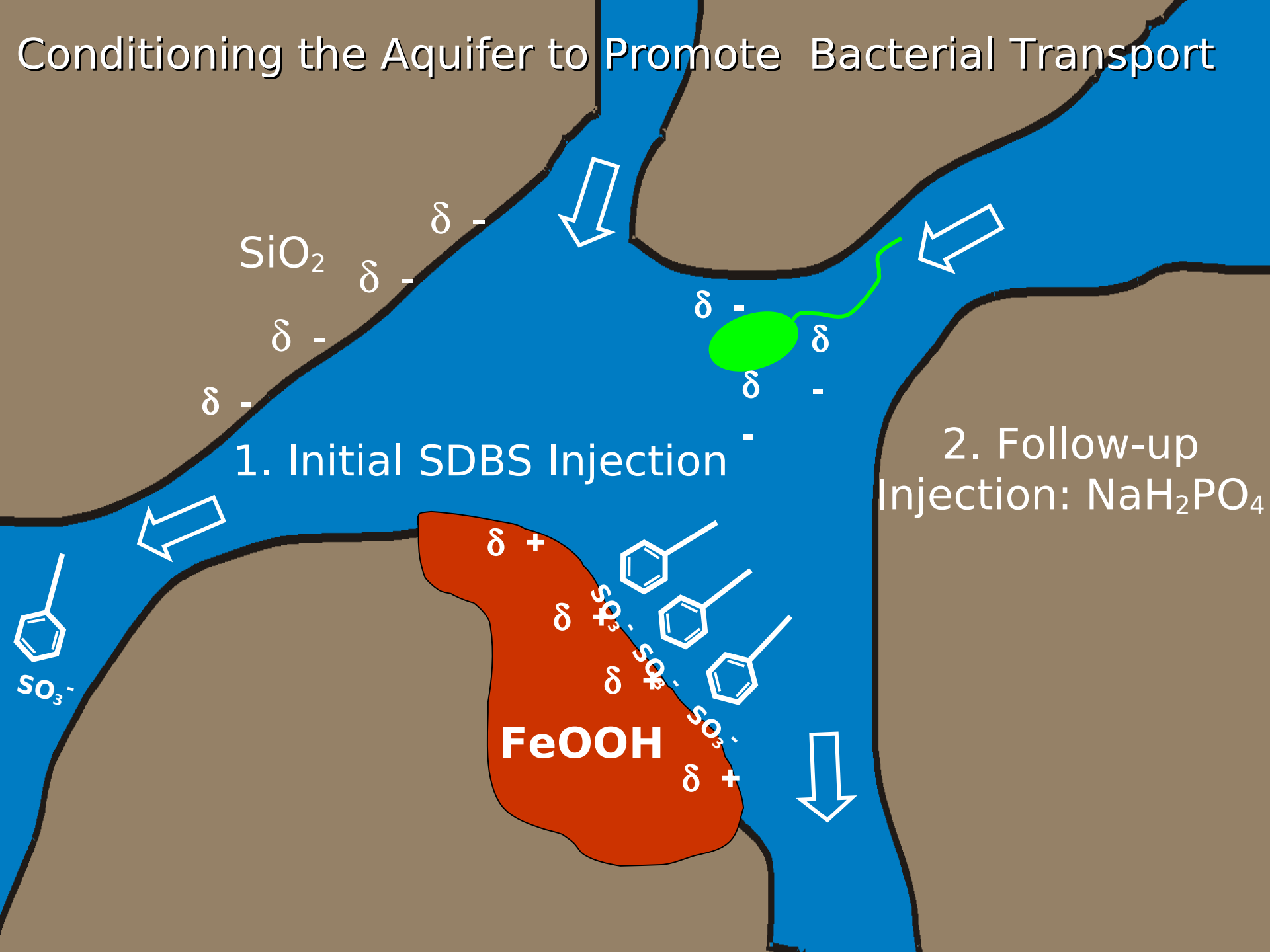

Fine-grained sediments
(reservoir for attractant)
Coarse-grained sediments
(advective transport)
Attractant
Gradient
Chemotactic
Migration ?

Basic Experimental Design
(Proposed to NSF)

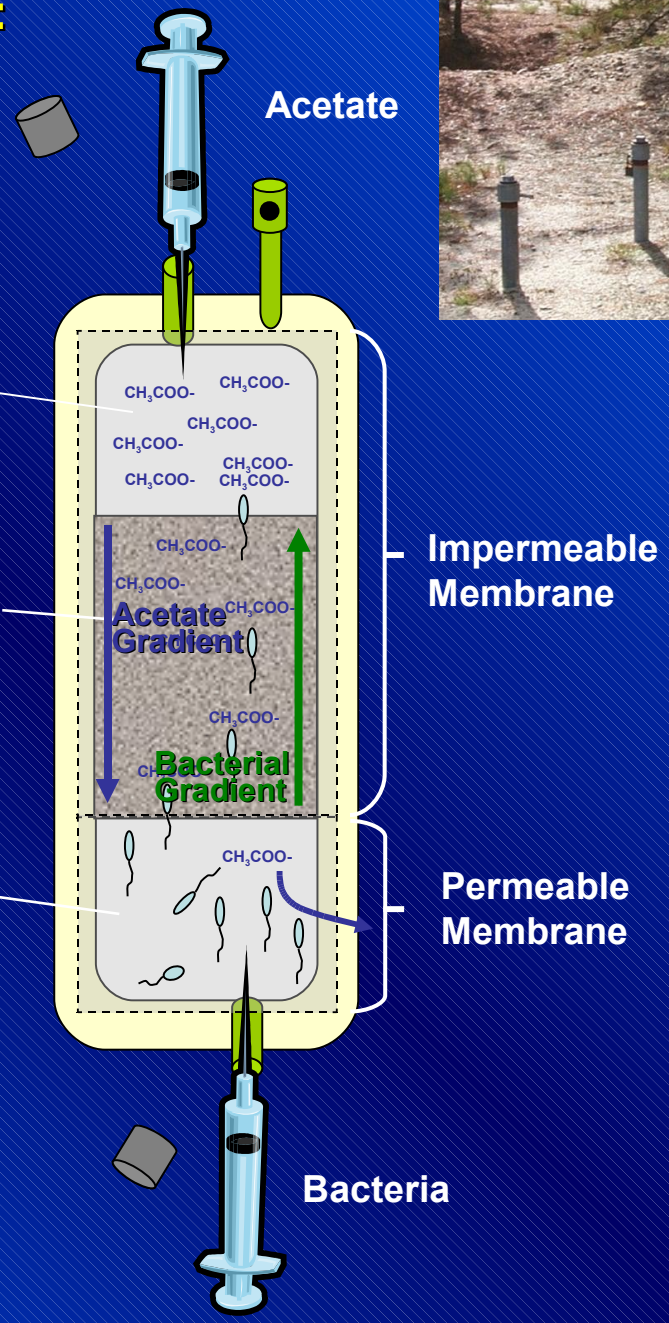



% BACTERIAL ATTACHMENT
100
80
60
40
20
0
3
4
6
7
8
9
10
pH
LAS
Uncontaminated
Groundwater
Uncontaminated Groundwater
+ LAS (anionic surfactant)- 14 mg/L
Cape Cod site

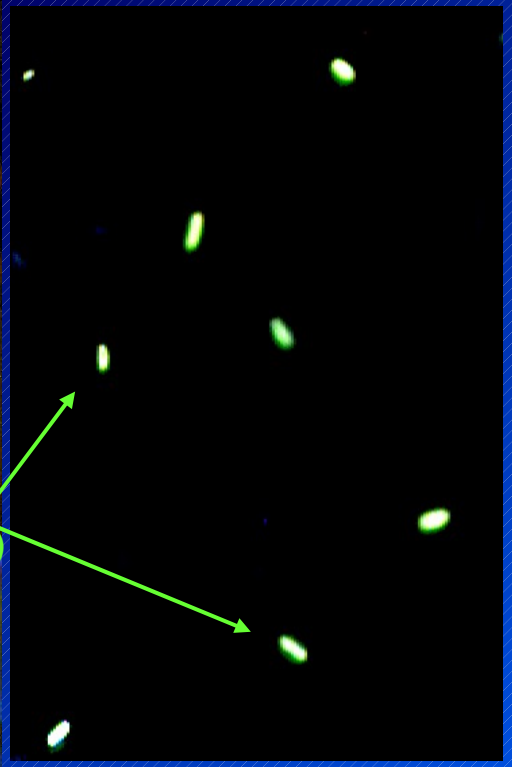
Conditioning the Aquifer to Promote Bacterial Transport



Preliminary Chemotaxis assessment: Modified down-well filter-chambers



Differentiating test and control *Pseudomonas stutzeri*



Test Bacterium

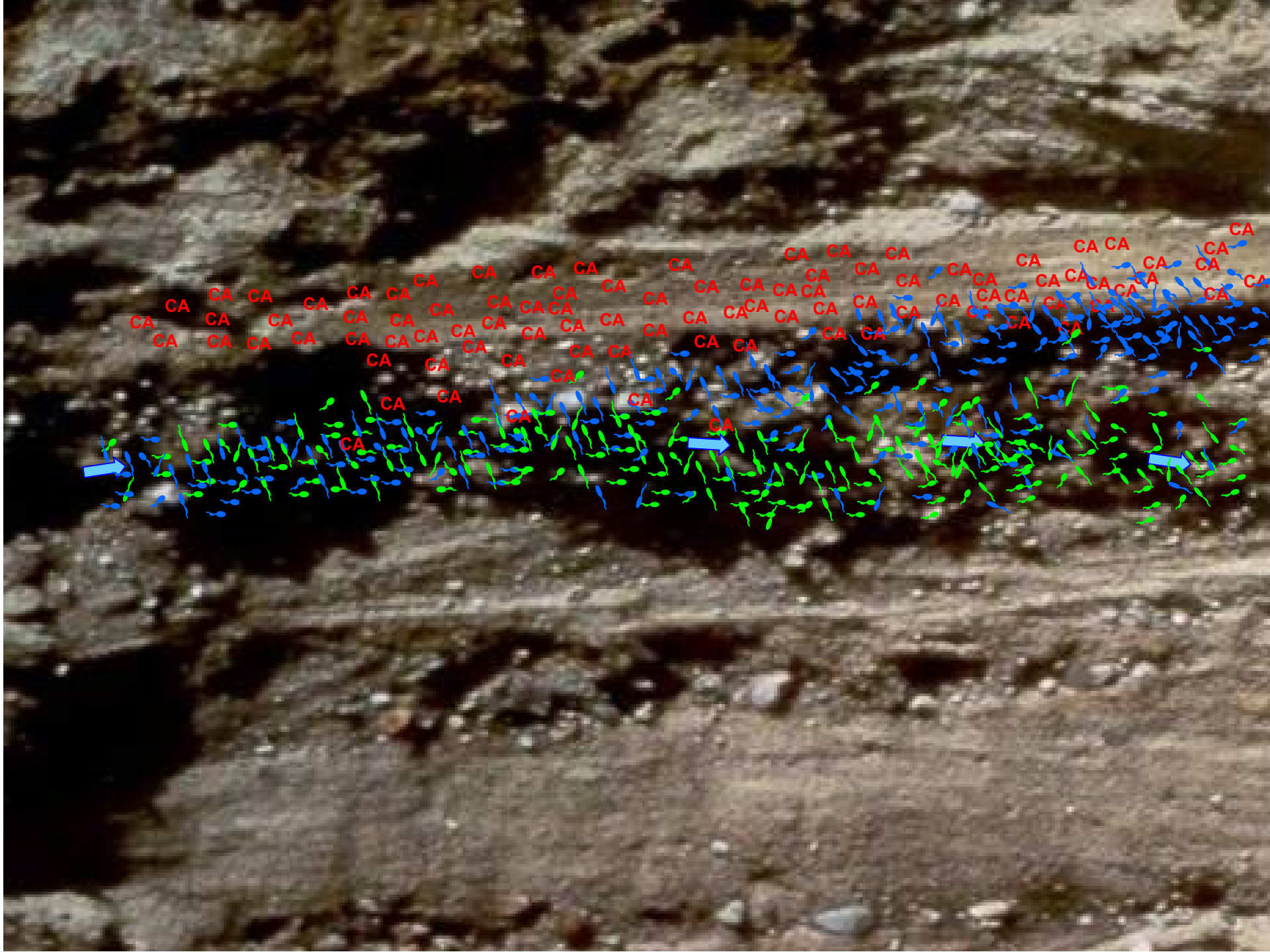
↓

Genetically Engineered to produce "BFP"

Contol Bacterium

↓

Stained with (DAPI + Sybr Gold)


CA