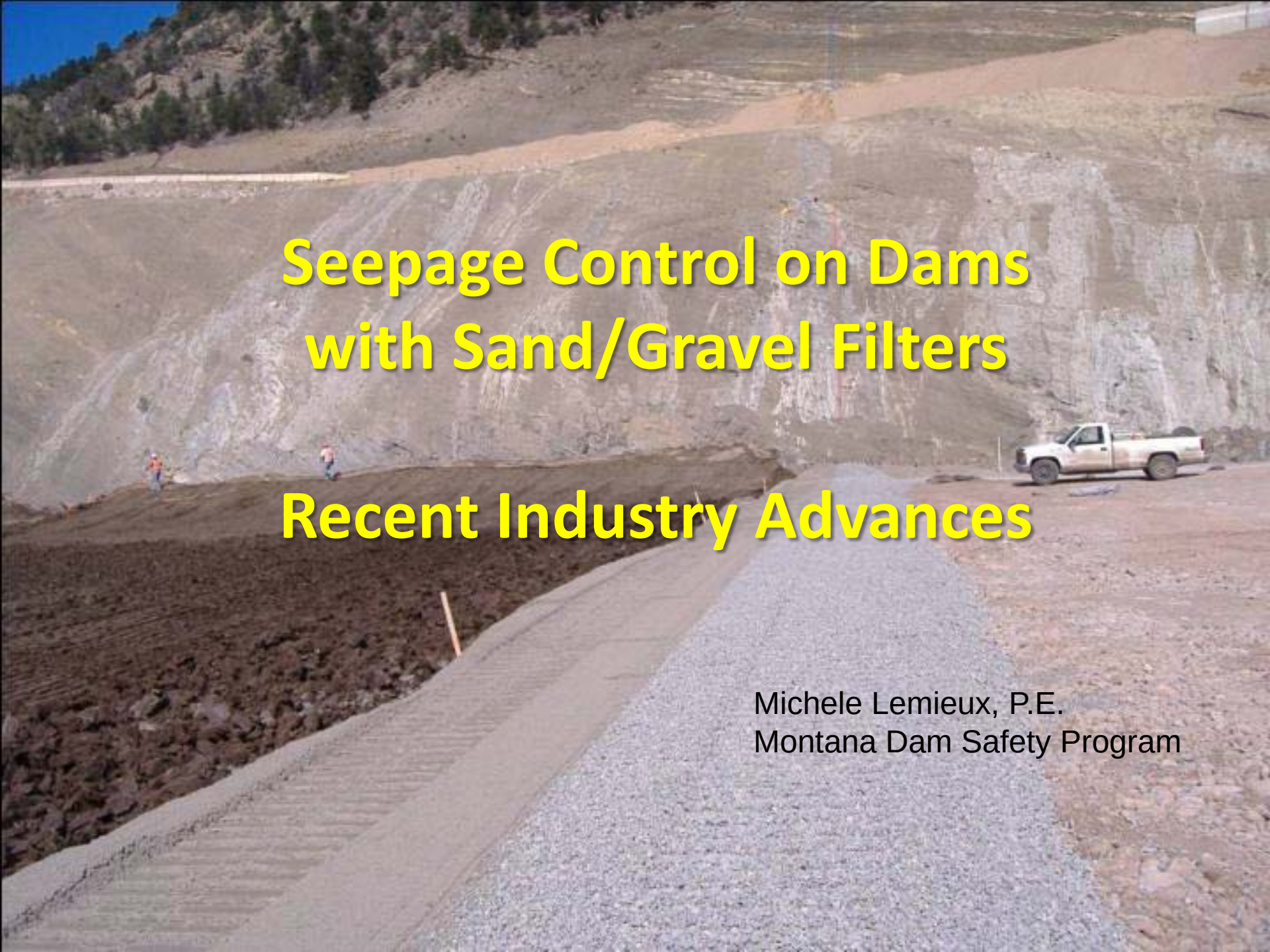


Seepage Control on Dams with Sand/Gravel Filters

Recent Industry Advances

Michele Lemieux, P.E.
Montana Dam Safety Program

Presentation Outline

- Background – Seepage and Dams
- Filter / Drain Design Steps – Overview
- Top 10 List of Recent Industry Advances

Seepage and Dams

Stability

Saturation of portions of an embankment causing loss of soil strength

Piping

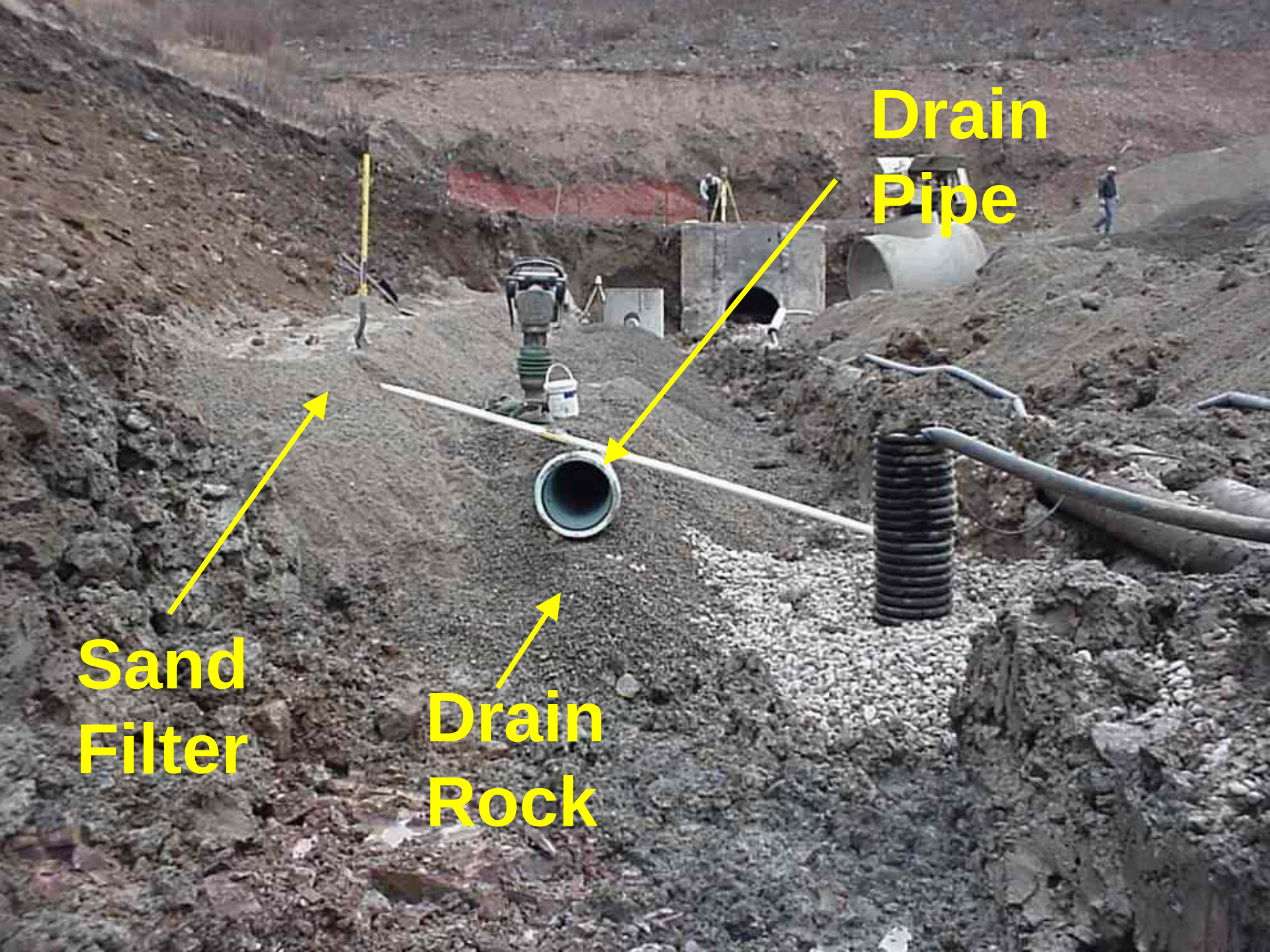
Movement of soil through an unprotected exit

Stability

Piping

Stability

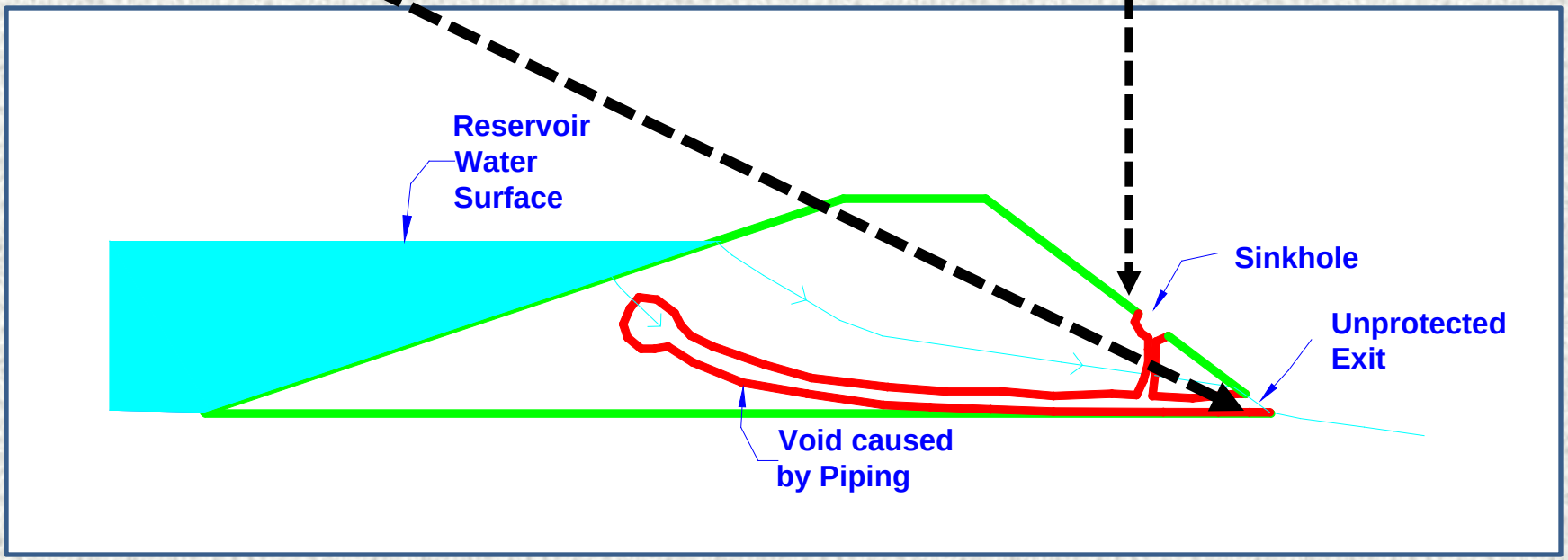
Piping


Drain
Pipe
Sand
Filter
Drain
Rock

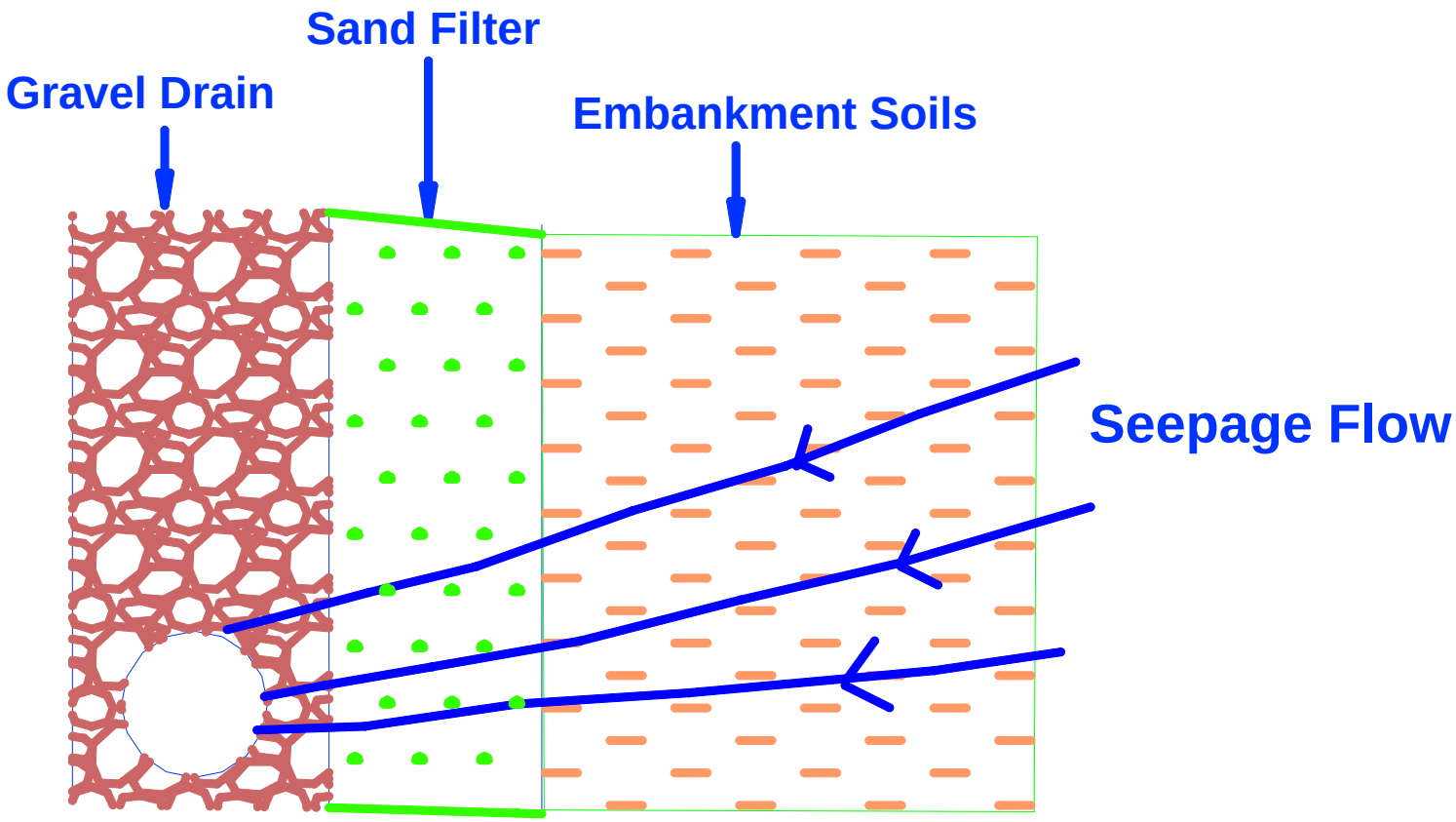

Filter
sand
Drain
Gravel

Embankment Soils – usually fine grained (clay silt)

Gravels


Reservoir
Water
Surface
Sinkhole
Unprotected
Exit
Void caused
by Piping

Filter / Drain Design Steps



1. Design Sand Filter to be compatible with embankment soils

2. Design Gravel Drain to be compatible with sand filter

3. Design drain pipe to be compatible with gravel drain

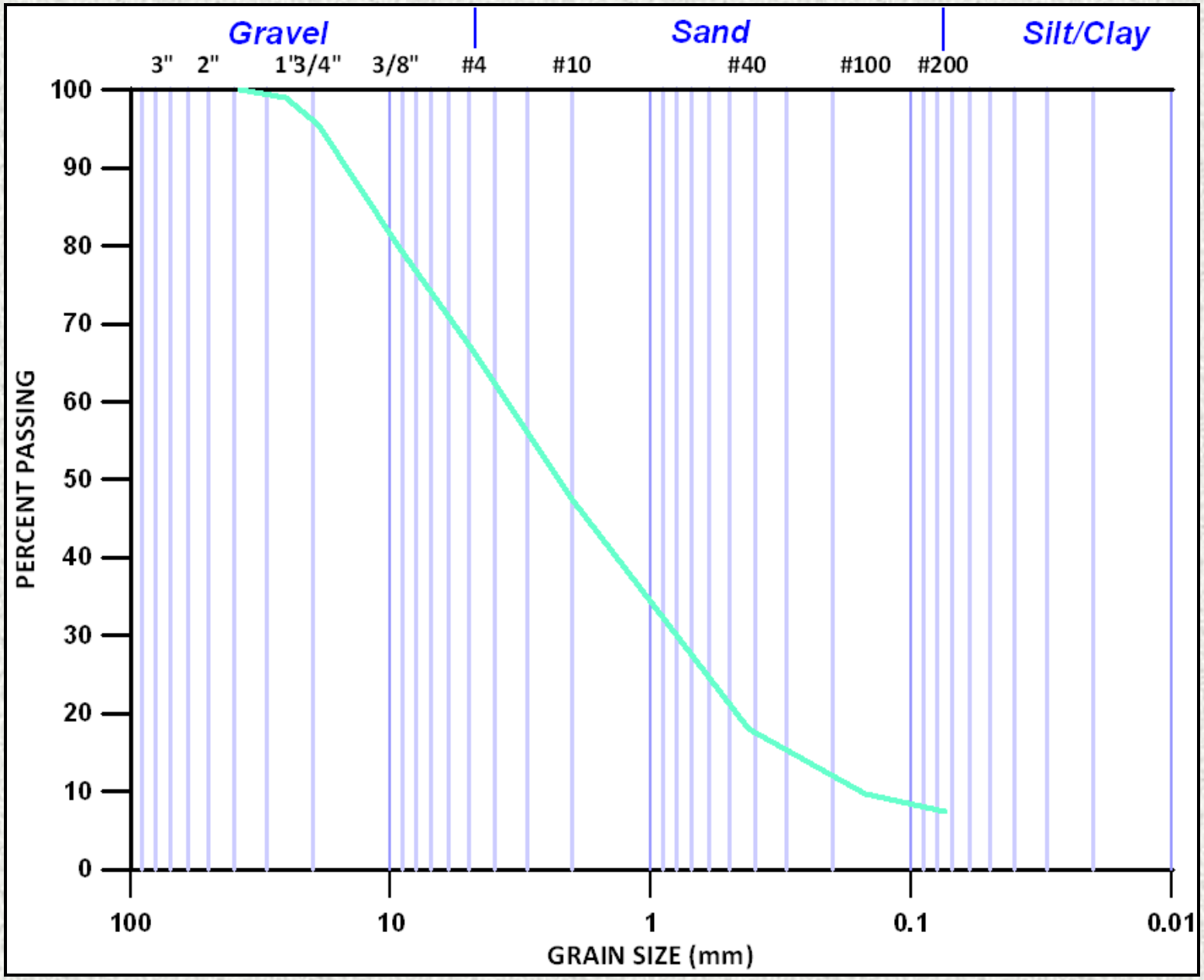
United States
Department of
Agriculture

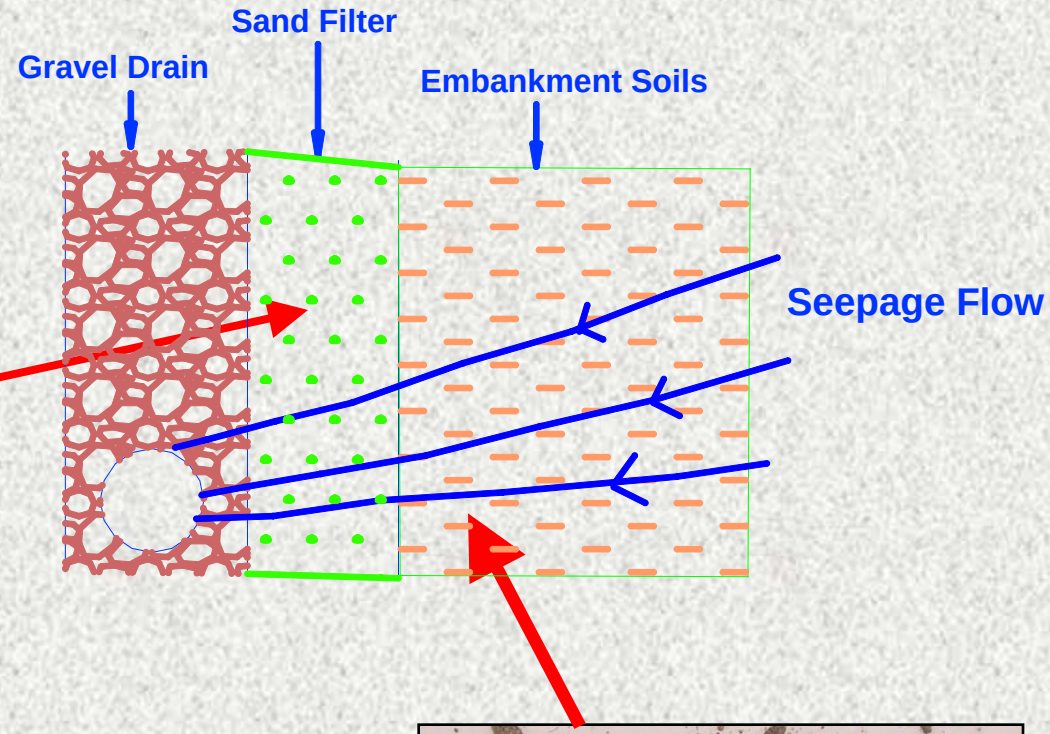
**Natural
Resources
Conservation
Service**

Part 633
National
Engineering
Handbook

Chapter 26 Gradation Design of Sand and Gravel Filters

Embankment Soil or “Base Soil”

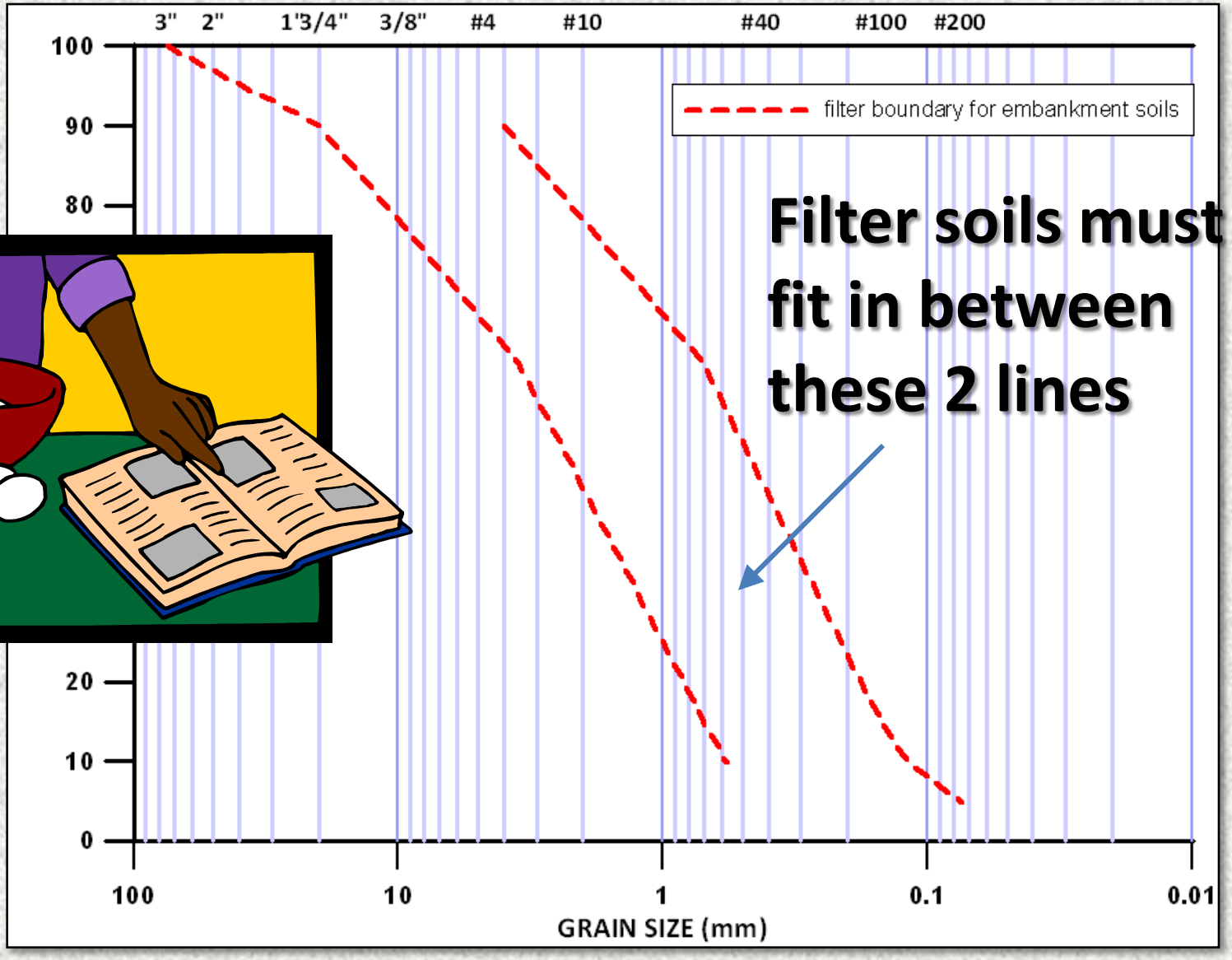

Gravel
Sand
Silt/Clay
3"
2"
1"3/4"
3/8"
#4
#10
#40
#100
#200
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
100
10
1
0.1
0.01
GRAIN SIZE (mm)

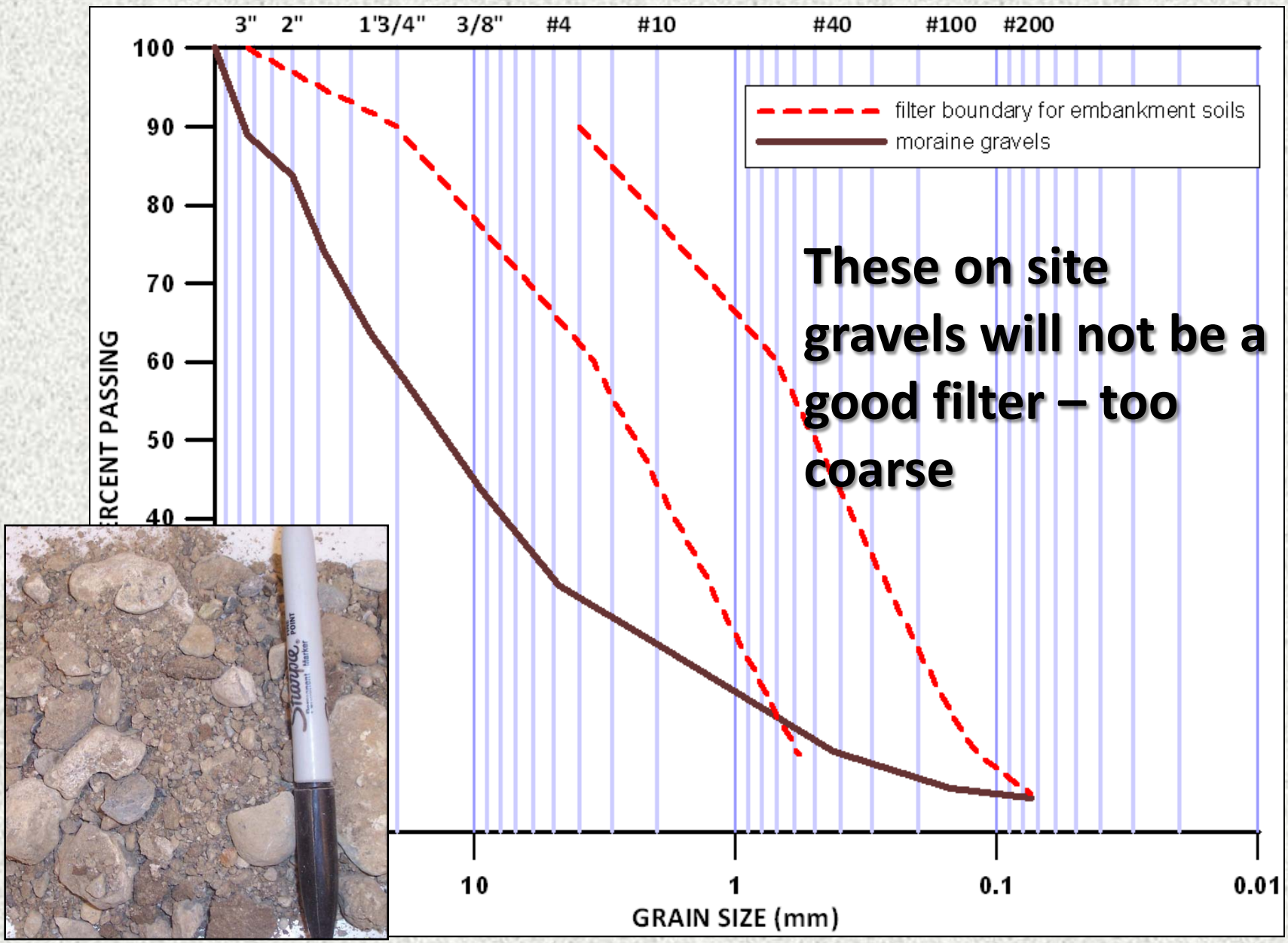

Gravel Drain
Sand Filter
Embankment Soils
Seepage Flow

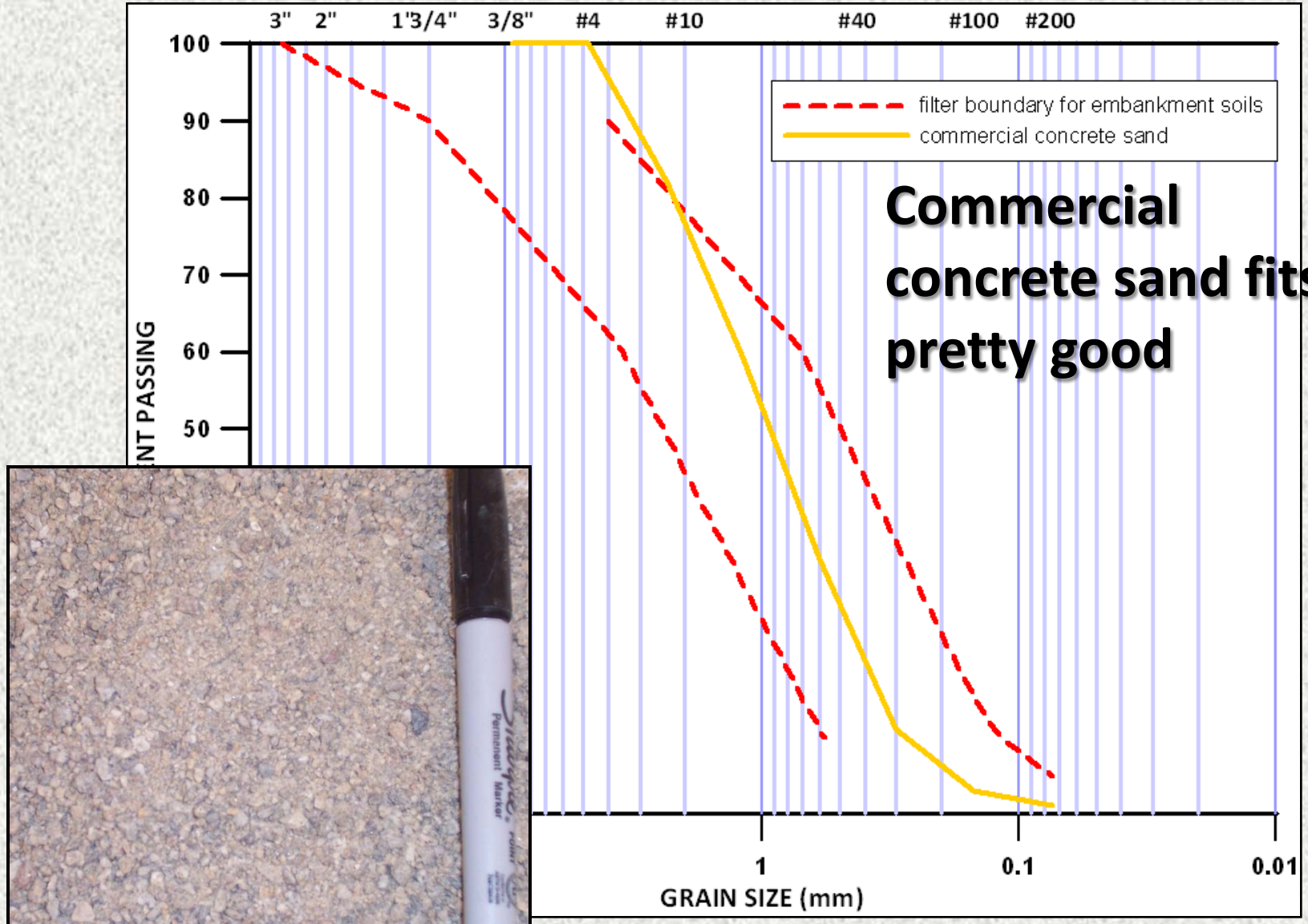

Filter

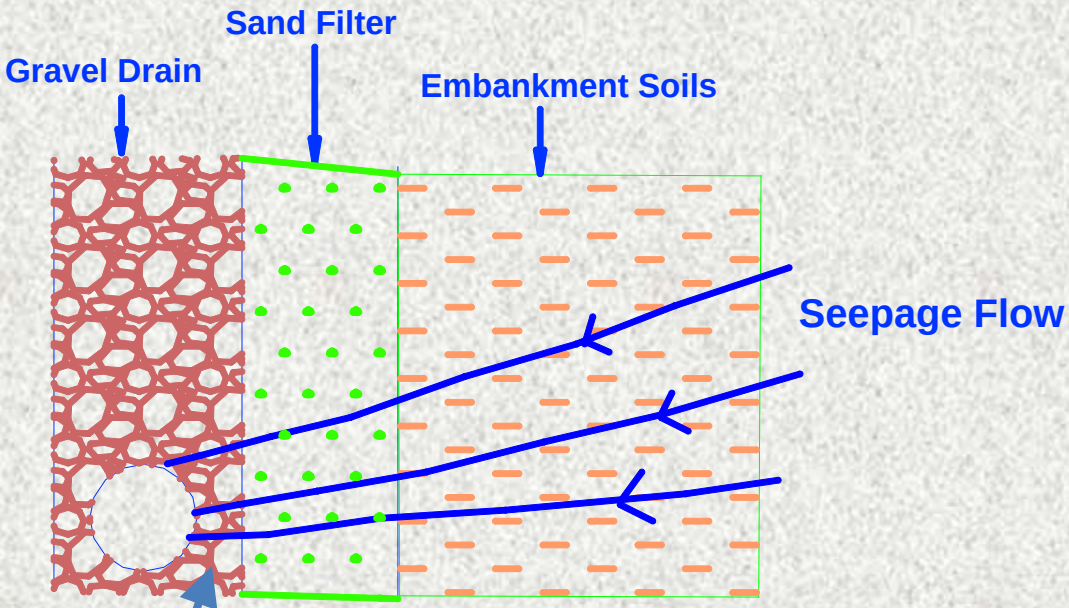
Base Soil


Sharpie
FINE POINT

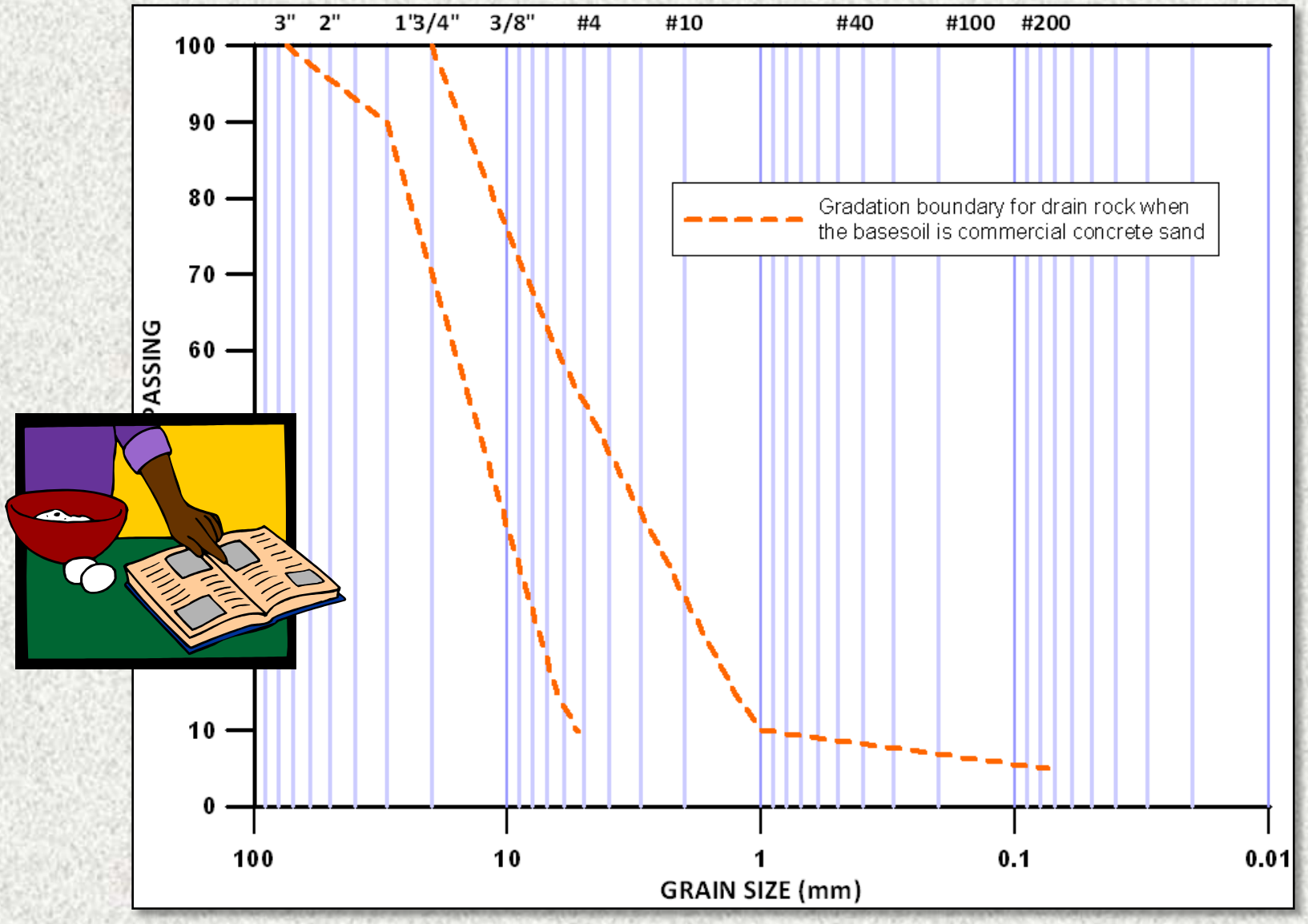

3" 2" 1'3/4" 3/8" #4 #10 #40 #100 #200
100
90
80
20
10
0
filter boundary for embankment soils
Filter soils must fit in between these 2 lines
100
10
1
0.1
0.01
GRAIN SIZE (mm)

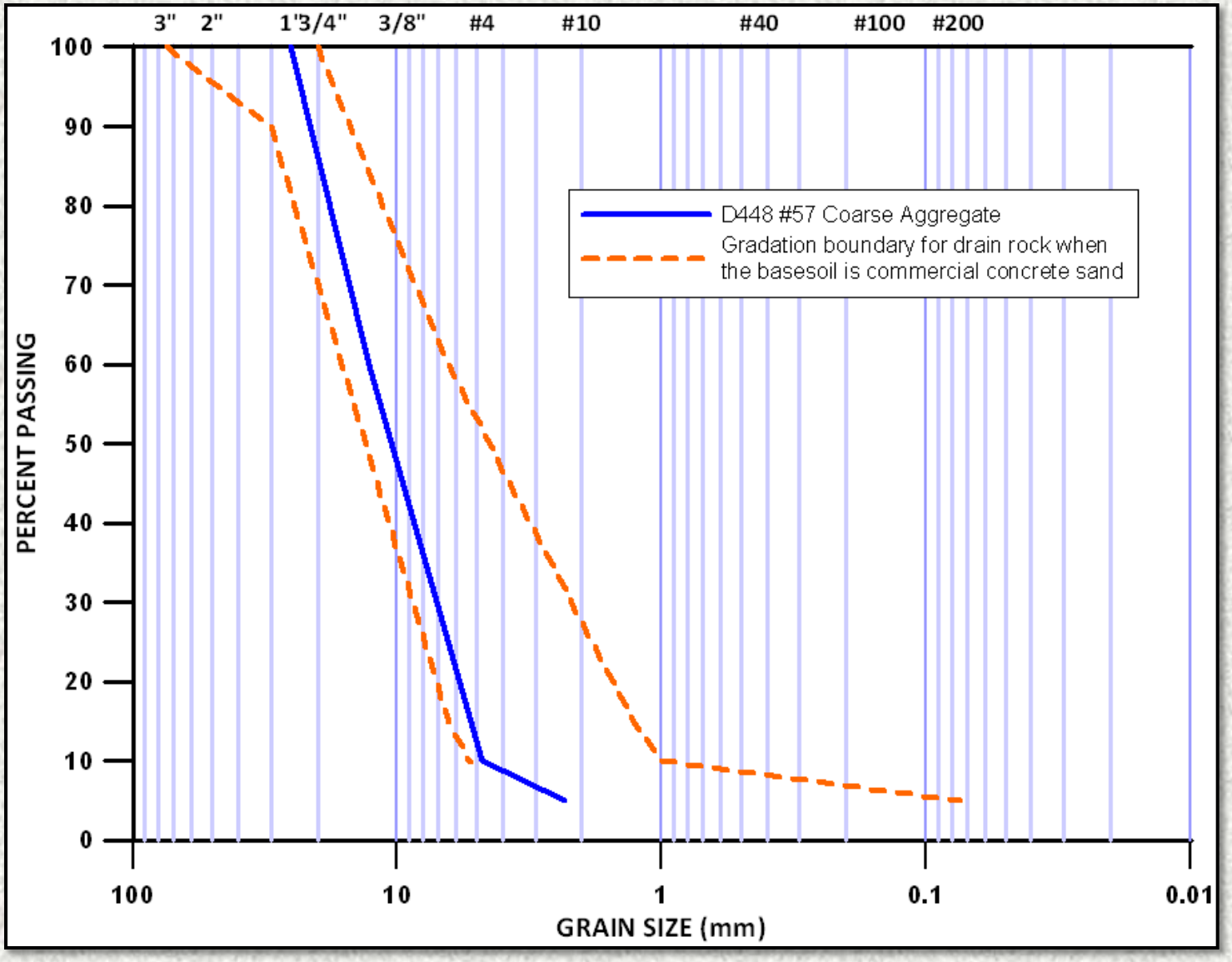

3"
2"
1'3/4"
3/8"
#4
#10
#40
#100
#200
100
90
80
70
60
50
40
filter boundary for embankment soils
moraine gravels
These on site gravels will not be a good filter – too coarse
10
1
0.1
0.01
GRAIN SIZE (mm)

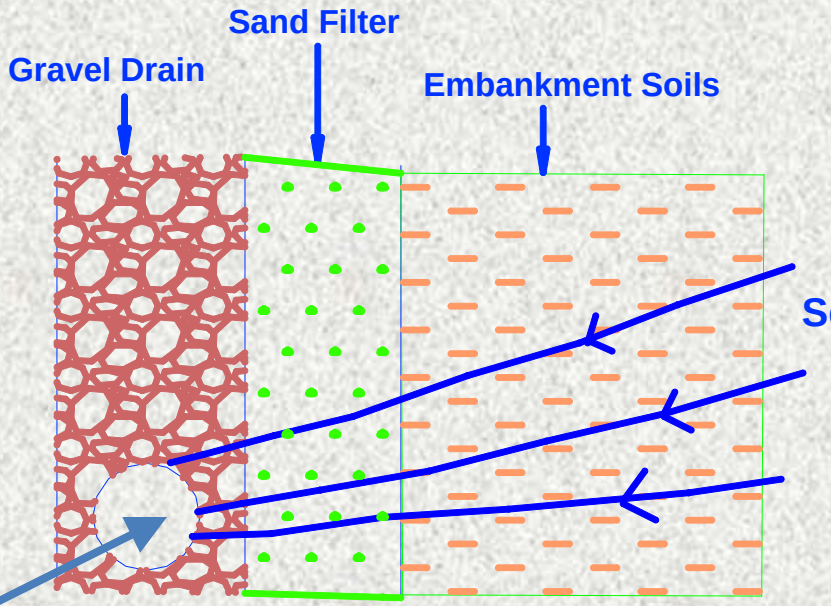

3" 2" 1"3/4" 3/8" #4 #10 #40 #100 #200
100
90
80
70
60
50
NT PASSING
filter boundary for embankment soils
commercial concrete sand
Commercial concrete sand fits pretty good
1
0.1
0.01
GRAIN SIZE (mm)



Drain Rock "Filter"


3"
2"
1"3/4"
3/8"
#4
#10
#40
#100
#200
100
90
80
70
60
10
0
PASSING
100
10
1
0.1
0.01
GRAIN SIZE (mm)
Gradation boundary for drain rock when the basesoil is commercial concrete sand


3"
2"
1'3/4"
3/8"
#4
#10
#40
#100
#200
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
D448 #57 Coarse Aggregate
Gradation boundary for drain rock when the basesoil is commercial concrete sand
100
10
1
0.1
0.01
GRAIN SIZE (mm)



Drain Rock

"Base Soil"

Drain Pipe

- ✓**Background – Seepage and Dams**
- ✓**Filter / Drain Design Steps – Overview**
- ***Top Ten List of Recent Industry Advances***

TOP TEN LIST

10. Don't use on-site soils for critical filter / drain applications

- *It* is rare to find natural materials that can satisfactorily serve as filter

- Tend to be gap graded, prone to segregation during placement
- Generally, have too many clay/silt size particles
- Washing on-site can be problematic for fall construction in Montana
- Uncertainty – variations in gradations and quantity of material

9. Keep fines content down: < 3% in stockpile, < 5% in place

- Sand and gravel tend to breakdown during placement

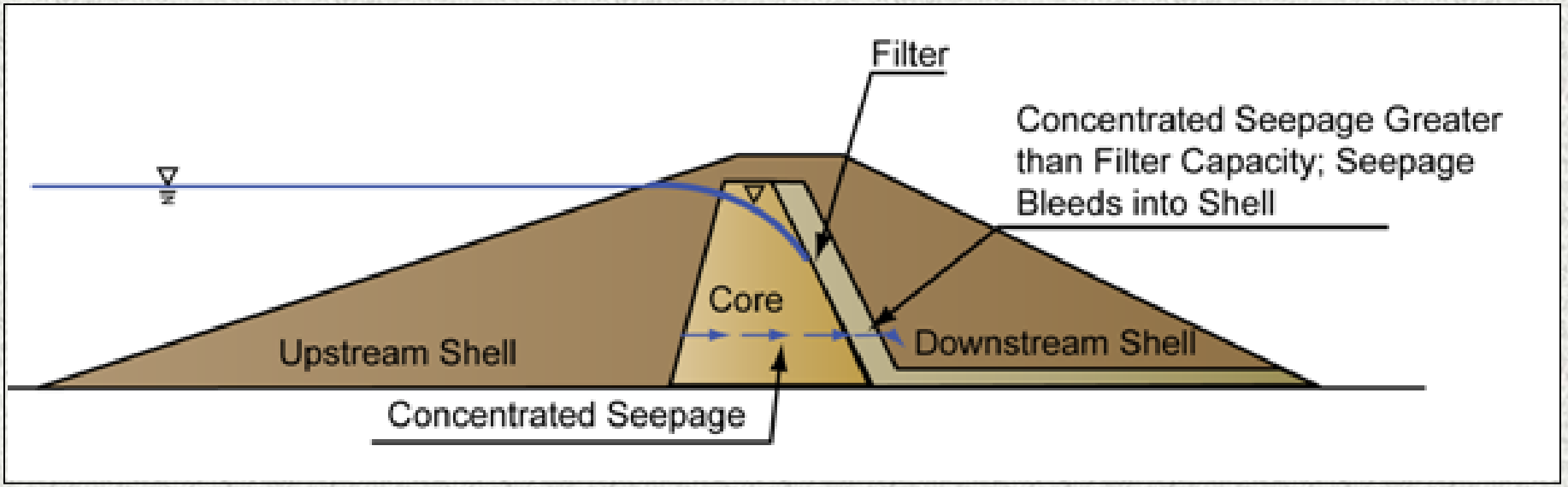
- Permeability goes down dramatically with increasing clay and silt. A soil with as little as 7% clay can be essentially impermeable

8. ASTM C33 concrete sand is an excellent filter for most embankment dams

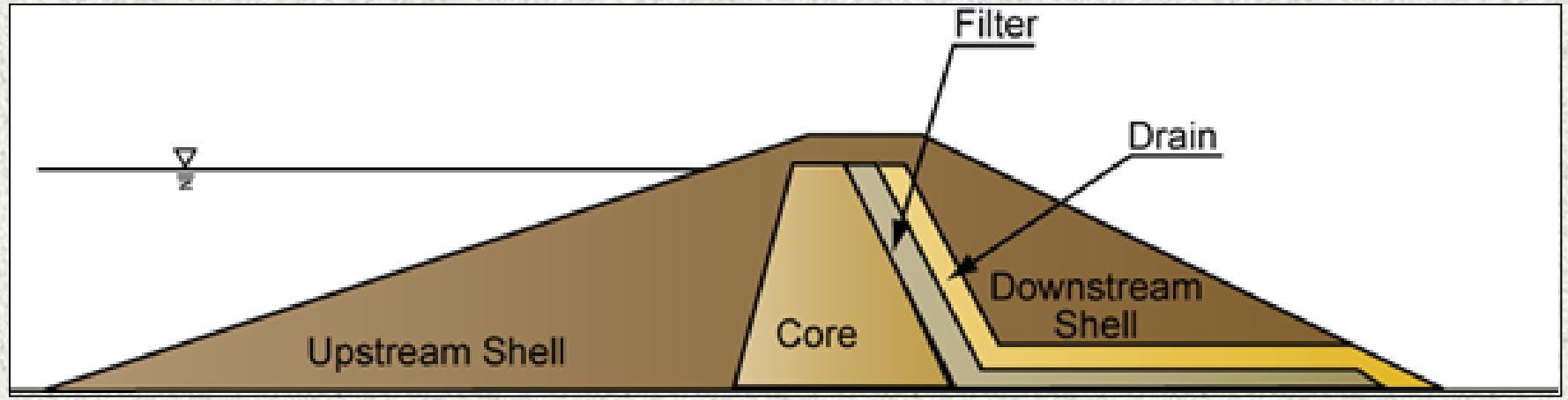
- *Readily available*
- *Perfect filter for MOST clay silt soils*

7. Don’t overestimate permeability of your concrete filter sand

7. Don’t overestimate permeability of your concrete filter sand



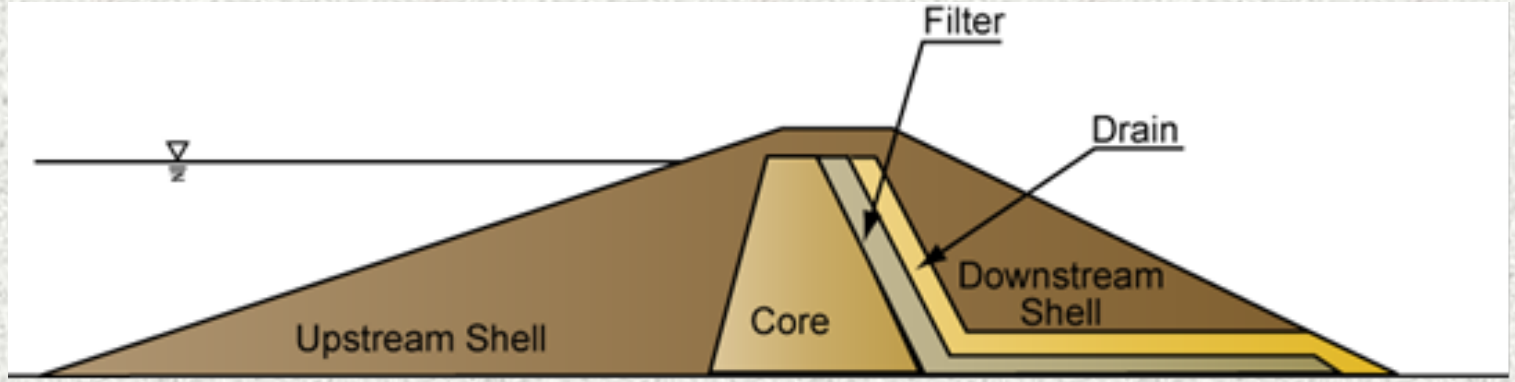
6. Put in a chimney filter when repairing your embankment

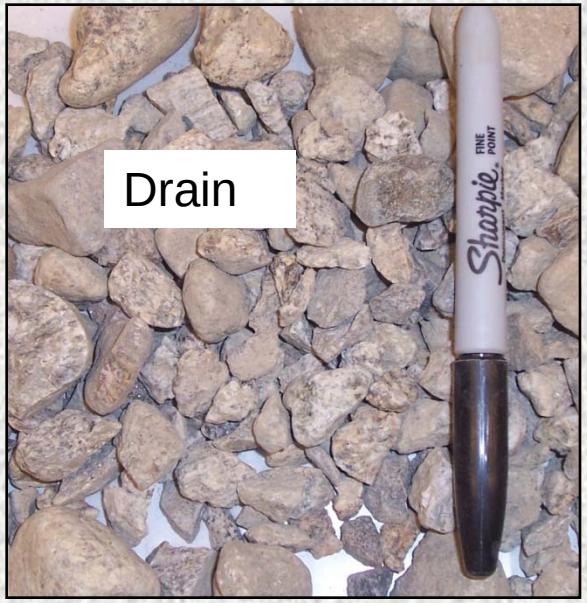


- *Overwhelming evidence of their effectiveness*

- *Prevents problems from construction defects (loose lifts, poor bond between lifts, pervious layers, desiccation, and dispersive soils)*

5. If there is a chance of concentrated flows, use 2 stages in your chimney filters





4. Design toe drain pipes to accommodate an inspection

- Plentiful cases where drain pipes get damaged during construction

BONUS!!!

- A pipe that fits a video camera generally has adequate capacity.

3. Make an informed choice of the plastic pipe in your toe drain

Report DSO-09-01

Physical Properties of Plastic Pipe Used in Reclamation Toe Drains

Dam Safety Technology Development Program

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

September 2009

~~Single Wall Corrugated HDPE~~

Dual Wall Corrugated HDPE

Joint Separation & Collapse

$ **Solid Wall HDPE**

- 10X Strength double wall corrugated HDPE

Solid Wall PVC pressure pipe

- 4X Strength double wall corrugated HDPE

2. Always design your toe drains with 2 stages

- Sand can clog pipe perforations
- Must have properly sized drain rock adjacent to perforations

1. Consider using method based specifications

- Type of equipment used for compaction, number of passes of equipment, moisture application is often left up to the contractor

- Over-compaction of filters and drains, breaks down particles, causing loss of permeability

- **For critical filters and drains, specify exactly how you want them constructed**

References will be posted at:

http://dnrc.mt.gov/wrd/water_op/dam_safety_technical_ref.asp